Muskrat Falls Review
Exhibit - GRK # 4
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# CONSERVATION AND DEMAND MANAGEMENT (CDM) POTENTIAL

## NEWFOUNDLAND and LABRADOR

## Residential, Commercial and Industrial Sectors

*Prepared for:*

**Newfoundland & Labrador Hydro and Newfoundland Power**

*Prepared by:*

**Marbek Resource Consultants Ltd.**

*January 18, 2008*

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## *–Summary Report–*

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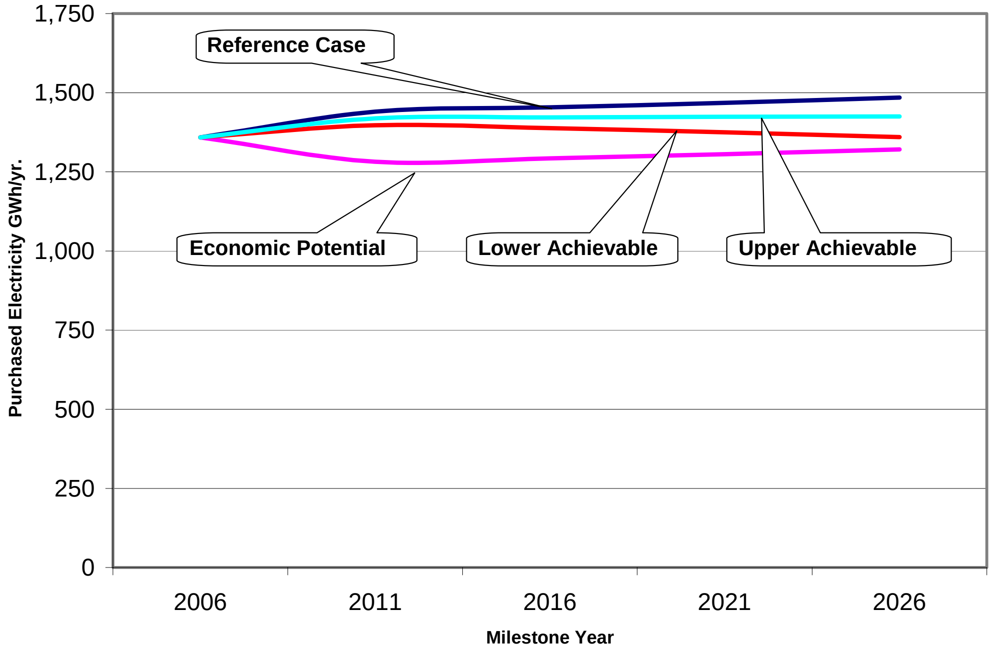

1,750
1,500
1,250
1,000
750
500
250
0
Reference Case
Economic Potential
Lower Achievable
Upper Achievable
Purchased Electricity GWh/yr.
2006
2011
2016
2021
2026
Milestone Year

# 1. INTRODUCTION

## 1.1 BACKGROUND AND OBJECTIVES

Newfoundland and Labrador Hydro and Newfoundland Power (collectively the Utilities) have partnered to produce this study, recognizing the role that each has in energy conservation and least cost electric utility planning within the province. Increasing electricity costs and the expectations of a growing number of their customers and stakeholders have contributed to the increased focus on conservation and demand management (CDM) and resulted in a number of recent initiatives and projects targeting energy savings in the province. This study is the next step in the Utilities efforts to develop a comprehensive plan for CDM in Newfoundland and Labrador. The Utilities envision electricity conservation and demand management (CDM) to be a valuable component in meeting the province's future electricity requirements.

This study will also be a significant component in the further implementation of the Province's recently released Energy Plan. The Energy Plan establishes a long-term vision for how the province's energy resources will be developed and utilized to benefit the people of the province today as well as for future generations. Electricity conservation and demand management (CDM) are an important component of the provincial Energy Plan as are the conservation and demand management components for the other energy resources of the province.

This report meets, in part, the requirements of the Public Utilities Board Order PU 8 2007 requiring NLH to file this study and a five-year plan for implementation of CDM programs in 2008.

The objective of this study is to identify the potential contribution of specific CDM technologies and measures in the Residential, Commercial and Industrial sectors and to assess their economic costs and benefits. The Newfoundland and Labrador economy is expected to grow over the next 20 years, with an associated increase in energy consumption. The benefits of increased penetration of energy efficiency technologies include reduced energy costs for individuals and businesses, as well as environmental benefits through reduced pollution and greenhouse gas emissions.

The outputs from this study will assist the Utilities CDM planners and others to develop specific CDM programs for implementation and to optimize the contribution of CDM technologies and measures to the province's overall energy future.

## 1.2 STUDY SCOPE

The scope of this study is summarized below.

- **Sector Coverage:** This study addresses the Residential, Commercial[1] and Industrial sectors. Consistent with the study's agreed upon scope, the Industrial sector is treated at a higher level than the Residential and Commercial sectors.

[1] The Commercial sector analysis includes street lighting.

- **Geographical Coverage**: The study addresses the customers of both utilities. Due to differences in cost and rate structures, the Utilities' customers are organized into two service regions, which in this report are referred to as: the Island and Isolated, and the Labrador Interconnected. For the purposes of this study, the isolated diesel system customers were combined with those in the Island service region due to their relatively small size and electricity usage.

- **Study Period**: This study covers a 20-year period. The Base Year is the calendar year 2006, with milestone periods at five-year increments: 2011, 2016, 2021 and 2026. The Base Year of 2006 was selected as it was the most recent calendar year for which complete customer data were available.

- **Technologies:** The study addresses conservation and demand management (CDM) measures. CDM refers to a broad range of potential measures; however, for the purposes of this study, it was agreed that the primary focus is on energy-efficiency measures. This includes measures that reduce electricity use as well as the associated electric demand. The study also provides a high-level treatment of selected demand management measures, such as direct control of space heating loads.[2]

## 1.3 MAJOR ANALYTIC STEPS

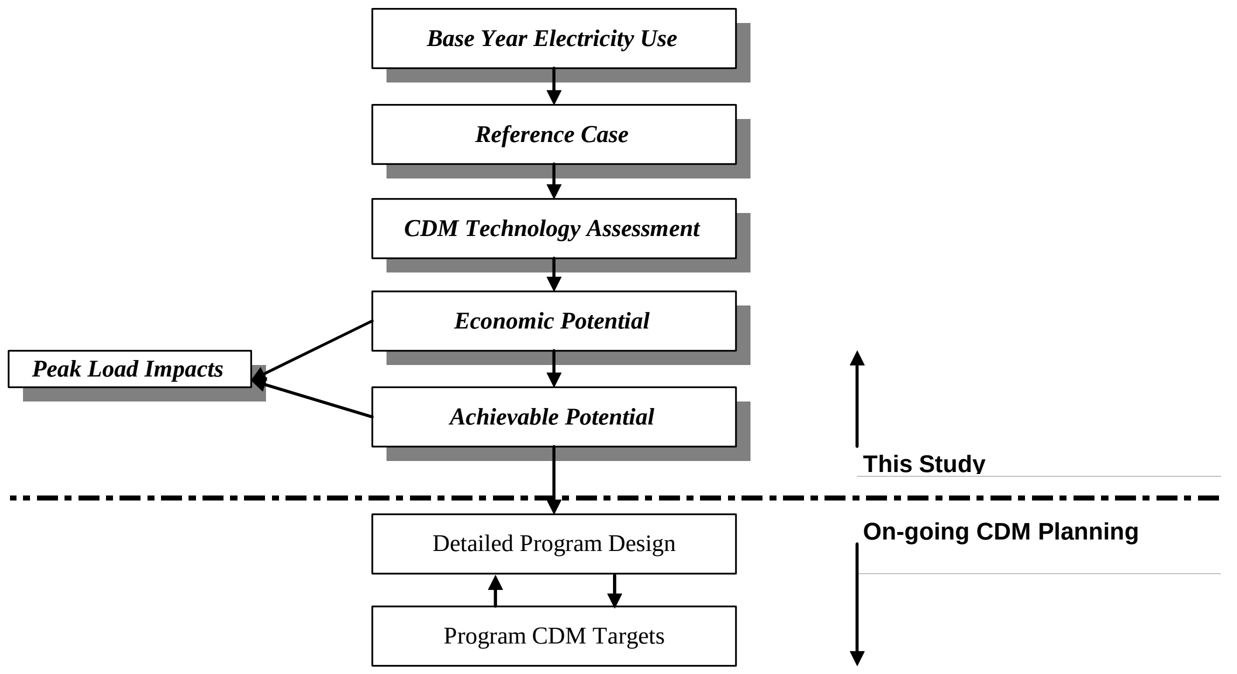
The major steps involved in the analysis are shown in Exhibit 1.1 and are discussed in greater detail in Section 1 of the individual sector reports. As illustrated in Exhibit 1.1, the results of this study, and in particular the estimation of Achievable Potential,[3] support the Utilities on-going work.

It should, however, be emphasized that the estimation of Achievable Potential is not synonymous with either the setting of specific targets or with program design. Both of these activities require additional market-specific investigation and planning.

[2] The information provided is based on the detailed analysis that Marbek is currently undertaking in other jurisdictions.

[3] The proportion of savings identified that could be achieved within the study period assuming specific customer, program and market conditions. Additional details are provided in the individual sector reports.

**Exhibit 1.1: Study Approach - Major Analytical Steps**




The analysis conducted within each of the three sectors followed a similar set of steps, as outlined below.

### *Step 1: Develop Base Year Calibration Using Actual Utilities Sales Data*

The Base Year (2006) is the starting point for the analysis. It provides a detailed description of "where" and "how" electricity is currently used, based on actual electricity sales.

The consultants compiled the best available data and used sector-specific macro models to estimate electricity use; they then compared the results to the Utilities actual billing data to verify their accuracy.

### *Step 2: Develop Reference Case*

The Reference Case uses the same sector-specific macro models to estimate the expected level of electricity consumption that would occur over the study period with no new (post-2006) Utilities' CDM initiatives. The Reference Case includes projected increases in electricity consumption based on expected rates of population and economic growth, using the growth rates included in the NLH 2006 load forecast.[4] The Reference Case also makes an estimate for some "natural" conservation, that is, conservation that occurs without Utilities' CDM programs. The Reference Case provides the point of comparison for the calculation of Economic and Achievable electricity saving potentials.

[4] Newfoundland & Labrador Hydro Long Term Planning (PLF) Review Forecast, Summer/Fall 2006.

***Step 3: Assess CDM Technologies***

The consultants researched a wide range of commercially available CDM technologies and practices that can enable the Utilities' customers to use electricity more efficiently. In each case, the consultants assessed how much electricity the CDM measures could save together with the expected cost, including purchase (capital), operating and maintenance costs.

For each CDM measure the consultants calculated a value for the cost per year per kilowatt-hour of saved electricity, referred to as the Cost of Conserved Energy (CCE). The CCE is calculated as the annualized incremental cost (including operating and maintenance) of the measure divided by the annual kilowatt-hour savings achieved, excluding any administrative or program costs to achieve full use of the measure. This approach allowed the consultants to compare a standardized cost for new technologies and measures with the cost of new electricity supply, or other electricity conserving measures, and to determine whether or not to include the CDM measure in the Economic Potential Forecast.

***Step 4: Estimate Economic Electricity Savings Potential***

To forecast the potential electricity savings that are defined as economic, the consultants used the sector-specific macro models to calculate the level of electricity consumption that would occur if the Utilities' customers installed all "cost-effective" technologies. "Cost effective" for the purposes of this study means that the CCE is less than or equal to the estimated cost of new electricity supply.

NLH determined that the avoided costs of new electricity supply to be used for this analysis are $0.0980/kWh for the Island and Isolated service region and $0.0432/kWh for the Labrador Interconnected service region. These avoided costs represent a future in which the Lower Churchill project is not built and there is no DC link from Labrador to the Island[5].

The Economic Potential Forecast incorporates all the CDM measures reviewed that have a CCE equal to or less than the avoided costs noted above. This forecast does not yet incorporate consideration of the many practical considerations that affect a customer's willingness to implement the CDM measures. Rather, it provides a valuable interim step towards determining the Achievable Potential (see Step 5).

NLH is currently studying the Lower Churchill/DC Link project. However, a decision on whether to proceed is not expected until 2009 and, even if the project proceeds, the earliest completion date would be in late 2014. This means that, regardless of the decision, the avoided cost values shown above will be in effect until the approximate mid point of the study period.

If the project does proceed, the avoided costs presented above are expected to change. To provide insight into the potential impacts of the Lower Churchill/DC Link project on this study, the consultants undertook a high-level financial sensitivity analysis.

[5] The avoided costs draw on the results of the earlier study conducted by NERA Economic Consulting, which is entitled: Newfoundland and Labrador Hydro. *Marginal Costs of Generation and Transmission*. May 2006. The avoided costs used in this study include generation, transmission and distribution.

***Step 5: Estimate Achievable Electricity Savings Potential***

The Achievable Potential is the proportion of the savings identified in the Economic Potential Forecast that could be achieved within the study period. Achievable Potential recognizes that it is difficult to induce customers to purchase and install all the electrical efficiency technologies that meet the criteria defined by the Economic Potential forecast. The results are, therefore, presented within an "upper" and "lower" range.[6]

The Upper Achievable Potential assumes a very aggressive program approach and a very supportive context, e.g., healthy economy, very strong public commitment to climate change mitigation, etc. However, the Upper Achievable Potential scenario also recognizes that there are limits to the scope of influence of any electric utility. It recognizes that some markets or submarkets may be so price sensitive or constrained by market barriers beyond the influence of CDM programs that they will only fully act if forced to by legal or other legislative means. It also recognizes that there are practical constraints related to the pace that existing inefficient equipment can be replaced by new, more efficient models or that existing building stock can be retrofitted to new energy performance levels

For the purposes of this study, the Upper Achievable Potential can, informally, be described as: "*Economic Potential less those customers that "can't" or "won't" participate."*

The Lower Achievable Potential assumes that existing CDM programs and the scope of technologies addressed are expanded, but at a more modest level than in the Upper Achievable Potential. Market interest and customer commitment to energy efficiency and sustainable environmental practices remain approximately as current. Similarly, federal, provincial and municipal government energy-efficiency and GHG mitigation efforts remain similar to the present

It is important to note that the Upper and Lower Achievable numbers are intended to bracket savings which could be expected to be attainable given the assumptions and scope of the study. As noted previously, Achievable Potential, although complementary, is not synonymous with the actual CDM targets that are established as part of the more detailed CDM program design process (which is beyond the scope of this current study).

***Step 6: Estimate Peak Load Impacts of Electricity Savings***

The electricity (electric energy) savings (GWh) calculated in the preceding steps were converted to peak load (electric demand) savings (MW)[7]. The study defined the Newfoundland and Labrador system peak period as:

> *The morning period from 7 am to noon and the evening period from 4 to 8 pm on the four coldest days during the December to March period; this is a total of 36 hours per year.*

[6] The Achievable Potential savings assume program start-up in 2007. Consequently, electricity savings in the first milestone year of 2011 will need to be adjusted to reflect actual program initiation dates. This step will occur during the detailed program design phase, which will follow this study.

[7] Peak load savings were modelled using Applied Energy Group's Cross-Sector Load Shape Library Model (LOADLIB).

The conversion of electricity savings to hourly demand drew on a library of specific sub sector and end use electricity use load shapes. Using the load shape data, the following steps were applied:

- Annual electricity savings for each combination of sub sector and end use were disaggregated *by month*
- Monthly electricity savings were then further disaggregated *by day type* (weekday, weekend day and peak day)
- Finally, each day type was disaggregated *by hour*.

## 1.4 CAVEATS

The reader should use the results presented in this report as best available estimates; major assumptions, information sources and caveats are noted throughout each of the main sector reports. Specific areas are noted below.

### 1.4.1 Data Quality and Assumptions

As in any study of this type, the results presented are based on a large number of important assumptions. Assumptions such as those related to the current penetration of energy-efficient technologies, the rate of future growth in the province's building stock and customer willingness to implement new CDM measures are particularly influential.

Wherever possible, the assumptions used in this study are consistent with those used by the Utilities and are based on best available information, which in many cases includes the professional judgment of the consultant team, Utilities personnel and local experts. The reader should use the results presented in this report as best available estimates; major assumptions, information sources and caveats are noted throughout the individual sector reports.

### 1.4.2 Interactive Effects

A systems approach was used to model the energy impacts of the CDM measures presented in the Economic and Achievable Potential phases of the study. In the absence of a systems approach, an accurate assessment of the total contribution of the energy-efficient upgrades would not be possible.

One of the reasons that this approach is necessary is to ensure that the interactive effects are appropriately considered. For example, in the Residential sector, the electricity savings from more efficient appliances and lighting result in reduced waste heat. During the space heating season, this appliance and lighting waste heat contributes to the building's internal heat gains, which lower the amount of heat that must be provided by the space heating system.

The magnitude of the interactive effects can be significant. Based on selected building energy use simulations, a 100 kWh savings in appliance or lighting electricity use could result in an increased space heating load of 50 kWh to 70 kWh in this jurisdiction, depending on housing dwelling type and geographical location. This is higher than the ratio of approximately 0.5 that is typical of other jurisdictions and is related largely to the length of the heating season, rather than its severity.

Newfoundland and Labrador experience more months in which heating is required than most other jurisdictions in Canada. Nonetheless, given that some fraction of the heat energy from lighting and other end uses escapes to the outside, the simulation may somewhat overstate the interaction. A ratio of 0.6 has been incorporated into the model to account for this uncertainty.

### 1.4.3 Program Design and Implementation Costs

The study results presented in this Summary Report and in the individual sector reports do not yet include expenditures related to program design and implementation. These costs are considered at the detailed program design phase, which will be completed following this study[8].

## 1.5 STUDY ORGANIZATION AND REPORTS

The study was organized and conducted by sector using a common methodology, as outlined above. The results for each sector are presented in three individual reports that are entitled:

- *Conservation and Demand Management Potential (2006 to 2026), Newfoundland and Labrador, Residential Sector*

- *Conservation and Demand Management Potential (2006 to 2026), Newfoundland and Labrador, Commercial Sector*

- *Conservation and Demand Management Potential (2006 to 2026), Newfoundland and Labrador, Industrial Sector*

The results of the individual sector reports are combined into this Summary Report. Finally, the study also prepared a brief CDM program evaluation report, which is presented under separate cover and is entitled:

- *Conservation and Demand Management Potential (2006 to 2026), Newfoundland and Labrador, Program Evaluation Guidelines*.

### 1.5.1 Summary Report Outline

This report presents a summary of the study results and is organized as follows:

- Section 2 presents the combined electricity and peak load savings for the three sectors.

[8] Addition of these costs may negatively impact the economic attractiveness of some measures currently included in the Achievable Potential estimates.

- Sections 3, 4 and 5 present a summary of the electricity and peak load savings for, respectively, the Residential, Commercial and Industrial sectors.

- Section 6 presents conclusions and next steps.

# 2. SUMMARY OF STUDY FINDINGS

The study findings confirm the existence of significant potential cost-effective opportunities for CDM in Newfoundland and Labrador's Residential, Commercial and Industrial sectors.

## 2.1 ELECTRICITY SAVINGS POTENTIAL

Exhibits 2.1 and 2.2 summarize the total combined electricity savings for the Residential, Commercial and Industrial sectors that have been identified in each of the individual sector reports for, respectively, the Island and Isolated and the Labrador Interconnected service regions.[9]

Highlights of the results for the Island and Isolated service region are shown in Exhibit 2.1. They include:

- In the Reference Case, total electricity consumption for the Island and Isolated service region increases from approximately 6,468 GWh/yr. in 2006 to about 7,685 GWh/yr. by 2026, an increase of about 19%
- In the Upper Achievable Potential scenario, electricity savings for the Island and Isolated service region are about 211 GWh/yr. in 2011 and increase to about 951 GWh/yr. by 2026. The electricity savings of 951 GWh/yr. in 2026 means that total electricity consumption would increase to about 6,737 GWh/yr., a decrease of about 12% relative to the Reference Case
- In the Lower Achievable Potential scenario, electricity savings for the Island and Isolated service region are about 117 GWh/yr. in 2011 and increase to about 556 GWh/yr. by 2026. The electricity savings of 556 GWh/yr. in 2026 means that total electricity consumption would increase to about 7,129 GWh/yr., a decrease of about 7% relative to the Reference Case.

**Exhibit 2.1: Achievable Electricity Savings Potential for the Island and Isolated Service Region**

| Milestone Year | Reference Case | Achievable Savings (GWh/yr.) | | Achievable Savings As % of Reference Case | |
|---|---|---|---|---|---|
| | | *Upper* | *Lower* | *Upper* | *Lower* |
| 2006 | 6,468 | - | - | - | - |
| 2011 | 6,888 | 211 | 117 | 3.1 | 1.7 |
| 2016 | 7,139 | 437 | 261 | 6.1 | 3.7 |
| 2021 | 7,427 | 679 | 414 | 9.1 | 5.6 |
| 2026 | 7,685 | 951 | 556 | 12.4 | 7.2 |

[9] Analysis for the two service regions was combined for the Industrial sector. Industrial reference electricity use and savings are included in Exhibit 2.1 only and refer exclusively to purchased electricity.

Highlights of the results for the Labrador Interconnected service region are shown in Exhibit 2.2. They include:

- In the Reference Case, total electricity consumption for the Labrador Interconnected service region increases from approximately 465 GWh/yr. in 2006 to about 540 GWh/yr. by 2026, an increase of about 16%
- In the Upper Achievable Potential scenario, electricity savings for the Labrador Interconnected service region are about 12 GWh/yr. in 2011 and increase to about 51 GWh/yr. by 2026. The electricity savings of 51 GWh/yr. in 2026 means that total electricity consumption for the Island and Isolated service region would increase to about 489 GWh/yr., a decrease of about 9% relative to the Reference Case
- In the Lower Achievable Potential scenario, electricity savings for the Labrador Interconnected service region are about 8 GWh/yr. in 2011 and increase to about 31 GWh/yr. by 2026. The electricity savings of 31 GWh/yr. in 2026 means that total electricity consumption for the Island and Isolated service region would increase to about 509 GWh/yr., a decrease of about 6% relative to the Reference Case.

**Exhibit 2.2: Achievable Electricity Savings Potential for the Labrador Interconnected Service Region**

| Milestone Year | Reference Case | Achievable Savings (GWh/yr.) | | Achievable Savings As % of Reference Case | |
|---|---|---|---|---|---|
| | | *Upper* | *Lower* | *Upper* | *Lower* |
| 2006 | 465 | - | - | - | - |
| 2011 | 499 | 12 | 8 | 2.4 | 1.6 |
| 2016 | 512 | 24 | 16 | 4.7 | 3.1 |
| 2021 | 525 | 37 | 23 | 7.0 | 4.4 |
| 2026 | 540 | 51 | 31 | 9.4 | 5.7 |

## 2.2 PEAK LOAD SAVINGS

The electricity savings noted above also result in a reduction in peak load requirements (MW), which can be of particular value to the Utilities during periods of high electricity demand[10].

The resulting peak load savings are presented in Exhibit 2.3.[11] As illustrated, the total peak load savings were estimated to be 154 MW and 89 MW by 2026 in, respectively, the Upper and Lower scenarios. In each case, the reductions are an average value over the peak period and are defined relative to the Reference Case.

[10] See Section 1.3 for peak period definition.

[11] Peak load impact was analyzed for the residential and commercial sectors only. Exhibit 2.3 presents the combined results for these two sectors.

## Exhibit 2.3: Total Achievable Peak Load Savings Potential

| **Service Region** | **Milestone Year** | **Peak Load Savings (MW)** | |
|---|---|---|---|
| | | Upper Achievable | Lower Achievable |
| Island and Isolated | 2011 | 27 | 14 |
| | 2016 | 60 | 36 |
| | 2021 | 99 | 61 |
| | 2026 | 144 | 83 |
| Labrador Interconnected | 2011 | 1.4 | 0.9 |
| | 2016 | 3.8 | 2.4 |
| | 2021 | 6.4 | 3.8 |
| | 2026 | 9.7 | 5.5 |

# 3. RESIDENTIAL SECTOR

The Residential sector includes single-family homes, attached dwellings and apartments as well as a small number of isolated and other dwellings.

## 3.1 APPROACH

The detailed end-use analysis of electrical efficiency opportunities in the Residential sector employed two linked modelling platforms: **HOT2000,** a commercially supported residential building energy-use simulation software, and **RSEEM** (Residential Sector Energy End-use Model), a Marbek in-house spreadsheet-based macro model. Peak load savings were modelled using Applied Energy Group's Cross-Sector Load Shape Library Model (LOADLIB).

The major steps in the general approach to the study are outlined in Section 1.3 above (*Major Analytic Steps*). Specific procedures for the Residential sector were as follows:

- **Modelling of Base Year –** The consultants used the Utilities' customer data to break down the Residential sector by four factors:

  - Type of dwelling (single detached, attached, apartment, etc.)
  - Heating category (electric or non-electric heat)
  - The age of the building (new versus existing)
  - Service region.

  To estimate the electricity used for space heating, the consultants factored in building characteristics such as insulation levels, floor space and airtightness using a variety of data sources, including the Energuide for Houses database, Utilities' billing data, local climate data and discussions with local contractors. They also used the results of Utilities' customer surveys that provided data on type of heating system, number and age of household appliances, renovation activity, etc. Based on the available data sources, the consultants calculated an average electricity use by end use for each dwelling type. The consultant's models produced a close match with actual Utilities' sales data.

- **Reference case calculations –** For the Residential sector, the consultants developed profiles of new buildings for each type of dwelling. They estimated the growth in building stock using the same data as that contained in the Utilities' most recent load forecast and estimated the amount of electricity used by both the existing building stock and the projected new buildings and appliances. As with the Base Year calibration, the consultants' projection closely matches the Utilities own 2006 forecast of future electricity requirements.

- **Assessment of CDM measures** –To estimate the economic and achievable electricity savings potentials, the consultants assessed a wide range of commercially available CDM measures and technologies such as:

  - Improved lighting systems
  - Thermal upgrades to the walls, roofs and windows of existing buildings
  - More efficient space heating equipment and controls
  - Measures to reduce hot water usage

- Improved designs for new buildings
- Reduced standby losses in computers and electronic equipment
- More efficient household appliances and other plug-in equipment.

## 3.2 ELECTRICITY SAVINGS

In, respectively, the Upper and Lower Achievable Potential scenarios, Residential Sector electricity savings are estimated to be between 439 and 236 GWh/yr. by 2026 in the Island and Isolated service region.[12]

A summary of the levels of annual electricity consumption contained in each of the forecasts addressed by the study is presented in Exhibits 3.1 and 3.2, by milestone year, and discussed briefly in the paragraphs below.

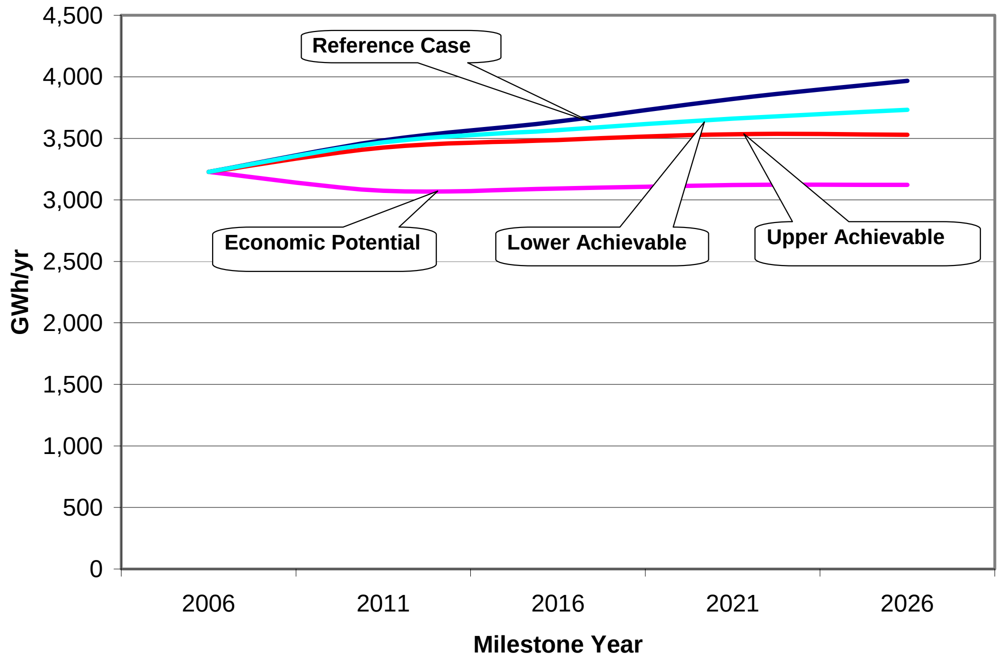
**Exhibit 3.1: Summary of Forecast Results for the Island and Isolated Service Region – Annual Electricity Consumption, Residential Sector (GWh/yr.)**

| Annual Consumption (GWh/yr.) | | | | Potential Annual Savings (GWh/yr.) | |
|---|---|---|---|---|---|
| Milestone Year | Reference Case | Achievable | | Achievable | |
| | | Upper | Lower | Upper | Lower |
| 2006 | 3,228 | | | | |
| 2011 | 3,483 | 3,425 | 3,468 | 58 | 16 |
| 2016 | 3,637 | 3,486 | 3,568 | 151 | 69 |
| 2021 | 3,821 | 3,533 | 3,660 | 288 | 161 |
| 2026 | 3,968 | 3,529 | 3,732 | 439 | 236 |

**Results are measured at the customer's point-of-use and do not include line losses.*

[12] The comparable results in 2026 for the Labrador Interconnected service region are between 24 and 12 GWh/yr. in, respectively, the Upper and Lower achievable scenarios. Additional details are provided in the Residential sector report and accompanying appendices.

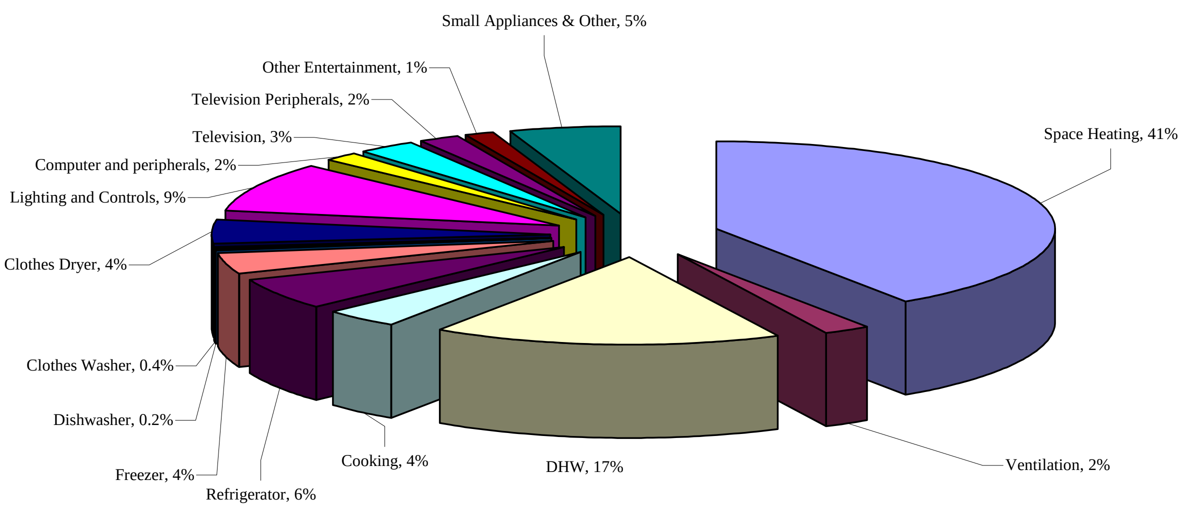
**Exhibit 3.2: Graphic of Forecast Results for the Island and Isolated Service Region – Annual Electricity Consumption, Residential Sector (GWh/yr.)**




## Base Year Electricity Use

In the Base Year of 2006, the Residential sector in the Island and Isolated service region consumed about 3,228 GWh. Exhibit 3.3 shows that space heating accounts for about 41% of total residential electricity use.[13] Domestic hot water (DHW) accounts for about 17% of the total electricity use, followed by kitchen appliances (14%) and lighting (9%). Household electronics (i.e., computers and peripherals, televisions and television peripherals) account for about 8% of electricity use.

**Exhibit 3.3: Base Year Electricity Use by End Use in the Island and Isolated Service Region, Residential Sector[14]**




13 Values are for all residential dwellings. Space heating share is much higher in electrically heated homes.

14 Values may not add to 100% due to rounding.

The overwhelming majority of residential electricity use in the Island and Isolated service region occurs in single detached dwellings (81%). The remaining electricity use is in attached dwellings (11%) followed by apartments (6%). Isolated and other residential buildings each account for about 1%.

***Reference Case***

In the absence of new Utilities' CDM initiatives, the study estimates that electricity consumption in the Residential sector will grow from 3,228 GWh/yr. in 2006 to about 3,968 GWh/yr. by 2026 in the Island and Isolated service region. This represents an overall growth of about 23% in the period and compares very closely with NLH's load forecast, which also included consideration of the impacts of "natural conservation."

***Economic Potential Forecast***

Under the conditions of the Economic Potential Forecast,[15] the study estimated that electricity consumption in the Residential sector would decline to about 3,124 GWh/yr. by 2026 in the Island and Isolated service region. Annual savings relative to the Reference Case are 846 GWh/yr. or about 21%.

***Achievable Potential***

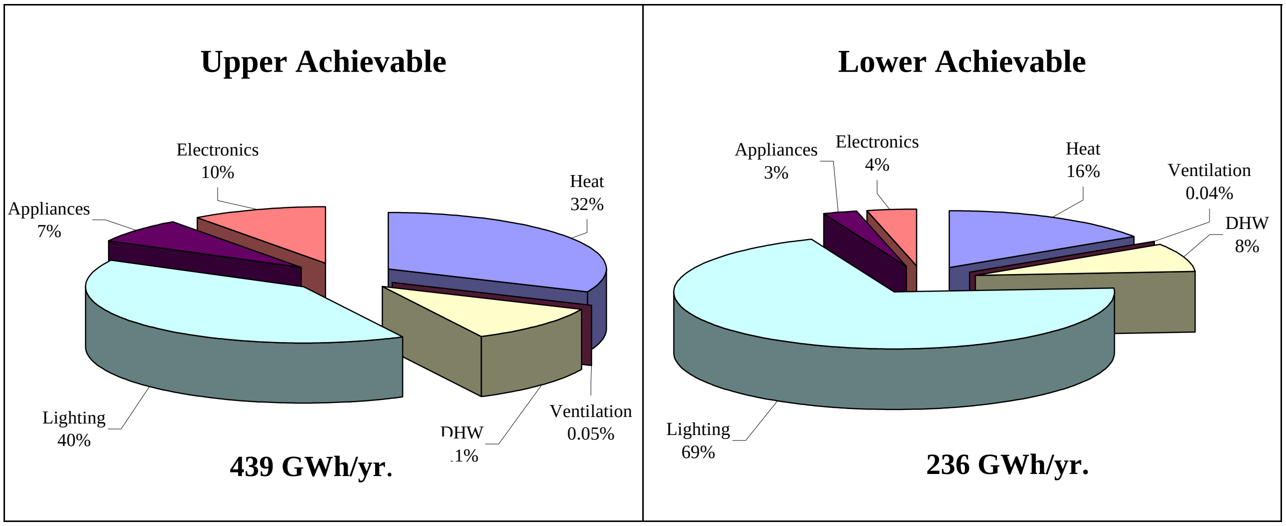
The Achievable Potential is the proportion of the economic electricity savings (as noted above) that could realistically be achieved within the study period. In the Residential sector within the Island and Isolated service region, the Achievable Potential for electricity savings was estimated to be 439 GWh/yr. and 236 GWh/yr. by 2026 in, respectively, the Upper and Lower scenarios.

The most significant Achievable savings opportunities were in the actions that addressed lighting and space heating, followed by water heating, household electronics (e.g., computers and peripherals, televisions and television peripherals) and large appliances.

Exhibit 3.4 shows the distribution of electricity savings in 2026 by end use in the Upper and Lower Achievable Potential scenarios.

[15] The level of electricity consumption that would occur if all equipment and building envelopes were upgraded to the level that is cost effective against future avoided electricity costs.

**Exhibit 3.4: Distribution of Electricity Savings by Major End Use in the Upper and Lower Achievable Scenarios, Island and Isolated Service Region, Residential Sector**[16]




## 3.3 PEAK LOAD SAVINGS

The electricity savings noted above also result in a reduction in peak load requirements (MW), which can be of particular value to the Utility during periods of high electricity demand[17].

The resulting Residential sector peak load savings for the Island and Isolated service region are presented in Exhibit 3.5.

**Exhibit 3.5: Peak Load Savings from Electricity Savings in the Island and Isolated Service Region, Residential Sector**

| Milestone Year | Electricity Savings (GWh/yr.) | | Peak Load Savings (MW) | |
|---|---|---|---|---|
| | Upper Achievable | Lower Achievable | Upper Achievable | Lower Achievable |
| 2011 | 58 | 16 | 11 | 3 |
| 2016 | 151 | 69 | 29 | 13 |
| 2021 | 288 | 161 | 58 | 32 |
| 2026 | 439 | 236 | 91 | 49 |

As illustrated in Exhibit 3.5, the Residential sector peak load savings was estimated to be 91 MW and 49 MW by 2026 in, respectively, the Upper and Lower scenarios. In each case, the reductions are an average value over the peak period and are defined relative to the Reference Case.[18]

[16] Values may not add to 100% due to rounding.

[17] See Section 1.3 for peak period definition.

[18] The comparable results for the Labrador Interconnected service region are between 6.5 and 3.3 MW in, respectively, the Upper and Lower achievable scenarios. Additional details are provided in the Residential sector report and accompanying appendices.

# 4. COMMERCIAL SECTOR

The Commercial sector includes office and retail buildings, hotels and motels, restaurants, warehouses and a wide variety of small buildings. In this study, it also includes buildings that are often classified as "institutional," such as hospitals and nursing homes, schools and universities. Street lighting is also included in the Commercial sector.

Throughout this report, use of the word "commercial" includes both commercial and institutional buildings unless otherwise noted.

## 4.1 APPROACH

The detailed end-use analysis of electrical efficiency opportunities in the Commercial sector employed two linked modelling platforms: **CEEAM** (Commercial Electricity and Emissions Analysis Model), a Marbek in-house simulation model developed in conjunction with Natural Resources Canada (NRCan) for modelling electricity use in commercial/institutional building stock, and **CSEEM** (Commercial Sector Energy End-use Model), an in-house spreadsheet-based macro model. Peak load savings were modelled using Applied Energy Group's Cross-Sector Load Shape Library Model (LOADLIB).

The major steps in the general approach to the study were outlined earlier in Section 1.3 (*Major Analytic Steps*). Specific procedures for the Commercial sector were as follows:

- **Modelling of Base Year –** Marbek compiled data that defines "where" and "how" electricity is currently used in existing commercial buildings. The consultants then created building energy use simulations for each type of commercial building and calibrated the models to reflect actual Utilities' customer sales data. Estimated savings for the Small Commercial, Other and Isolated categories were derived from the results of the modelled segments. They did not directly model those categories because they are extremely diverse and the electricity use of individual categories is relatively small. The consultant's model produced a close match with actual Utilities' sales data.

- **Reference case calculations –** For the Commercial sector, Marbek developed detailed profiles of new buildings in each of the building segments, estimated the growth in building stock and estimated "natural" changes affecting electricity consumption over the study period. As with the Base Year calibration, the consultants' projection closely matches the Utilities 2006 forecast of future electricity requirements.

- **Assessment of CDM Measures –** To estimate the economic and achievable electricity savings potentials, the consultants assessed a wide range of commercially available CDM measures and technologies such as:

  - More efficient lighting systems and office equipment
  - Improved construction in new buildings
  - Upgraded heating, ventilating and cooling systems.

## 4.2 ELECTRICITY SAVINGS

In, respectively, the Upper and Lower Achievable Potential scenarios, Commercial Sector electricity savings are estimated to be between 387 and 261 GWh/yr. by 2026 in the Island and Isolated service region. [19]

A summary of the levels of annual electricity consumption contained in each of the forecasts addressed by the study is presented in Exhibits 4.1 and 4.2, by milestone year, and discussed briefly in the paragraphs below.

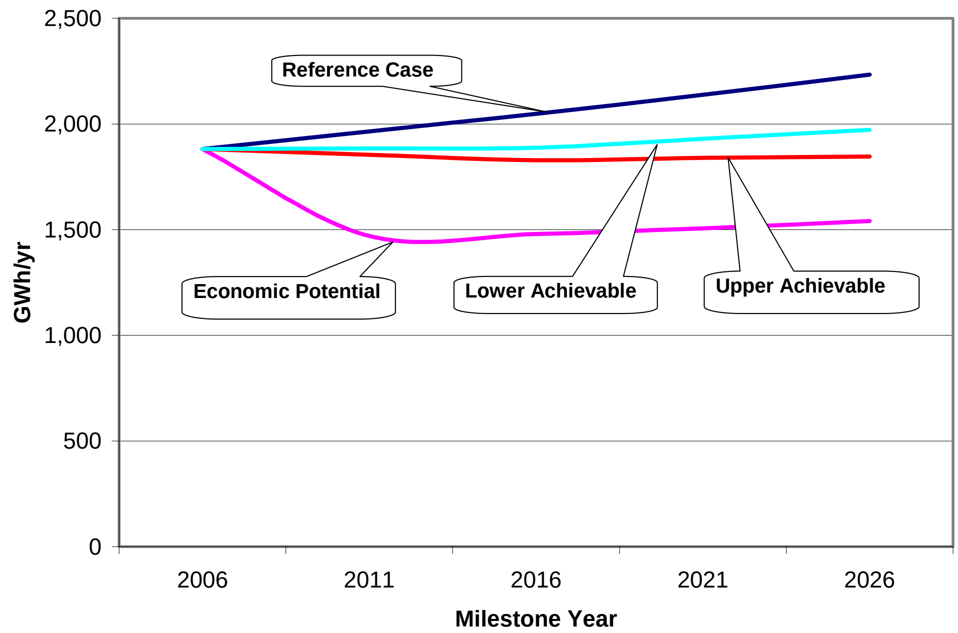
**Exhibit 4.1: Summary of Forecast Results for the Island and Isolated Service Region – Annual Electricity Consumption, Commercial Sector (GWh/yr.)**

| Annual Consumption (GWh/yr.) Commercial Sector | | | | | | Potential Annual Savings (GWh/yr.) | | |
|---|---|---|---|---|---|---|---|---|
| Milestone Year | Base Year | Reference Case | Economic | Achievable | | Economic | Achievable | |
| | | | | Upper | Lower | | Upper | Lower |
| 2006 | 1,881 | 1,881 | | | | | | |
| 2011 | | 1,965 | 1,471 | 1,855 | 1,884 | 494 | 110 | 80 |
| 2016 | | 2,048 | 1,479 | 1,828 | 1,888 | 569 | 220 | 160 |
| 2021 | | 2,138 | 1,506 | 1,840 | 1,930 | 632 | 298 | 209 |
| 2026 | | 2,233 | 1,541 | 1,846 | 1,972 | 693 | 387 | 261 |

**Results are measured at the customer's point-of-use and do not include line losses.*

[19] The comparable results for the Labrador Interconnected service region are between 27 and 19 GWh/yr. in, respectively, the Upper and Lower achievable scenarios. Additional details are provided in the Commercial sector report and accompanying appendices.

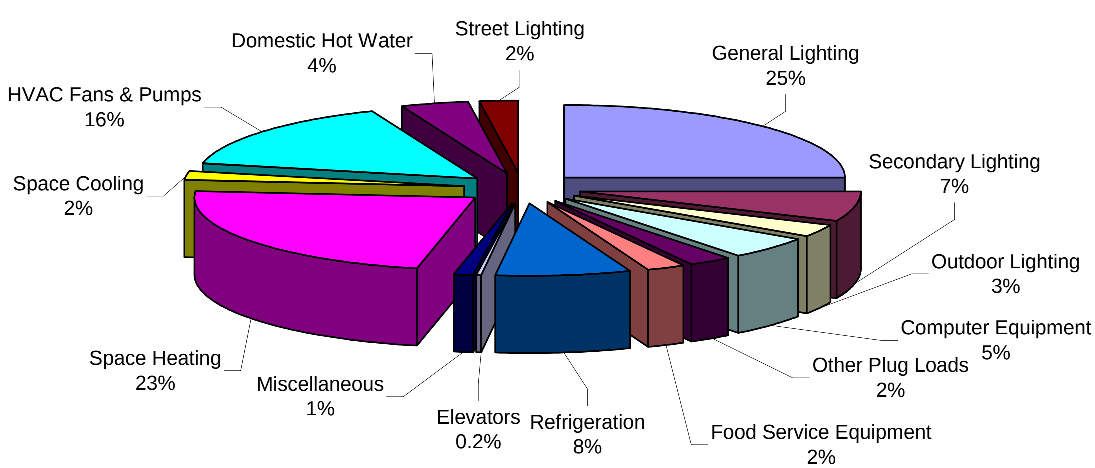
**Exhibit 4.2: Graphic of Forecast Results for the Island and Isolated Service Region – Annual Electricity Consumption, Commercial Sector (GWh/yr.)**




## Base Year Electricity Use

In the Base Year of 2006, the Commercial sector in the Island and Isolated service region consumed about 1,881 GWh. Exhibit 4.3 shows that space lighting accounts for about 32% of total commercial electricity use, space heating accounts for about 23%, followed by HVAC fans and pumps (16%) and refrigeration (8%).

**Exhibit 4.3: Base Year Electricity Use by End Use in the Island and Isolated Service Region, Commercial Sector[20]**




[20] Values may not add to 100% due to rounding.

In the Island and Isolated Service Region, the Small commercial sub sector accounts for the largest share of the total electricity consumption at 28%, followed by Office at 17%, Other Buildings at 8% and Food Retail at 7%.

### *Reference Case*

In the absence of new Utility initiatives, the study estimates that electricity consumption in the Commercial sector will grow from 1,881 GWh/yr. in 2006 to about 2,233 GWh/yr. by 2026 in the Island and Isolated service region. This represents an overall growth of about 19% in the period and compares very closely with NLH's load forecast, which also included consideration of the impacts of "natural conservation."

### *Economic Potential Forecast*

Under the conditions of the Economic Potential Forecast,[21] the study estimated that electricity consumption in the Commercial sector would fall to about 1,541 GWh/yr. by 2026 in the Island and Isolated service region. Annual savings relative to the Reference Case are 693 GWh/yr., or about 31%.

### *Achievable Potential*

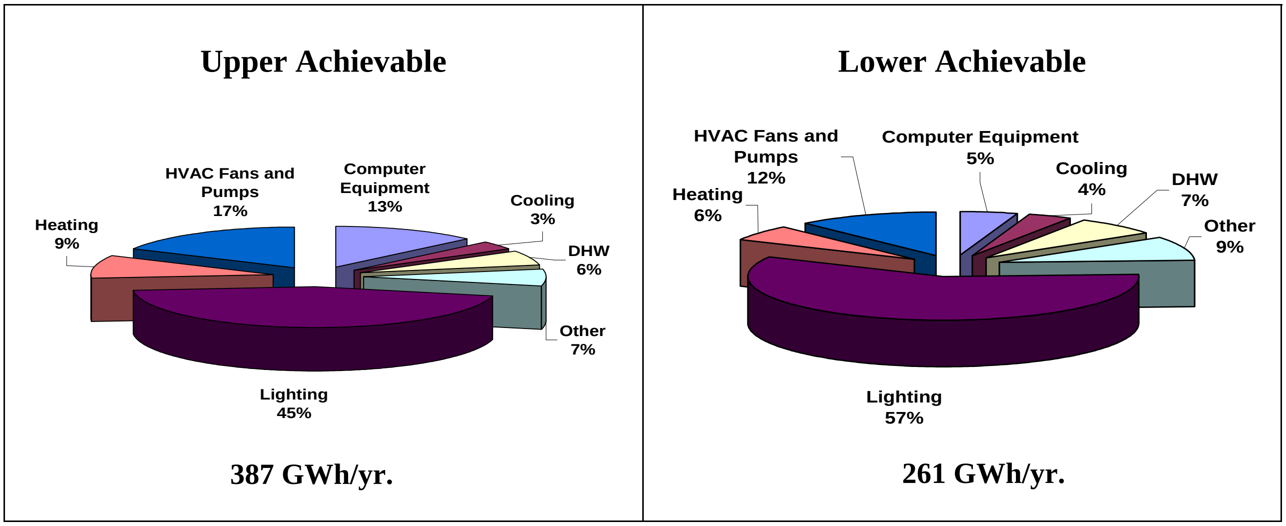
The Achievable Potential is the proportion of the economic electricity savings (as noted above) that could realistically be achieved within the study period. In the Commercial sector within the Island and Isolated service region, the Achievable Potential for electricity savings was estimated to be 387 GWh/yr. and 261 GWh/yr. by 2026 in, respectively, the Upper and Lower scenarios.

The most significant achievable savings opportunities were in the actions that addressed lighting, HVAC fans and pumps and space heating.

Exhibit 4.4 shows the distribution of electricity savings in 2026 by end use in the Upper and Lower Achievable Potential scenarios.

[21] The level of electricity consumption that would occur if all equipment and building envelopes were upgraded to the level that is cost effective against future avoided electricity costs.

**Exhibit 4.4: Distribution of Electricity Savings by Major End Use in the Upper and Lower Achievable Scenarios, Island and Isolated Service Region, Commercial Sector**[22]




## 4.3 PEAK LOAD SAVINGS

The electricity savings noted above also result in a reduction in peak load requirements (MW), which can be of particular value to the Utility during periods of high electricity demand[23].

The resulting Commercial sector peak load savings are presented in Exhibit 4.5.

**Exhibit 4.5: Peak Load Savings from Electricity Savings in the Island and Isolated Service Region, Commercial Sector**

| Milestone Year | Energy Savings (GWh/yr.) | | Peak Demand Reduction (MW) | |
|---|---|---|---|---|
| | Upper Achievable | Lower Achievable | Upper Achievable | Lower Achievable |
| 2011 | 110 | 80 | 16 | 11 |
| 2016 | 220 | 160 | 32 | 23 |
| 2021 | 298 | 209 | 42 | 28 |
| 2026 | 387 | 261 | 54 | 35 |

As illustrated in Exhibit 4.5, the Commercial sector peak load savings were estimated to be 54 MW and 35 MW by 2026 in, respectively, the Upper and Lower scenarios. In each case, the reductions are an average value over the peak period and are defined relative to the Reference Case.[24]

[22] Values may not add to 100% due to rounding.

[23] See Section 1.3 for peak period definition.

[24] The comparable results for the Labrador Interconnected service region are between 3.2 and 2.2 MW in, respectively, the Upper and Lower achievable scenarios. Additional details are provided in the Commercial sector report and accompanying appendices.

# 5. INDUSTRIAL SECTOR

The Industrial sector consists of large transmission level customers from the Mining, Pulp and Paper and Oil Refining sub sectors that use more than 50 GWh of electricity annually and over 400 small and medium facilities that use less than 50 GWh annually, including Fishing and Fish Processing, Manufacturing and Other customer categories.

## 5.1 APPROACH

The detailed end-use analysis of electrical efficiency opportunities in the Industrial sector employed Marbek's customized spreadsheet model. The model is organized by major industrial sub sector and major end use.

Electricity end-use profiles were developed for the six sub sectors described above. The profiles map proportionally how much electricity is used by each of the end uses for each sub sector. These profiles represent the sub sector archetypes and are used in the model to calculate the electricity used by each end use for each sub sector.

Three archetype profiles were developed for large industry based on the results of a survey of the six facilities included in these sub sectors.[25] In each case, site personnel provided data, which addressed both the allocation of electricity use by end use and general best practices implemented at the sites. A copy of the survey instrument is contained in Appendix A of the industrial sector report.

Experience from previous industry studies in other Canadian jurisdictions provided the necessary archetype end-use profiles for the three Small and Medium industrial sub sectors. These profiles were reviewed by industry experts familiar with industry in Newfoundland and Labrador and were revised to be representative of the province's industrial sub sectors.

The major steps in the general approach to the study are outlined in Section 1.3 above (*Major Analytic Steps*). Specific procedures for the Industrial sector were as follows:

- **Modelling of Base Year –** The consultants compiled data on Newfoundland and Labrador's Industrial sector from the Utilities Load Forecasting Department and from a survey questionnaire that was completed by each of the large customers. The macro model results produced a close match with actual Utilities' sales data.

- **Reference Case calculations -** The consultants prepared a Reference Case forecast based on projected growth forecasts provided by NLH, which includes anticipated closing of existing facilities and opening of new facilities. The possibility of new industrial load on the system, related to the processing of nickel from Voisey's Bay in Labrador, is not included due to the uncertainty with the processing technology. The self-generated electricity consumption was frozen for the 20-year forecast.

- **Assessment of CDM Measures –**To estimate the economic and achievable electricity savings potentials, the consultants assessed a wide range of commercially available CDM

[25] The results were also compared with those from detailed studies of similar industries undertaken by Marbek and were found to compare well.

measures and technologies such as more efficient systems for pumps, air displacement (fans), compressed air, material conveyance (such as conveyor belts and chains), industrial refrigeration as well as more efficient, industrial lighting, electric motors, etc.

## 5.2 ELECTRICITY SAVINGS

In, respectively, the Upper and Lower Achievable Potential scenarios, Industrial Sector electricity savings are estimated to be between 125 and 59 GWh/yr. by 2026 in the Island and Isolated and Labrador Interconnected service regions.[26]

A summary of the levels of annual electricity consumption contained in each of the forecasts addressed by the study is presented in Exhibits 5.1 and 5.2, by milestone year, and discussed briefly in the paragraphs below.

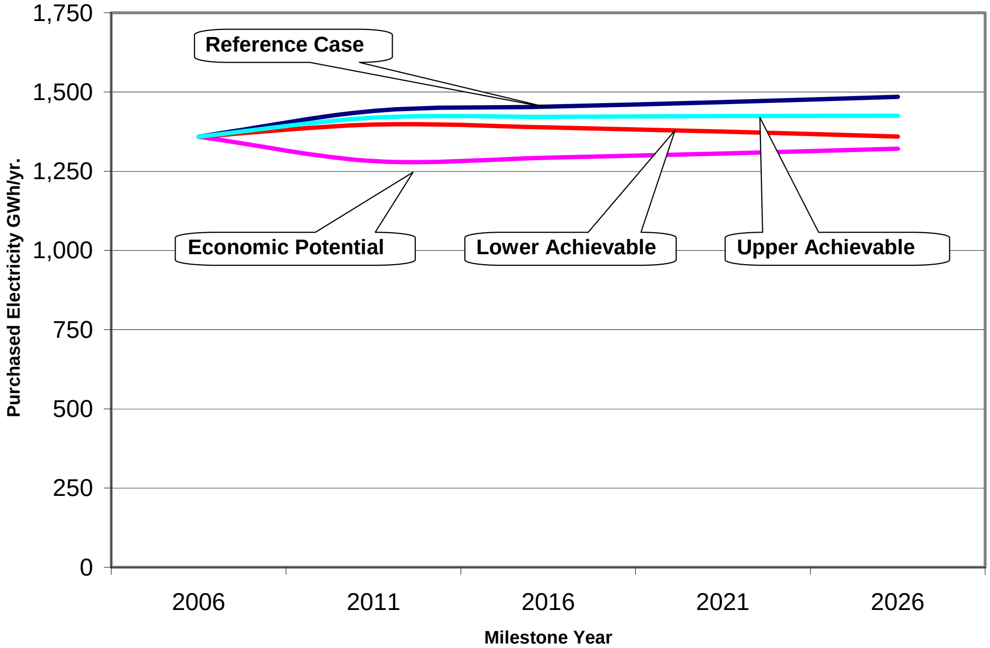
**Exhibit 5.1: Summary of Forecast Results for the Island and Isolated and Labrador Interconnected Service Regions – Annual Electricity Consumption, Industrial Sector (GWh/yr.)**

| Annual Consumption (GWh/yr.) Industrial Sector | | | | | | Potential Annual Savings (GWh/yr.) | | |
|---|---|---|---|---|---|---|---|---|
| Milestone Year | Base Year | Reference Case | Economic | Achievable | | Economic | Achievable | |
| | | | | Upper | Lower | | Upper | Lower |
| 2006 | 1,359 | 1,359 | | | | | | |
| 2011 | | 1,440 | 1,282 | 1,397 | 1,419 | 158 | 43 | 21 |
| 2016 | | 1,454 | 1,293 | 1,388 | 1,422 | 161 | 66 | 32 |
| 2021 | | 1,468 | 1,306 | 1,375 | 1,424 | 162 | 93 | 44 |
| 2026 | | 1,484 | 1,321 | 1,360 | 1,425 | 164 | 125 | 59 |

**Results are measured at the customer's point-of-use and do not include line losses.*

26 Analysis for the two service regions was combined for the Industrial sector.

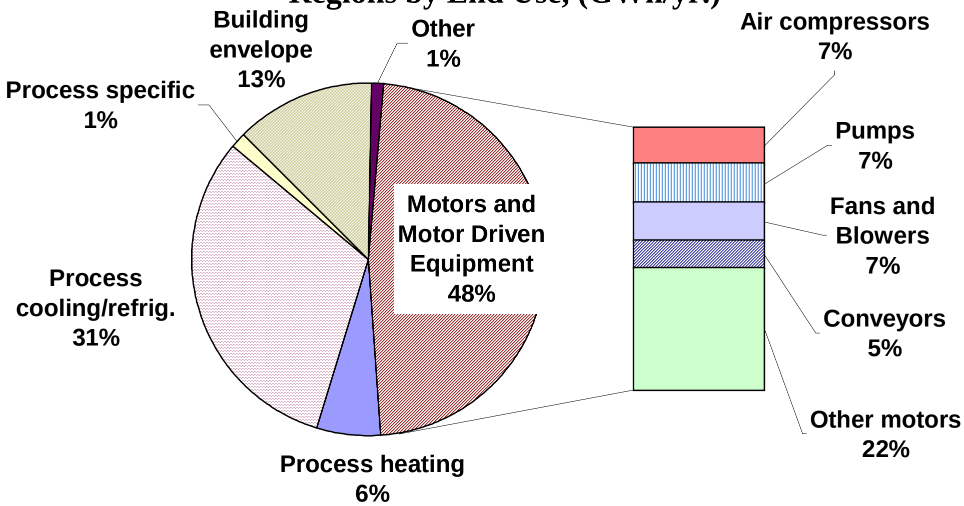
**Exhibit 5.2: Reference Case versus Upper and Lower Achievable Potential Electricity Consumption in the Industrial Sector (GWh/yr.)**




### *Base Year Electricity Use*

In the Base Year of 2006, the Island and Isolated and Labrador Interconnected Service Regions consumed about 4,558 GWh, of which 1,359 GWh was purchased electricity[27]. The Large industrial sub sector consumed 79% of the total purchased electricity. Exhibit 5.3 shows the purchase electricity use by end use for the Small and Medium industrial sector. Most of the electricity is used by motor and motor drive equipment (48% of the total) and process cooling and refrigeration/freezing (31% of the total).

**Exhibit 5.3: Small and Medium Industry Base Year Modelled Annual Purchased Electricity Consumption for the Island and Isolated and Labrador Interconnected Service Regions by End Use, (GWh/yr.)**




[27] Self-generated electricity was beyond the study scope.

***Reference Case***

In the absence of new Utilities' CDM initiatives, the study estimates that purchased electricity consumption in the Industrial sector will grow from 1,359 GWh/yr. in 2006 to about 1,484 GWh/yr. by 2026 in the Island and Isolated and Labrador Interconnected service regions. This represents an overall growth of about 9% in the period and compares very closely with NLH's load forecast, which also included consideration of the impacts of "natural conservation."

***Economic Potential Forecast***

Under the conditions of the Economic Potential Forecast,[28] the study estimated that electricity consumption in the Industrial sector would decline to about 1,321 GWh/yr. by 2026 in the Island and Isolated and Labrador Interconnected Service Regions. Annual savings relative to the Reference Case are 164 GWh/yr. or about 11%.

***Achievable Potential***

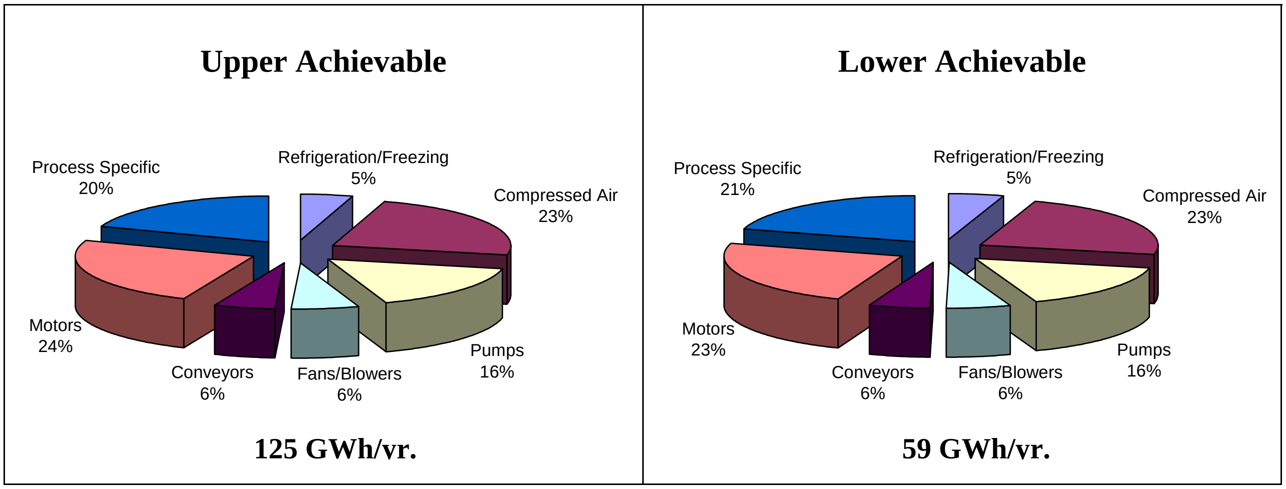
The Achievable Potential is the proportion of the economic electricity savings (as noted above) that could realistically be achieved within the study period. In the Industrial sector within the Island and Isolated and Labrador Interconnected service regions, the Achievable Potential for electricity savings was estimated to be 125 GWh/yr. and 59 GWh/yr. by 2026 in, respectively, the Upper and Lower scenarios.

The most significant Achievable savings opportunities were in the actions that addressed motors and compressed air for the Small and Medium Sector, and process specific equipment in the Large industrial sector.

Exhibit 5.4 shows the distribution of electricity savings in 2026 by end use in the Upper and Lower Achievable Potential scenarios.

[28] The level of electricity consumption that would occur if all equipment were upgraded to the level that is cost effective against future avoided electricity costs.

**Exhibit 5.4: Distribution of Electricity Savings by Major End Use in the Upper and Lower Achievable Scenarios, Industrial Sector[29]**




## 5.3 PEAK LOAD SAVINGS

The study did not attempt to estimate peak load savings for the Industrial sector. This approach is consistent with the study scope and recognizes both the greater level of complexity posed by this sector and the absence of the required load shape data.

[29] Values may not add to 100% due to rounding.

# 6. CONCLUSIONS AND NEXT STEPS

This study has confirmed the existence of significant cost-effective CDM potential within Newfoundland and Labrador's Residential, Commercial and Industrial sectors. The study results provide:

- Specific estimates of the potential CDM savings opportunities, defined by sector, sub sector, end use and, in several cases, specific technology(s)

- A baseline set of energy technology penetrations and energy use practices that can assist in the design of specific programs.

The next step[30] in this process involves the selection of a cost-effective portfolio of CDM programs and the setting of specific CDM targets and spending levels as well as deciding how to best account for CDM expenditures.

## 6.1 CDM SPENDING LEVELS

To provide a preliminary reference point for this next step in the program development process, the study team conducted a brief literature search in an attempt to identify typical CDM spending levels in other jurisdictions. The literature search identified two (relatively) recent studies that had addressed similar issues on behalf of other Canadian utilities. The two studies are:

- *Demand-Side Management: Determining Appropriate Spending Levels and Cost-Effectiveness Testing,* which was prepared by Summit Blue Consulting and the Regulatory Assistance Project for the Canadian Association of Members of Public Utility Tribunals (CAMPUT). The study was completed in January 2006.

- *Planning and Budgeting for Energy Efficiency/Demand-Side Management Programs*, which was prepared by Navigant Consulting for Union Gas (Ontario) Limited. The study was completed in July 2005.

The CAMPUT study, which included a review of U.S. and Canadian jurisdictions, concluded that an annual CDM expenditure equal to about 1.5% of annual electricity revenues might be appropriate for a utility (or jurisdiction) that is in the early stages of CDM[31] programming. This level of funding recognizes that it takes time to properly introduce programs into the market place.

The same study found that once program delivery experience is gained, a ramping up to a level of about 3% of annual electricity revenues is appropriate. The study also notes that higher percentages may be warranted if rapid growth in electricity demand is expected or if there is an increasing gap between demand and supply due to such things as plant retirements or siting limitations. The current emphasis on climate change mitigation measures would presumably also fall into a similar category of potential CDM drivers.

[30] Full treatment of these next steps is beyond the scope of the current project.

[31] The term DSM (demand-side management) and CDM are used interchangeably in this section.

The CAMPUT study also notes that even those states with 3% of annual revenues as their CDM target have found that there are more cost-effective CDM opportunities than could be met by the 3% funding. The finding is consistent with the situation in British Columbia. In the case of BC Hydro, CDM expenditures over the past few years have been about 3.3% of electricity revenues.[32] However, the results of BC Hydro's recently completed study (Conservation Potential Review (CPR) 2007) identified over 20,000 GWh of remaining cost-effective CDM opportunities by 2026. The magnitude of remaining cost-effective CDM opportunities combined with the aggressive targets set out in British Columbia's provincial Energy Plan suggest that BC Hydro's future CDM expenditures are likely to increase significantly if the new targets are to be met.

***Additional notes:***

- Neither of the studies noted above found any one single, simple model for setting CDM spending levels and targets. Rather, the more general conclusion is that utilities use a number of different approaches that are reasonable for their context. In fact, the CAMPUT report identified seven approaches to setting CDM spending levels.

    - Based on cost-effective CDM potential estimates
    - Based on percentages of utility revenues
    - Based on Mills/kWh of utility electric sales
    - Levels set through resource planning process
    - Levels set through the restructuring process
    - Tied to projected load growth
    - Case-by-case approach.

- The CAMPUT study also notes that, although not always explicit, a key issue in most jurisdictions is resolving the trade off between wanting to procure all cost-effective energy-efficiency measures and concerns about the resulting short-term effect on rates. The study concluded that CDM budgets based on findings from an Integrated Resource Plan or a benefit-cost assessment tend to accept whatever rate effects are necessary to secure the overall resource plan, inclusive of the cost-effective energy-efficiency measures.

## 6.2 COST ACCOUNTING OF CDM EXPENDITURES

The benefits of CDM programs include reduced energy costs for customers, reduced capital requirements and improved operating costs for utilities and environmental and economic benefits for society. However, the realization of these benefits can require significant expenditures. CDM expenditures include the cost of the efficient technology or action to the customer and the cost to the utility of the policy or program to encourage its use; in the case of many electric utilities, the related costs of CDM programs may also include revenue losses. The cost accounting of the related CDM expenditures is, therefore, another important consideration in the process of developing and implementing CDM programs.

One of the important considerations in the treatment of CDM expenditures is whether to expense or capitalize them. To provide preliminary insight into this issue, the study conducted a brief

[32] CAMPUT, 2006. p. 14.

literature review and held discussions with personnel involved with BC Hydro's Power Smart program.

The allocation of CDM program costs involves deciding between those that are expensed in the given year, and those that are capitalized and, hence, depreciated over a number of years. The results of the brief literature review indicated that both practices occur throughout jurisdictions in North America.

On the one hand, the expensing of CDM costs tends to be less expensive in the long run because there are no carrying costs included. However, in the short term, especially where programs are being developed for the first time, there may be rate impacts. On the other hand, capitalizing of CDM costs reduces the immediate cost to implement the program but the carrying cost of the non-amortized balances add to the overall costs of implementing the program.[33]

Discussions with BC Hydro Power Smart personnel indicated that the utility wrestled with this issue during the initiation of their CDM programs. The following points provide a rough framework for how that utility addresses this allocation issue:[34]

- Upfront development costs, such as market assessments, program planning, etc., are allocated to annual operation and maintenance (O&M) budgets and are, therefore, expensed.
- Electricity savings that occur as a result of CDM program implementation-related costs are considered to be an asset. Hence, once a CDM program reaches the implementation phase, all related expenses are linked to the acquisition of that electricity saving asset. All related expenses are, therefore, capitalized (deferred capital).
- In theory, the depreciation period for the capital asset (electricity savings) should be approximately the same as the life of the measures being implemented. For example, if the CDM measure promotes implementation of compact fluorescent lamps (CFLs), which have an average life of about five years, then the depreciation period should also be five years.
- In practice, most CDM program initiatives are likely to involve multiple measures, each having a different life span. In response, BC Hydro uses an average depreciation life in the range of 10 to 12 years for all their CDM initiatives.
- Inevitably, "grey" program cost areas will be encountered. In these cases, the experience to date suggests that it may be preferable to err towards capitalizing the cost item. This approach helps to smooth out multi-year CDM program budgets by reducing program exposure in a given year.

Based on the results of the preliminary review undertaken for this study, it appears that the approach to the treatment of future CDM expenditures by the Utilities can be better defined at

[33] *Demand-Side Management: Determining Appropriate Spending Levels and Cost-Effectiveness Testing.* Prepared by Summit Blue Consulting and the Regulatory Assistance Project for the Canadian Association of Members of Public Utility Tribunals (CAMPUT). January 30, 2006. p. 34.

[34] Discussion with Murray Bond, Manager of Evaluation, Measurement and Verification. Power Smart. November 12, 2007.

such time as there is more certainty regarding expenditure levels, funding sources, and potential impacts on customer rates.

# CONSERVATION AND DEMAND MANAGEMENT (CDM) POTENTIAL

# NEWFOUNDLAND and LABRADOR

# Residential Sector

***–Final Report–***

*Prepared for:*

**Newfoundland & Labrador Hydro and**
**Newfoundland Power**

*Prepared by:*

**Marbek Resource Consultants Ltd.**

*In association with:*

**Sustainable Housing and Education Consultants**
**and**
**Applied Energy Group**

*January 18, 2008*

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# EXECUTIVE SUMMARY

## ❑ Background and Objectives

Newfoundland and Labrador Hydro and Newfoundland Power (collectively the Utilities) have partnered to produce this study, recognizing the role that each has in energy conservation and least cost electric utility planning within the province. Increasing electricity costs and the expectations of a growing number of their customers and stakeholders have contributed to the increased focus on conservation and demand management (CDM) and resulted in a number of recent initiatives and projects targeting energy savings in the province. This study is the next step in the Utilities efforts to develop a comprehensive plan for CDM in Newfoundland and Labrador. The Utilities envision electricity conservation and demand management (CDM) to be a valuable component in meeting the province's future electricity requirements.

This study will also be a significant component in the further implementation of the Province's recently released Energy Plan. The Energy Plan establishes a long-term vision for how the province's energy resources will be developed and utilized to benefit the people of the province today as well as for future generations. Electricity conservation and demand management (CDM) are an important component of the provincial Energy Plan as are the conservation and demand management components for the other energy resources of the province.

This report meets, in part, the requirements of the Public Utilities Board Order PU 8 2007 requiring NLH to file this study and a five-year plan for implementation of CDM programs in 2008.

The objective of this study is to identify the potential contribution of specific CDM technologies and measures in the Residential, Commercial and Industrial sectors and to assess their economic costs and benefits. The Newfoundland and Labrador economy is expected to grow over the next 20 years, with an associated increase in energy consumption. The benefits of increased penetration of energy efficiency technologies include reduced energy costs for individuals and businesses, as well as environmental benefits through reduced pollution and greenhouse gas emissions.

The outputs from this study will assist the Utilities CDM planners and others to develop specific CDM programs for implementation and to optimize the contribution of CDM technologies and measures to the province's overall energy future.

## ❑ Scope and Organization

This study covers a 20-year study period from 2006 to 2026 and addresses the Residential, Commercial and Industrial sectors as well as street lighting. The study addresses the customers from both utilities. Due to differences in cost and rate structures, the Utilities' customers are organized into two service regions, which in this report are referred to as the Island and Isolated, and the Labrador Interconnected. For the purposes of this study, the isolated diesel system customers have been combined with those in the Island service region due to their relatively small size and electricity usage.

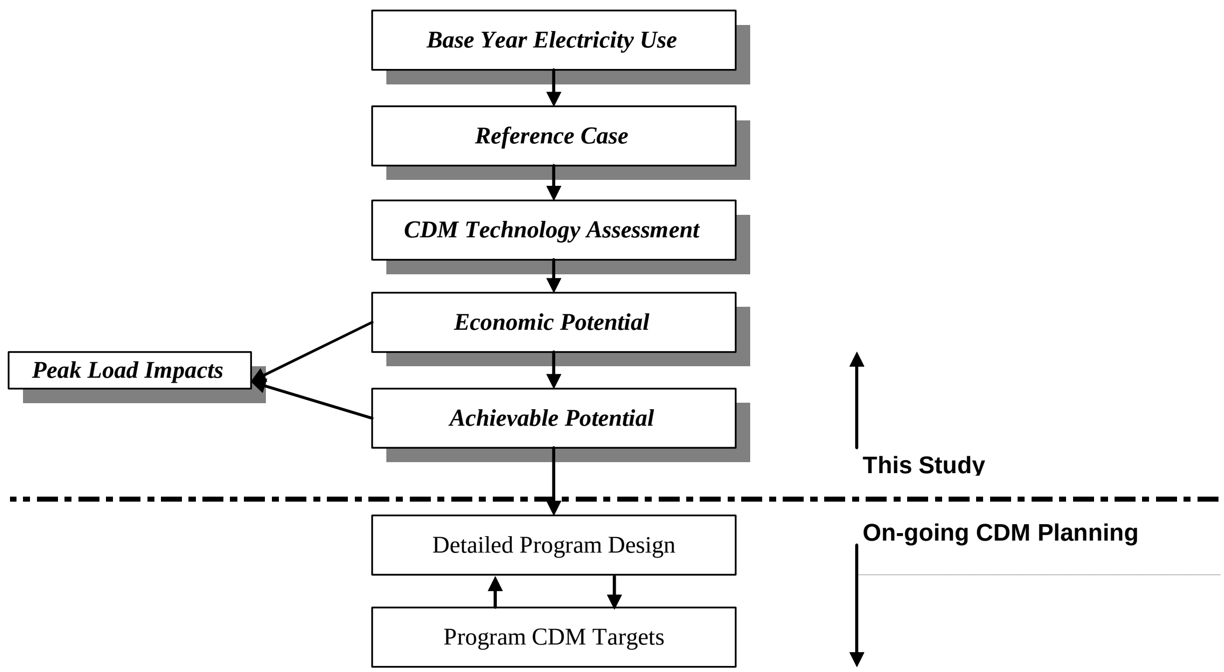
The study reviews all commercially viable electrical efficiency technologies or measures. In addition, the study also reviews selected peak load reduction and fuel switching measures.

## ❑ Approach

The detailed end-use analysis of electrical efficiency opportunities in the Residential sector employed two linked modelling platforms: **HOT2000,** a commercially supported residential building energy-use simulation software, and **RSEEM** (Residential Sector Energy End-use Model), a Marbek in-house spreadsheet-based macro model. Peak load savings were modelled using Applied Energy Group's Cross-Sector Load Shape Library Model (LOADLIB).

The major steps involved in the analysis are shown in Exhibit ES1 and are discussed in greater detail in Chapter 1. As illustrated in Exhibit ES1, the results of this study, and in particular the estimation of Achievable Potential,[1] support the on-going work of the Utilities; however, it should be emphasized that the estimation of Achievable Potential is not synonymous with either the setting of specific targets or with program design.

**Exhibit ES1: Study Approach - Major Analytical Steps**




## ❑ Overall Study Findings[2]

As in any study of this type, the results presented in this report are based on a large number of important assumptions. Assumptions such as those related to the current penetration of energy-efficient technologies, the rate of future growth in the province's building stock and customer willingness to implement new CDM measures are particularly influential. Wherever possible, the assumptions used in this study are consistent with those used by the Utilities and are based on

[1] The proportion of savings identified that could realistically be achieved within the study period without consideration for budgetary constraints.
[2] Consistent with the study scope, the results presented in this Executive Summary address the Island and Isolated service region. The main report provides a similar breakdown for the Labrador Interconnected service region.

best available information, which in many cases includes the professional judgement of the consultant team, Utilities' personnel and local experts. The reader should, therefore, use the results presented in this report as best available estimates; major assumptions, information sources and caveats are noted throughout the report.

The study findings confirm the existence of significant potential cost-effective opportunities for CDM in Newfoundland and Labrador's Residential sector. Electricity savings from efficiency improvements within the Island and Isolated service region would provide between 439 and 236 GWh/yr. of electricity savings by 2026 in, respectively, the Upper and Lower Achievable scenarios. The most significant Achievable Savings opportunities were in the actions that addressed lighting, space heating and household electronics (e.g., computers and peripherals, televisions and television peripherals).

The study also assessed the peak load reductions that would result from the electricity savings (noted above). Electricity savings would provide peak load reductions of approximately 103 to 55 MW during the Utilities' typical Winter Peak Day[3] by 2026 in, respectively, the Upper and Lower Achievable scenarios.

### ❑ Summary of Electricity Savings

A summary of the levels of annual electricity consumption contained in each of the forecasts addressed by the study is presented in Exhibits ES2 and ES3, by milestone year, and discussed briefly in the paragraphs below.

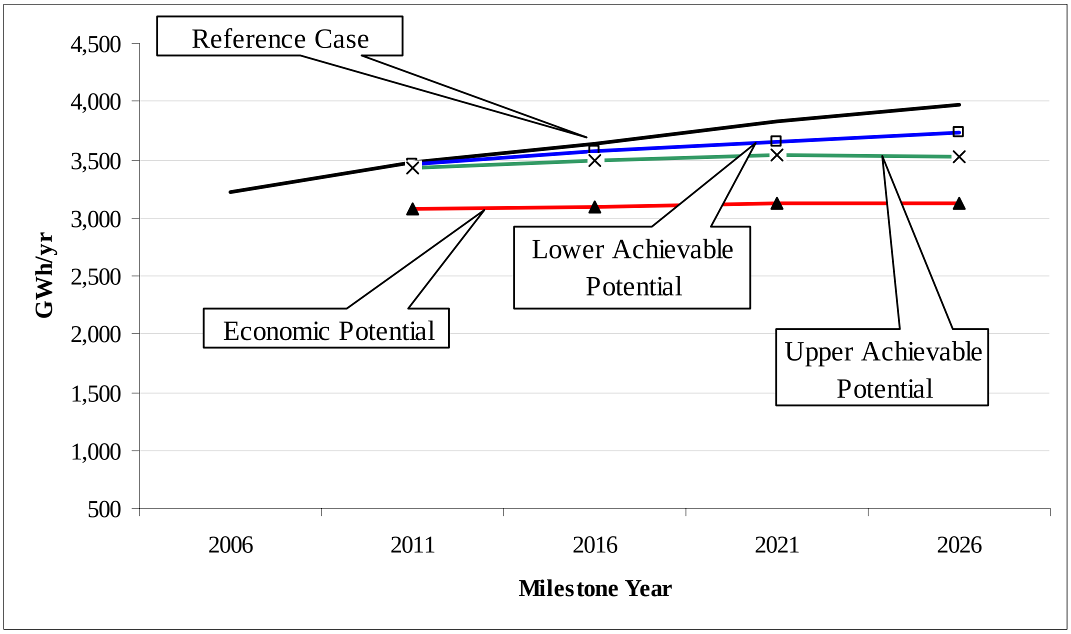
**Exhibit ES2: Summary of Forecast Results for the Island and Isolated Service Region – Annual Electricity Consumption, Residential Sector (GWh/yr.)**

| Annual Consumption (GWh/yr.) Residential Sector | | | | | | Potential Annual Savings (GWh/yr.) | | |
|---|---|---|---|---|---|---|---|---|
| Milestone Year | Base Year | Reference Case | Economic | Achievable | | Economic | Achievable | |
| | | | | Upper | Lower | | Upper | Lower |
| 2006 | 3,228 | 3,228 | | | | | | |
| 2011 | | 3,483 | 3,074 | 3,425 | 3,468 | 409 | 58 | 16 |
| 2016 | | 3,637 | 3,092 | 3,486 | 3,568 | 545 | 151 | 69 |
| 2021 | | 3,821 | 3,120 | 3,533 | 3,660 | 701 | 288 | 161 |
| 2026 | | 3,968 | 3,122 | 3,529 | 3,732 | 846 | 439 | 236 |

*Results are measured at the customer's point-of-use and do not include line losses.

[3] Winter Peak Day is defined as the weekday hours from 7 am to noon and 4 pm to 8 pm on the four coldest days in the December to March period; totals 36 hours.

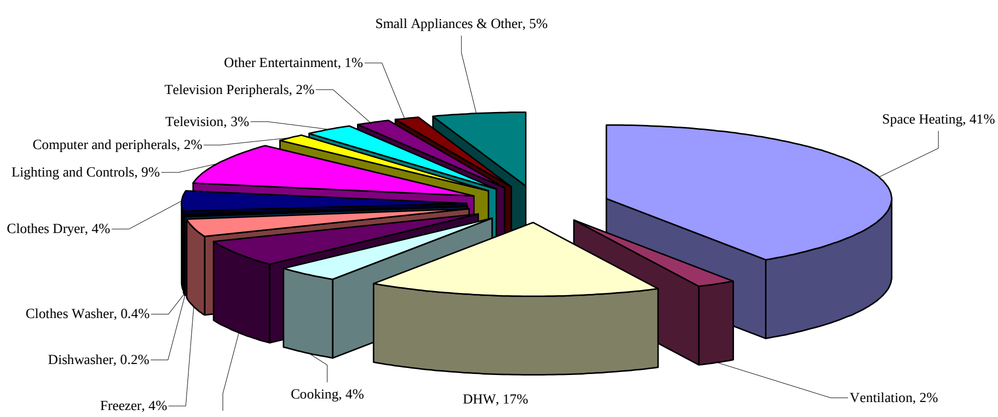
**Exhibit ES3: Graphic of Forecast Results for the Island and Isolated Service Region – Annual Electricity Consumption, Residential Sector (GWh/yr.)**




## Base Year Electricity Use

In the Base Year of 2006, the Residential sector in the Island and Isolated service region consumed about 3,228 GWh. Exhibit ES4 shows that space heating accounts for about 41% of total residential electricity use.[4] Domestic hot water (DHW) accounts for about 17% of the total electricity use, followed by kitchen appliances (14%) and lighting (9%). Household electronics (i.e., computers and peripherals, televisions and television peripherals) account for about 8% of electricity use.

**Exhibit ES4: Base Year Electricity Use by End Use in the Island and Isolated Service Region, Residential Sector**




*Totals may not add to 100% due to rounding.*

[4] Values are for all residential dwellings. Space heating share is much higher in electrically heated homes.

The overwhelming majority of residential electricity use in the Island and Isolated service region occurs in single detached dwellings (81%). The remaining electricity use is in attached dwellings (11%) followed by apartments (6%). Isolated and other residential buildings each account for about 1%.

***Reference Case***

In the absence of new utility CDM initiatives, the study estimates that electricity consumption in the Residential sector will grow from 3,228 GWh/yr. in 2006 to about 3,968 GWh/yr. by 2026 in the Island and Isolated service region. This represents an overall growth of about 23% in the period and compares very closely with NLH's load forecast, which also included consideration of the impacts of "natural conservation."

***Economic Potential Forecast***

Under the conditions of the Economic Potential Forecast,[5] the study estimated that electricity consumption in the Residential sector would decline to about 3,124 GWh/yr. by 2026 in the Island and Isolated service region. Annual savings relative to the Reference Case are 844 GWh/yr. or about 21%.

***Achievable Potential***

The Achievable Potential is the proportion of the economic electricity savings (as noted above) that could realistically be achieved within the study period. In the Residential sector within the Island and Isolated service region, the Achievable Potential for electricity savings was estimated to be 439 GWh/yr. and 236 GWh/yr. by 2026 in, respectively, the Upper and Lower scenarios.

Consistent with the results in the Economic Potential Forecast, the most significant Achievable savings opportunities were in the actions that addressed lighting and space heating, followed by water heating, household electronics (e.g., computers and peripherals, televisions and television peripherals) and large appliances.

- ❑ **Peak Load Savings**

The electricity savings noted above also result in a reduction in capacity requirements (MW), which can be of particular value to the Utilities during periods of high electricity demand. The study defined the Newfoundland Labrador system peak period as:

> *The morning period from 7 am to noon and the evening period from 4 to 8 pm on the four coldest days during the December to March period; this is a total of 36 hours per year.*

The resulting peak load reductions are presented in Exhibit ES5. As illustrated in Exhibit ES5, the Residential sector peak load savings was estimated to be 103 MW and 55 MW by 2026 in, respectively, the Upper and Lower scenarios. In each case, the reductions are an average value over the peak period and are defined relative to the Reference Case.

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[5] The level of electricity consumption that would occur if all equipment and building envelopes were upgraded to the level that is cost effective against future avoided electricity costs.

**Exhibit ES5: Peak Load Savings from Electricity Savings in the Island and Isolated Service Region, Residential Sector**

| Milestone Year | Electricity Savings (GWh/yr.) | | Peak Load Savings (MW) | |
|---|---|---|---|---|
| | Upper Achievable | Lower Achievable | Upper Achievable | Lower Achievable |
| 2011 | 58 | 16 | 11 | 3 |
| 2016 | 151 | 69 | 29 | 13 |
| 2021 | 288 | 161 | 58 | 32 |
| 2026 | 439 | 236 | 91 | 49 |

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# 1. INTRODUCTION

## 1.1 BACKGROUND AND OBJECTIVES

Newfoundland and Labrador Hydro and Newfoundland Power (collectively the Utilities) have partnered to produce this study, recognizing the role that each has in energy conservation and least cost electric utility planning within the province. Increasing electricity costs and the expectations of a growing number of their customers and stakeholders have contributed to the increased focus on conservation and demand management (CDM) and resulted in a number of recent initiatives and projects targeting energy savings in the province. This study is the next step in the Utilities efforts to develop a comprehensive plan for CDM in Newfoundland and Labrador. The Utilities envision electricity conservation and demand management (CDM) to be a valuable component in meeting the province's future electricity requirements.

This study will also be a significant component in the further implementation of the Province's recently released Energy Plan. The Energy Plan establishes a long-term vision for how the province's energy resources will be developed and utilized to benefit the people of the province today as well as for future generations. Electricity conservation and demand management (CDM) are an important component of the provincial Energy Plan as are the conservation and demand management components for the other energy resources of the province.

This report meets, in part, the requirements of the Public Utilities Board Order PU 8 2007 requiring NLH to file this study and a five-year plan for implementation of CDM programs in 2008.

The objective of this study is to identify the potential contribution of specific CDM technologies and measures in the Residential, Commercial and Industrial sectors and to assess their economic costs and benefits. The Newfoundland and Labrador economy is expected to grow over the next 20 years, with an associated increase in energy consumption. The benefits of increased penetration of energy efficiency technologies include reduced energy costs for individuals and businesses, as well as environmental benefits through reduced pollution and greenhouse gas emissions.

The outputs from this study will assist the Utilities CDM planners and others to develop specific CDM programs for implementation and to optimize the contribution of CDM technologies and measures to the province's overall energy future.

## 1.2 STUDY SCOPE

The scope of this study is summarized below.

- **Sector Coverage:** This study addresses the Residential, Commercial and Industrial sectors as well as street lighting. It was agreed that the Industrial sector would be treated at a much higher level than the Residential and Commercial sectors.

- **Geographical Coverage**: The study addresses the customers from both utilities. Due to differences in cost and rate structures, the Utilities' customers are organized into two service regions, which in this report are referred to a: the Island and Isolated, and the Labrador Interconnected. For the purposes of this study, the isolated diesel system customers have been combined with those in the Island service region due to their relatively small size and electricity usage.

- **Study Period**: This study covers a 20-year period. The Base Year is the calendar year 2006, with milestone periods at five-year increments: 2011, 2016, 2021 and 2026. The Base Year of 2006 was selected as it was the most recent calendar period for which complete customer data were available.

- **Technologies:** The study addresses conservation and demand management (CDM) measures. CDM refers to a broad range of potential measures (see Section 1.3, Definitions); however, for the purposes of this study, it was agreed that the primary focus is on energy-efficiency measures. This includes measures that reduce electricity use as well as the associated capacity impact on a winter peak period. The study also provides a high-level treatment of selected demand management measures, such as direct control of space heating loads, etc.[6]

### 1.2.1 Data Caveat

As in any study of this type, the results presented in this report are based on a large number of important assumptions. Assumptions such as those related to the current penetration of energy-efficient technologies, the rate of future growth in the province's building stock and customer willingness to implement new CDM measures are particularly influential. Wherever possible, the assumptions used in this study are consistent with those used by the Utilities and are based on best available information, which in many cases includes the professional judgement of the consultant team, Utilities' personnel and local experts. The reader should, therefore, use the results presented in this report as best available estimates; major assumptions, information sources and caveats are noted throughout the report.

## 1.3 DEFINITIONS

This study uses numerous terms that are unique to analyses such as this one and consequently it is important to ensure that readers have a clear understanding of what each term means when applied to this study.

***Base Year Electricity Use*** The Base Year is the starting point for the analysis. It provides a detailed description of "where" and "how" electrical energy is currently used in the existing Residential sector building stock. Building electricity use simulations were undertaken for the major dwelling types and calibrated to actual utility customer billing data for the Base Year. As noted previously, the Base Year for this study is the calendar year 2006.

[6] The information provided is based on the detailed analysis that Marbek is currently undertaking in other jurisdictions.

***Reference Case Electricity Use (includes Natural Conservation)***

The Reference Case Electricity Use estimates the expected level of electrical energy consumption that would occur over the study period in the absence of new (post-F2006) utility-based CDM initiatives. It provides the point of comparison for the subsequent calculation of "economic" and "achievable" electrical energy potentials. Creation of the Reference Case required the development of profiles for new buildings in each of the dwelling types, estimation of the expected growth in building stock and appliances and, finally, an estimation of "natural" changes affecting electricity consumption over the study period. The Reference Case aligns well with the NLH Long Term Planning (PLF) Review Forecast, Summer/Fall 2006.

***Conservation and Demand Management (CDM) Measures***

CDM refers to a broad range of potential measures that can include: energy efficiency (use more efficiently), energy conservation (use less), demand management (use less during peak periods), fuel switching (use a different fuel to provide the energy service) and self-generation/co-generation (displace load off of grid).

As noted in Section 1.2, it was agreed that the primary focus is on energy-efficiency measures. This includes measures that reduce electricity use as well as the associated capacity impact on a winter peak period.

***The Cost of Conserved Energy (CCE)***

The CCE is calculated for each energy-efficiency measure and operating and maintenance (O&M) practice. The CCE is the annualized incremental capital and O&M cost of the upgrade measure divided by the annual energy savings achieved, excluding any administrative or program costs. The CCE represents the cost of conserving one kWh of electricity; it can be compared directly to the cost of supplying one new kWh of electricity.

***Economic Potential Electricity Forecast***

The Economic Potential Electricity Forecast is the level of electricity consumption that would occur if all equipment and building envelopes were upgraded to the level that is cost effective against the future avoided cost of electricity in the Newfoundland and Labrador Hydro service area (for this study, the value was set at $0.0980/kWh for the Island and Isolated service region and $0.0432/kWh for the Labrador Interconnected service region).[7] All the energy-efficiency upgrades included in the technology assessment that had a CCE equal to, or less than, the preceding avoided costs of new electricity supply were incorporated into the Economic Potential Forecast.

[7] Sensitivity analysis was also conducted using avoided cost values expected to prevail if the Lower Churchill/DC Link project is completed.

***Achievable Potential*** The Achievable Potential is the proportion of the savings identified in the Economic Potential Forecast that could realistically be achieved within the study period. Achievable Potential recognizes that it is difficult to induce customers to purchase and install all the electrical efficiency technologies that meet the criteria defined by the Economic Potential Forecast. The results are presented as a range, defined as "upper" and "lower."

## 1.4 APPROACH

To meet the objectives outlined above, the study was conducted within an iterative process that involved a number of well-defined steps. At the completion of each step, the client reviewed the results and, as applicable, revisions were identified and incorporated into the interim results. The study then progressed to the next step. A summary of the steps is presented below.

***Step 1:*** **Develop Base Year Electricity Calibration Using Actual Utility Billing Data**

- Compile and analyze available data on Newfoundland and Labrador's existing building stock.
- Develop detailed technical descriptions of the existing building stock.
- Undertake computer simulations of electricity use in each building type and compare these with actual building billing and audit data.
- Compile actual utility billing data.
- Create sector model inputs and generate results.
- Calibrate sector model results using actual utility billing data.

***Step 2:*** **Develop Reference Case Electricity Use**

- Compile and analyze building design, equipment and operations data and develop detailed technical descriptions of the new building stock.
- Develop computer simulations of electricity use in each new building type.
- Compile data on forecast levels of building stock growth and "natural" changes in equipment efficiency levels and/or practices.
- Define sector model inputs and create forecasts of electricity use for each of the milestone years.
- Compare sector model results with NLH load forecast for the study period.

***Step 3:*** **Identify and Assess Energy-efficiency Measures**

- Develop list of energy-efficiency upgrade measures.
- Compile detailed cost and performance data for each measure.
- Identify the baseline technologies employed in the Reference Case, develop energy-efficiency upgrade options and associated electricity savings for each option and determine the CCE for each upgrade option.

***Step 4:*** **Estimate Economic Electricity Savings Potential**

- Compile utility economic data on the forecast cost of new electricity generation; costs of \$0.0980/kWh and \$0.0432/kWh were selected as the economic screens for, respectively, the Island and Isolated and Labrador Interconnected service regions.

- Screen the identified energy-efficiency upgrade options from Step 3 against the utility economic data.
- Identify the combinations of energy-efficiency upgrade options and building types where the cost of saving one kilowatt of electricity is equal to, or less than, the cost of new electricity generation.
- Apply the economically attractive electrical efficiency measures from Step 3 within the energy use simulation model developed previously for the Reference Case.
- Determine annual electricity consumption in each building type and end use when the economic efficiency measures are employed.
- Compare the electricity consumption levels when all economic efficiency measures are used with the Reference Case consumption levels and calculate the electricity savings.

***Step 5:*** **Estimate Achievable Potential Electricity Savings**

- "Bundle" the electricity and peak load reduction opportunities identified in the Economic Potential Forecasts into a set of opportunities.
- For each of the identified opportunities, create an Opportunity Profile that provides a high-level implementation framework, including measure description, cost and savings profile, target sub sectors, potential delivery allies, barriers and possible synergies.
- Review historical achievable program results and prepare preliminary Assessment Worksheets.
- Conduct a full day workshop involving the client, the consultant team and technical experts to reach general agreement on "upper" and "lower" range of achievable potential.

***Step 6:*** **Estimate Peak Load Impacts of Electricity Savings**

- The electricity (electric energy) savings (GWh) calculated in the preceding steps were converted to peak load (electric demand) savings (MW).[8]
- The study defined the Newfoundland and Labrador system peak period as the morning period from 7 am to noon and the evening period from 4 to 8 pm on the four coldest days of the year during the December to March period; this is a total of 36 hours per year.
- The conversion of electricity savings to hourly demand drew on a library of specific sub sector and end use electricity load shapes. Using the load shape data, the following steps were applied:
  - Annual electricity savings for each combination of sub sector and end use were disaggregated *by month*
  - Monthly electricity savings were then further disaggregated *by day type* (weekday, weekend day and peak day)
  - Finally, each day type was disaggregated *by hour*.

[8] Peak load savings were modeled using Applied Energy Group's Cross-Sector Load Shape Library Model (LOADLIB).

## 1.5 ANALYTICAL MODELS

The analysis of the Residential sector employed two linked modelling platforms:

- HOT2000, a commercially supported, residential building energy-use simulation software
- RSEEM (Residential Sector Energy End-use Model), a Marbek in-house spreadsheet-based macro model.

HOT2000 was used to define household heating, cooling and domestic hot water (DHW) electricity use for each of the residential building archetypes. HOT2000 uses state-of-the-art heat loss/gain and system modelling algorithms to calculate household electricity use. It addresses:

- Electric, natural gas, oil, propane and wood space heating systems
- DHW systems from conventional to high-efficiency condensing systems
- The interaction effect between space heating appliances and non-space heating appliances, such as lights and refrigerators.

The outputs from HOT2000 provide the space heating/cooling energy-use intensity (EUI) inputs for the Thermal Archetype module of RSEEM.

RSEEM consists of three modules:

- A General Parameters module that contains general sector data (e.g., number of dwellings, growth rates, etc.)
- A Thermal Archetype module, as noted above, which contains data on the heating and cooling loads in each archetype
- An Appliance Module that contains data on appliance saturation levels, fuel shares, unit electricity use, etc.

RSEEM combines the data from each of the modules and provides total use of electricity by service region, dwelling type and end use. RSEEM also enables the analyst to estimate the impacts of the electrical efficiency measures on the Utilities' on-peak system demand.

## 1.6 STUDY ORGANIZATION AND REPORTS

The study was organized and conducted by sector using a common methodology, as outlined above. The results for each sector are presented in individual reports as well as in a summary report. They are entitled:

- *Conservation and Demand Management Potential (2006 to 2026), Newfoundland and Labrador, Residential Sector*

- *Conservation and Demand Management Potential (2006 to 2026), Newfoundland and Labrador, Commercial Sector*

- *Conservation and Demand Management Potential (2006 to 2026), Newfoundland and Labrador, Industrial Sector*

- *Conservation and Demand Management Potential (2006 to 2026), Newfoundland and Labrador, Residential, Commercial and Industrial Sectors, Summary Report*

The study also prepared a brief CDM program evaluation report, which is entitled:

- *Conservation and Demand Management Potential (2006 to 2026), Newfoundland and Labrador, Program Evaluation Guidelines*.

This report presents the Residential sector results; it is organized as follows:

- Section 2 presents a profile of Residential sector Base Year electricity use in Newfoundland and Labrador, including a discussion of the major steps involved and the data sources employed.

- Section 3 presents a profile of Residential sector Reference Case electricity use in Newfoundland and Labrador for the study period 2006 to 2026, including a discussion of the major steps involved.

- Section 4 identifies and assesses the economic attractiveness of the selected energy-efficiency technology measures for the Residential sector.

- Section 5 presents the Residential sector Economic Potential Electricity Forecast for the study period 2006 to 2026.

- Section 6 presents the estimated Upper and Lower Achievable Potential for electricity savings for the study period 2006 to 2026.

- Section 7 presents conclusions and next steps.

- Section 8 presents a listing of major references.

# 2. BASE YEAR (2006) ELECTRICITY USE

## 2.1 INTRODUCTION

This section provides a profile of Base Year (2006) electricity use in Newfoundland and Labrador's Residential sector. The discussion is organized into the following sub sections:

- Segmentation of Base Year Housing Stock
- Definition of End Uses
- Estimation of Net Space Heating Loads
- Development of Thermal Archetypes
- Annual Appliance Electricity Use
- Appliance Saturation
- Estimation of Fuel Share, by End Use
- Average Electricity Use Per Unit
- Summary of Model Results.

## 2.2 SEGMENTATION OF BASE YEAR HOUSING STOCK

The first major task in developing the Base Year electricity calibration involved the segmentation of the residential building stock on the basis of four factors:

- Dwelling type
- Service region
- Vintage
- Heating category (electrically heated versus non-electrically heated).

Based on discussions with the Utilities' personnel, it was agreed that Newfoundland and Labrador's existing residential stock would be segmented into the following dwelling types:

- Single-family detached, pre-2007 – electric space heat
- Single-family detached, pre-2007 – non-electric space heat
- Attached,[9] pre-2007 – electric space heat
- Attached, pre-2007 – non-electric space heat
- Apartment,[10] pre-2007 – electric space heat
- Apartment, pre-2007 – non-electric space heat
- Isolated (all residences in diesel communities)
- Other – includes very low use facilities and non-dwellings such as garages, sheds, wells, etc.
- Vacant and Partial – includes dwelling units that are either vacant all the time (such as homes owned by people who have moved away) or are used only seasonally (including cottages). The energy consumption of this residential stock is not reported in the remainder of this document.

[9] Includes the main dwellings above a basement apartment.
[10] Includes basement apartments, which make up about 50% of the units defined under this category.

Utility customer billing data was used to develop a breakdown of the Residential sector into the above dwelling types. The same customer data was also used to further divide the total population of each dwelling type by service region and primary heating type.

A summary is provided in Exhibit 2.1 and highlights are presented below:

- The Utilities currently service about 228,000 residential dwelling units between the two service regions; the Island and Isolated service region accounts for approximately 96.5% of the total residential customers served by the Utilities.
- 8% of residential dwellings are currently listed as vacant or partially occupied. This includes seasonal homes or cottages as well as vacant residences. These buildings have been separated out from the other dwelling types in the Base Year as their inclusion may result in an understating of the energy consumption.
- Of those residential units that are currently fully occupied, approximately 76% are single-family detached, followed by 11% attached units, 9% apartment units, and 2% other types of dwellings. The remaining 2% is made up of isolated dwellings.
- Electricity is the primary space heating fuel in approximately 55% of the provincial housing stock in the Island and Isolated service region and 92% of the provincial housing stock in the Labrador Interconnected service region.
- The inclusion of single-family dwellings with a basement apartment in the dwelling type "Attached," may result in energy consumption in this segment being slightly higher than is typical of other areas of Canada.

**Exhibit 2.1: Existing Newfoundland and Labrador Residential Units by Dwelling Type, Service Region and Primary Heating Source**

| Dwelling Type | Units | | |
|---|---|---|---|
| | **Island and Isolated** | **Labrador Interconnected** | **Total** |
| Single Family Detached, Electric Heat | 80,300 | 5,031 | **85,331** |
| Single Family Detached, Non-Electric Heat | 74,231 | 103 | **74,334** |
| Attached, Electric Heat | 15,227 | 1,663 | **16,890** |
| Attached, Non-Electric Heat | 5,060 | 34 | **5,094** |
| Apartment, Electric Heat | 16,399 | 462 | **16,861** |
| Apartment, Non-Electric Heat | 2,728 | 9 | **2,737** |
| Isolated | 3,491 | 0 | **3,491** |
| Other | 3,512 | 606 | **4,118** |
| Vacant and Partial | 18,970 | 0 | **18,970** |
| **Subtotal** | **219,918** | **7,908** | **227,826** |

*Source: NLH-NP customer billing data.*

## 2.3 DEFINITION OF END USES

Electricity use within each of the dwelling types noted above is further defined on the basis of specific end uses. In this study, an end use is defined as, "the final application or final use to which energy is applied. End uses are the services of economic value to the users of energy."

A summary of the major Residential sector end uses used in this study is provided in Exhibit 2.2, together with a brief description of each.

**Exhibit 2.2: Residential Electric End Uses**

| End Use | Description |
|---|---|
| Space heating | All space heating, including both central heating and supplementary heating |
| Space cooling | Saturation of space cooling is very low in Newfoundland and Labrador; the model includes any space cooling energy use under "Small Appliance & Other" |
| Ventilation | Primarily the furnace fan, but also includes the fan in heat recovery ventilators as well as kitchen and bathroom fans |
| Domestic Hot Water (DHW) | Heating of water for DHW use. Does not include hydronic space heating |
| Cooking | Includes ranges, separate ovens and cook tops and microwave ovens |
| Refrigerator | |
| Freezer | |
| Dishwasher | |
| Clothes washer | |
| Clothes dryer | |
| Lighting | Includes interior, exterior and holiday lighting |
| Computer and peripherals | Printers, scanners, modems, faxes, PDA and cell phone chargers |
| Television | |
| Television peripherals | Set top boxes, including digital cable converters and satellite converters |
| Other electronics | Stereos, DVD players, VCRs, boom boxes, radios, video gaming systems, security systems |
| Small Appliance & Other | There are hundreds of additional items within this category, each accounting for a fraction of a percent of household energy use, e.g., hair dryers, doorbells, garage door openers, block heaters, home medical equipment, electric lawnmowers |

## 2.4 ESTIMATION OF NET SPACE HEATING LOADS

Net space heating load is the space heating load of a building that must be met by the space heating system. This is equal to the total heat loss through the building envelope minus solar and internal gains.

The net space heating loads for each combination of dwelling type and service region were developed based on the following combination of data sources:

- Marbek's database of residential energy consumption from other jurisdictions
- Current utility sales data combined with knowledge of the energy consumption and saturation of other end uses.

The net space heating load for each dwelling type is given by the following equation:

$$NetHL_1 = HL_1 + a_{i,1} * s_{i,1}$$

Where: $NetHL_1$ = Net heating load for dwelling type #1
$HL_1$ = Load on primary heating appliance for dwelling type #1
$a_{i,1}$ = Average consumption for supplementary heating in dwelling type #1
$s_{i,1}$ = Saturation of supplementary heating in dwelling type #1

$HL_1$ was estimated for each dwelling type and service region, based on the Utilities' customer sales data for electric and non-electrically heated dwellings combined with data on the electricity consumption of non-space heating end uses. The values for $a_{i1}$ and $s_{i1}$ were developed based on the estimated share of space heating that is provided by electricity (versus supplementary fuels), as taken from the Utilities' Residential End-use Surveys (REUS). The net space heating loads are presented in Exhibit 2.3 by dwelling type and service region.

It should be noted that the values shown in Exhibit 2.3 are not fuel specific; rather, they represent the total tertiary space heat load for each dwelling. The efficiency of the space heating appliances used to meet these loads are considered in subsequent stages of the analysis.

**Exhibit 2.3: Existing Residential Units, 2006 (kWh/yr.) Net Space Heating Loads by Dwelling Type[11]**

| Dwelling Type | Island and Isolated | Labrador Interconnected |
|---|---|---|
| Single Family Detached, Electric Heat | 12,554 | 29,379 |
| Single Family Detached, Non-Electric Heat | 16,700 | 39,081 |
| Attached, Electric Heat | 11,377 | 27,294 |
| Attached, Non-Electric Heat | 15,134 | 36,309 |
| Apartment, Electric Heat | 5,742 | 8,745 |
| Apartment, Non-Electric Heat | 5,742 | 8,745 |
| Isolated | 12,293 | N/A |
| Other | 10,036 | 5,411 |

[11] Net space heating load is the space heating load of a building that must be met by the space heating system over a full year. This is equal to the total heat loss through the building envelope minus solar and internal gains. Values shown for non-electrically heated dwellings are shown in kilowatt hours for format consistency. Work in other jurisdictions has shown significantly higher space heating energy consumption in homes with oil and gas furnaces than in homes with electric heat, even after accounting for furnace efficiency. The reasons for this require more research, but may include factors such as greater air leakage where air intake is required for combustion or homeowners turning down individual electric baseboards in unoccupied rooms.

### 2.4.1 Development of Thermal Archetypes – Existing Stock

The next major step involved the development of a thermal archetype for each of the major dwelling types noted in Exhibit 2.3 using HOT2000.

Each HOT2000 file contains a comprehensive physical description of the size, layout and thermal characteristics of each dwelling type. HOT2000 then uses these inputs to create a full computer model of the residence, calculating loads, interactive effects and energy consumption. In each case, the net heating and cooling loads simulated by HOT2000 were calibrated to the values shown in Exhibit 2.3, which had been established on the basis of the sources described above. The process of calibrating simulation models to the loads estimated from available data served to further confirm the estimated loads. Adjustments were made to the estimates as required.

The physical and operating characteristics of each residential thermal archetype were researched using a number of sources, including:

- Database of EnerGuide for Houses (EGH) evaluations in Newfoundland and Labrador
- Natural Resources Canada (NRCan) and Statistics Canada housing data
- Consultations with energy auditors and residential housing experts located in Newfoundland and Labrador.

For the existing housing stock, archetypes were created for the two primary dwelling types in each service region: single-family detached and attached. A brief description of each housing archetype is provided below.

❑ **Single-family Dwellings**

For the Island and Isolated service region, a “typical” existing, single-detached dwelling can be defined as a single-story bungalow of approximately 93.5m$^2$ (1000 ft$^2$), with a finished basement. This home has 7.7 m$^2$ (83 ft$^2$) of windows, defined as double-glazed, mostly with wood or vinyl frames. Walls are represented by RSI-2.4 (R-13.5) insulation values, ceilings RSI-4.5 (R-25.5) and the basement is insulated to a value of RSI-0.6 (R-3.5). The houses are typically not very airtight with about five air changes per hour (ac/h) at 50 Pascal (Pa) depressurization. Typically, there is no central ventilation system.

For the Labrador Interconnected service region, a “typical” existing, single-detached dwelling can be defined as a single-story bungalow of approximately 85 m$^2$ (915 ft$^2$), with a heated basement. This home has 6.1 m$^2$ (66 ft$^2$) of windows, defined as double-glazed, mostly with wood or vinyl frames. Walls are represented by RSI-2.1 (R-12) insulation values, ceilings RSI-4 (R-23) and there is no insulation in the basement. The houses are typically not very airtight with about seven air changes per hour (ac/h) at 50 Pascal (Pa) depressurization. Typically, there is no central ventilation system.

- **Attached Dwellings**

For the Island and Isolated service region, a "typical" existing, attached dwelling can be defined as a two-story middle-unit of approximately 104 $m^2$ (1120 $ft^2$), with a finished basement. This home has 7.2 $m^2$ (77 $ft^2$) of windows, defined as double-glazed, mostly with wood or vinyl frames. Walls are represented by RSI-2.4 (R-13.5) insulation values, ceilings RSI-4.5 (R-25.5) and the basement is insulated to a value of RSI-0.6 (R-3.5). The houses are typically not very airtight with about five air changes per hour (ac/h) at 50 Pascal (Pa) depressurization. Typically, there is no central ventilation system.

For the Labrador Interconnected service region, a "typical" existing, attached dwelling can be defined as a two-story middle-unit of approximately 104 $m^2$ (1120 $ft^2$) with a heated basement. This home has 7.2 $m^2$ (77 $ft^2$) of windows, defined as double-glazed, mostly with wood or vinyl frames. Walls are represented by RSI-2.1 (R-12) insulation values, ceilings RSI-4 (R-23) and there is no insulation in the basement. The houses are typically not very airtight with about seven air changes per hour (ac/h) at 50 Pascal (Pa) depressurization. Typically, there is no central ventilation system.

## 2.5 ANNUAL APPLIANCE ELECTRICITY USE

The next major task involved the development of estimated average annual unit electricity consumption (UEC) values for each of the major residential appliances.

While most appliances have increased in efficiency over time, there is no evident correlation or available data that links the age of the dwelling and the age of the appliances in it. Older homes likely have had major appliances replaced several times and newer homes can have old appliances transferred from previous residences. Lacking any definite relation between the age of the home and the age of an appliance, an average value for all in-place appliances was used for all existing vintages. This was based on an appliance stock model that takes into account the expected useful life of each type of appliance, the rate of purchase and retirement of appliances, the average annual consumption of newly purchased appliances in a given year and the average annual consumption of appliances being retired in a given year. The stock average consumption thus evolves with time. In any specific year, the average age of appliances in place is assumed to be half of the expected useful life of the appliance and the stock average is built up of all the appliances purchased and installed up to that point.

Exhibits 2.4 and 2.5 summarize the estimated average annual UEC for major end-use appliances in, respectively, the Island and Isolated and Labrador Interconnected service regions.

The values shown in Exhibits 2.4 and 2.5 apply to the current stock mix. Further discussion is provided below.

## Exhibit 2.4: Annual Appliance Electricity Use (UEC) for the Island and Isolated Service Region, (kWh/yr.)

| Dwelling Type | Ventilation | DHW | Cooking | Refrigerator | Freezer | Dishwasher | Clothes washer | Clothes dryer | Lighting | Computer etc. | Television | TV peripherals | Other electronics | Small apps & Other |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Single Family Detached, Electric Heat | 121 | 3,301 | 633 | 830 | 650 | 75 | 64 | 820 | 1,515 | 394 | 178 | 226 | 159 | 902 |
| Single Family Detached, Non-Electric Heat | 800 | 3,301 | 633 | 830 | 650 | 75 | 64 | 820 | 1,515 | 394 | 178 | 226 | 159 | 902 |
| Attached, Electric Heat | 110 | 2,991 | 488 | 830 | 650 | 58 | 48 | 615 | 1,373 | 394 | 178 | 226 | 159 | 428 |
| Attached, Non-Electric Heat | 725 | 2,991 | 488 | 830 | 650 | 58 | 48 | 615 | 1,373 | 394 | 178 | 226 | 159 | 428 |
| Apartment, Electric Heat | 55 | 2,239 | 378 | 560 | 370 | 49 | 41 | 490 | 693 | 394 | 178 | 226 | 159 | 135 |
| Apartment, Non-Electric Heat | 275 | 2,239 | 378 | 560 | 370 | 49 | 41 | 490 | 693 | 394 | 178 | 226 | 159 | 135 |
| Isolated | 118 | 3,301 | 806 | 813 | 827 | 73 | 63 | 803 | 1,483 | 385 | 174 | 221 | 156 | 883 |
| Other | 97 | 2,639 | 506 | 664 | 520 | 60 | 51 | 656 | 1,211 | 315 | 142 | 180 | 127 | 721 |

## Exhibit 2.5: Annual Appliance Electricity Use (UEC) for the Labrador Interconnected Service Region, (kWh/yr.)

| Dwelling Type | Ventilation | DHW | Cooking | Refrigerator | Freezer | Dishwasher | Clothes washer | Clothes dryer | Lighting | Computer etc. | Television | TV peripherals | Other electronics | Small apps & Other |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Single Family Detached, Electric Heat | 121 | 3,961 | 633 | 830 | 650 | 75 | 64 | 820 | 1,818 | 394 | 178 | 226 | 159 | 902 |
| Single Family Detached, Non-Electric Heat | 800 | 3,961 | 633 | 830 | 650 | 75 | 64 | 820 | 1,818 | 394 | 178 | 226 | 159 | 902 |
| Attached, Electric Heat | 112 | 3,680 | 488 | 830 | 650 | 58 | 48 | 615 | 1,689 | 394 | 178 | 226 | 159 | 428 |
| Attached, Non-Electric Heat | 743 | 3,680 | 488 | 830 | 650 | 58 | 48 | 615 | 1,689 | 394 | 178 | 226 | 159 | 428 |
| Apartment, Electric Heat | 36 | 2,687 | 378 | 560 | 370 | 49 | 41 | 490 | 832 | 394 | 178 | 226 | 159 | 135 |
| Apartment, Non-Electric Heat | 179 | 2,687 | 378 | 560 | 370 | 49 | 41 | 490 | 832 | 394 | 178 | 226 | 159 | 135 |
| Other | 22 | 730 | 117 | 153 | 120 | 14 | 12 | 151 | 335 | 72 | 33 | 42 | 29 | 166 |

### ❑ Occupancy

Occupancy rates[12] for each dwelling type were based on residential utility data from other jurisdictions. They are used, as applicable, to estimate electricity use for occupant-sensitive end uses, such as DHW, laundry and lighting. Exhibit 2.6 summarizes the occupancy rates, by dwelling type. The table indicates, for example, that 12% of single-family dwellings are occupied by only one person, 42% by two persons and 46% by three or more persons.

**Exhibit 2.6: Occupancy Rates by Dwelling Type**

| Occupants | SFD | Attached | Apt |
|---|---|---|---|
| 1 | 12% | 27% | 54% |
| 2 | 42% | 40% | 35% |
| 3+ | 46% | 33% | 12% |

### ❑ Ventilation

Ventilation electricity is associated with fan/blower electricity in heating systems, kitchen fans, bathroom fans and heat recovery ventilators.

A furnace fan UEC of 700 kWh (heat mode only) is assumed for single-family dwellings having central forced air heating systems. This value is towards the upper range of Canadian end-use metered data, as reported in a study conducted for Natural Resources Canada, and is consistent with the relatively longer heating season experienced in Newfoundland and Labrador.[13]

For the purpose of estimating kitchen and bathroom fan electricity, it was assumed that a typical exhaust fan is rated at 75 Watts and operates, on average, for two hours per day. In homes with heat supplied by baseboard electric or by hydronic systems, these exhaust fans are the predominant ventilation load. With two such fans in a typical house, consumption would be approximately 100-110 kWh/yr.

The UEC for a forced air system includes the energy from both the furnace fan and the exhaust fans. The UEC for a baseboard electric system includes only the energy from the latter. The ventilation UEC values shown in Exhibits 2.4 and 2.5 for electrically heated dwellings in Newfoundland and Labrador reflect the mix between forced air systems (under 2% of electrically heated homes) and baseboard systems.

### ❑ Domestic Hot Water

UEC estimates for DHW assume a per capita hot water consumption of 45 litres per person per day and a temperature rise of 45°C. Exhibit 2.7 shows the distribution of DHW load by major end use.

[12] Electricity use related to personal consumption increases with number of occupants in dwelling.
[13] This area is the focus of extensive research efforts. *See*: Gusdorf, John, *Final Report on the Project to Measure the Effects of ECM Furnace Motors on Gas Use at the CCHT Research Facility,* Natural Resources Canada, January 2003. Current estimates of fan energy use vary widely; upper range estimates (heat mode only) exceed 1,000 kWh/yr. Continuous ventilation or use with space cooling equipment would increase fan motor consumption.

**Exhibit 2.7: Distribution of DHW Electricity Use by End Use in Existing Stock, (kWh/yr.)**

| End Use | Sample Electricity Use Single Family Detached (kWh/yr.) | % |
|---|---|---|
| Personal Use | 1,155 | 35 |
| Dishwashing | 759 | 23 |
| Clothes Washing | 891 | 27 |
| Standby Losses | 495 | 15 |
| Total | 3,301 | 100 |

*Note: Any differences in totals are due to rounding.*

The DHW values shown in Exhibit 2.7 are based on a combination of sources including available data from other jurisdictions, NRCan studies (NRCan, 2005) and the results of conditional demand analysis and customer survey work done by both NP and NLH in the 1990s.[14]

### ❑ Cooking Appliances, Refrigerator, Freezer and Dishwasher

UEC estimates for the existing stock of this group of food preparation and storage appliances were obtained from *The End Use Energy Data Handbook* (NRCan, 2005). The values shown for dishwashers are for mechanical electricity only; hot water use is included with the DHW UEC.

### ❑ Clothes Washer and Dryer

Appliance UEC data was obtained from *The End Use Energy Data Handbook* (NRCan, 2005) and adjusted by region and dwelling type based on previous data. The values shown for clothes washers are for mechanical electricity only; hot water use is included with the DHW UEC.

### ❑ Computers

UEC data for computers is based on Marbek's current work for BC Hydro.[15] UEC varies with occupancy rate by region and dwelling type.

### ❑ Lighting

The lighting loads shown in Exhibits 2.4 and 2.5 were developed from the following sources:

- Residential utility data on lighting types and usage patterns from other jurisdictions
- *The End Use Energy Data Handbook* (NRCan, 2005).

Exhibit 2.8 shows the derivation of lighting UECs.

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[14] The values shown in Exhibit 2.7 do not include combustion efficiency; therefore, if the water is heated using oil or propane, the on-site energy consumption would be higher than shown in Exhibit 2.7.
[15] Marbek Resource Consultants, *Conservation Potential Review – 2007*. Prepared for BC Hydro. 2007.

### Exhibit 2.8: Derivation of Lighting UECs

| | | |
|---|---|---|
| **Incandescent** | | |
| *Number of regularly used bulbs* | | |
| SFD/Duplex | 16 | |
| Row | 15 | |
| Apt | 8 | |
| Mobile/Other | 8 | |
| Average wattage | 60 | |
| Average Hours/year | 1,200 | |
| **Fluorescent** | | |
| (includes linear tubes and CFLs) | | |
| *Number of regularly used linear lamps/CFLs* | *Linear* | *CFL* |
| SFD/Duplex | 2 | 2 |
| Row | 2 | 3 |
| Apt | 1 | 3 |
| Mobile/Other | 1 | 2 |
| Average wattage (including ballast) | 48 | 15 |
| Average Hours/year | 1,200 | 1,200 |
| **Holiday/Other Lighting** | | |
| (includes garden and other outdoor lighting) | | |
| Average wattage | | |
| SFD/Duplex | 350 | |
| Row | 250 | |
| Apt | 0 | |
| Mobile/Other | 225 | |
| Average Hours/year | 300 | |
| **Total Base Year Energy Use** | | |
| SFD/Duplex | 1,388 | |
| Row | 1,373 | |
| Apt | 693 | |

## ❑ Television

UEC data for televisions was obtained from *Technology and Market Profile: Consumer Electronics* (Marbek, 2006). Saturation of televisions (number of sets per household) is adjusted by dwelling type based on data from the “Frequency Per Dwelling Type 2005” Survey (see Section 2.6) but consumption per television is not varied by dwelling type in this study.

## ❑ Television Peripherals

UECs, saturations and numbers per household for television peripherals were obtained from *Technology and Market Profile: Consumer Electronics* (Marbek, 2006) and other published data. A weighted UEC for the end use as a whole was generated from these numbers as shown in Exhibit 2.9. UEC varies with occupancy rate by dwelling type and region.

**Exhibit 2.9: Derivation of UEC for Television Peripherals**

| | % of TV households | UEC kWh/yr |
|---|---|---|
| **Digital Cable Service** | 17% | |
| Digital Adaptor | 17% | 82 |
| Standard Digital STB | 14% | 194 |
| Advanced Digital STB | 3% | 325 |
| | Average UEC | 299 |
| **Satellite Service** | 21% | |
| Standard Satellite STB | 17% | 141 |
| Advanced Satellite STB | 4% | 273 |
| | Average UEC | 166 |
| | **Total Weighted UEC** | **226** |

## ❑ Other Electronics

Due to the large presence of electronic entertainment devices in many residential dwellings, this end use was separated from the general "Other" category. UECs were obtained from *Technology and Market Profile: Consumer Electronics* (Marbek, 2006), *Residential Miscellaneous Electricity Use* (LBL) and other published data. A weighted UEC for the end use as a whole was then generated from these numbers as shown in Exhibit 2.10.

**Exhibit 2.10: Derivation of UECs for Other Electronics**

| | Penetration | Number Per Household | UEC (kWh/yr) | Weighted UEC (kWh/yr) |
|---|---|---|---|---|
| DVD | 72% | 1.2 | 35 | 30 |
| VCR | 69% | 1.3 | 55 | 49 |
| Audio System | 29% | 1.3 | 55 | 21 |
| Surround Sound | 25% | 1 | 50 | 13 |
| Compact Audio | 79% | 1.5 | 25 | 30 |
| Game Console | 25% | 1.3 | 55 | 18 |
| | | | **Total Weighted UEC** | **160** |

## ❑ Small Appliances and Other

"Other" end uses include a wide range of appliances and equipment found in most homes. Reliable data on the actual annual electricity use of this collection of appliances and equipment within Newfoundland and Labrador is not available.

Exhibit 2.11 illustrates the major items included in this end use and presents sample UEC data estimated in earlier studies undertaken in other jurisdictions.[16] It should be noted that actual UECs for individual appliances will vary from those shown in Exhibit 2.11 and are affected by factors such as saturations by dwelling type, occupancy rates and service region. Saturation

[16] Lawrence Berkeley National Laboratory (LBL), *Residential Miscellaneous Electricity Use*, 1997.

information from LBL was not applied for this study because reliable information for Newfoundland and Labrador was not available. The "Other" category is not built up based on detailed analysis, but is an approximation only. The LBL data provided should be treated as being illustrative of the types of energy-using items in the category and how much electricity they typically use.

**Exhibit 2.11: Typical UECs for Selected "Other" Appliances**

| Appliance | UEC (kWh/yr) | Appliance | UEC (kWh/yr) |
|---|---|---|---|
| Home radio, small/clock | 18 | Timer | 18 |
| Battery Charger | 21 | Hot Plate | 30 |
| Clock | 18 | Stand Mixers | 1 |
| Power Strip | 3 | Hand-Held Rechargeable | 16 |
| Vacuum | 31 | Hand-Held Electric Vacuum | 4 |
| Hand Mixers | 2 | Air Corn Popper | 6 |
| Iron | 53 | Security System | 195 |
| Hair Dryer | 36 | Perc Coffee | 65 |
| Toaster | 39 | Deep Fryer | 20 |
| Auto Coffee Maker | 116 | Waterbed Heaters | 900 |
| Blender | 7 | Humidifier | 100 |
| Heating Pads | 3 | Electric Toothbrush | 20 |
| Doorbell | 18 | Hot Oil Corn Popper | 2 |
| Answering Machine | 29 | Women's Shaver | 12 |
| Can Opener | 3 | Aquariums | 548 |
| Slow Cooker | 16 | Espresso Maker | 19 |
| Curling Iron | 1 | Electric Lawn Mower | 100 |
| Food Slicer | 1 | Mounted Air Cleaner | 500 |
| Garbage Disposer | 10 | Multi-fcn Device | 41 |
| Electric Knife | 1 | Heat Tape | 100 |
| Portable Fans | 8 | Auto Engine Heaters | 250 |
| Men's Shaver | 13 | Electric Kettle | 75 |
| Waffle Iron/Sandwich Grill | 25 | Bottled Water Dispenser | 300 |
| Electric Blankets | 120 | Central Vacuum | 24 |
| Garage Door Opener | 30 | Grow Lights | 800 |
| Hair Setter | 10 | Home Medical Equipment | 400 |

## 2.6 APPLIANCE SATURATION

Exhibits 2.12 and 2.13 summarize the saturation levels that are used in the present analysis for, respectively, the Island and Isolated and Labrador Interconnected service regions. In each case, the assumed saturation levels are developed from the most recent utility REUS. Saturations were obtained through querying the database, by end use and dwelling type; minor refinements were made in selected cases to assist in calibration.

**Exhibit 2.12: Appliance Saturation Levels for Island and Isolated in 2006, (%)**

| Dwelling Type | Ventilation | DHW | Cooking | Refrigerator | Freezer | Dishwasher | Clothes washer | Clothes dryer | Lighting | Computer etc. | Television | TV peripherals | Other electronics | Small apps & Other |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Single Family Detached, Electric Heat | 100% | 100% | 100% | 119% | 108% | 48% | 99% | 96% | 100% | 77% | 242% | 158% | 147% | 100% |
| Single Family Detached, Non-Electric Heat | 100% | 100% | 100% | 119% | 108% | 48% | 99% | 96% | 100% | 77% | 242% | 158% | 147% | 100% |
| Attached, Electric Heat | 100% | 100% | 110% | 121% | 74% | 40% | 96% | 92% | 100% | 83% | 234% | 153% | 143% | 100% |
| Attached, Non-Electric Heat | 100% | 100% | 110% | 121% | 74% | 40% | 96% | 92% | 100% | 83% | 234% | 153% | 143% | 100% |
| Apartment, Electric Heat | 100% | 100% | 100% | 101% | 50% | 15% | 55% | 54% | 100% | 58% | 166% | 109% | 101% | 100% |
| Apartment, Non-Electric Heat | 100% | 100% | 100% | 101% | 50% | 15% | 55% | 54% | 100% | 58% | 166% | 109% | 101% | 100% |
| Isolated | 100% | 100% | 99% | 67% | 116% | 23% | 86% | 87% | 100% | 34% | 157% | 103% | 96% | 100% |
| Other | 50% | 20% | 0% | 5% | 5% | 0% | 5% | 5% | 100% | 0% | 5% | 3% | 3% | 100% |

**Exhibit 2.13: Appliance Saturation Levels for Labrador Interconnected in 2006, (%)**

| Dwelling Type | Ventilation | DHW | Cooking | Refrigerator | Freezer | Dishwasher | Clothes washer | Clothes dryer | Lighting | Computer etc. | Television | TV peripherals | Other electronics | Small apps & Other |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Single Family Detached, Electric Heat | 100% | 100% | 100% | 99% | 105% | 62% | 93% | 94% | 100% | 60% | 177% | 116% | 108% | 100% |
| Single Family Detached, Non-Electric Heat | 100% | 100% | 100% | 99% | 105% | 62% | 93% | 94% | 100% | 60% | 177% | 116% | 108% | 100% |
| Attached, Electric Heat | 100% | 100% | 100% | 89% | 98% | 66% | 98% | 98% | 100% | 64% | 170% | 112% | 104% | 100% |
| Attached, Non-Electric Heat | 100% | 100% | 100% | 89% | 98% | 66% | 98% | 98% | 100% | 64% | 170% | 112% | 104% | 100% |
| Apartment, Electric Heat | 100% | 100% | 100% | 75% | 58% | 17% | 58% | 58% | 100% | 17% | 142% | 93% | 86% | 100% |
| Apartment, Non-Electric Heat | 100% | 100% | 100% | 75% | 58% | 17% | 58% | 58% | 100% | 17% | 142% | 93% | 86% | 100% |
| Other | 50% | 20% | 0% | 5% | 5% | 0% | 5% | 5% | 100% | 0% | 5% | 3% | 3% | 100% |

## 2.7 ESTIMATION OF FUEL SHARE, BY END USE

Data on fuel shares, for all end uses except space heating, is taken from the most recent utility REUS. In the case of space heating, the starting point was the distribution of space heating appliances, by fuel type, as reported in the REUS and in the EnerGuide for Houses database:

- Electricity in non-electrically heated dwellings, and
- Non-electric sources in electrically heated dwellings.

Exhibits 2.14 and 2.15 summarize the electricity fuel shares assumed for each of the end uses included in the present analysis for, respectively, the Island and Isolated and Labrador Interconnected service regions. The space heating fuel shares presented in these exhibits[17] have been selected on the basis that they provide a reasonable fit with:

- General market description (i.e., known distribution of heating appliances by fuel)
- Electricity sales to different categories of homes.

The market share of electricity for space heating is a combination of the fuel shares shown in the exhibits below and the relative numbers of dwellings in the electric category and the non-electric category. For example, Exhibit 2.15 shows 94% of the space heating energy in electrically-heated homes is supplied by electricity (the rest is assumed to be provided by auxiliary heating sources such as wood stoves. As shown earlier in Exhibit 2.1, 98% of single-family dwellings in the Labrador Interconnected service region are in the electrically heated category. Therefore, the assumption used for market share of electric heat in single-family dwellings in the Labrador Interconnected service region is 98% x 94% = 92%. The market share of electricity for both space heating and water heating is very high in the Labrador Interconnected service region, largely due to the very low retail price of electricity.

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[17] Adjustment of fuel shares for space heating was done in tandem with the adjustment of space heating loads described in Section 2.4 above.

## Exhibit 2.14: Electricity Fuel Shares for the Island and Isolated in 2006, (%)

| Dwelling Type | Space Heating | Ventilation | DHW | Cooking | Refrigerator | Freezer | Dishwasher | Clothes washer | Clothes dryer | Lighting | Computer etc. | Television | TV peripherals | Other electronics | Small apps & Other |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Single Family Detached, Electric Heat | 95% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% |
| Single Family Detached, Non-Electric Heat | 4% | 100% | 63% | 98% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% |
| Attached, Electric Heat | 95% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% |
| Attached, Non-Electric Heat | 4% | 100% | 25% | 98% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% |
| Apartment, Electric Heat | 95% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% |
| Apartment, Non-Electric Heat | 4% | 100% | 56% | 98% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% |
| Isolated | 5% | 100% | 83% | 98% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% |
| Other | 52% | 100% | 50% | 98% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% |

## Exhibit 2.15: Electricity Fuel Shares for Labrador Interconnected in 2006, (%)

| Dwelling Type | Space Heating | Ventilation | DHW | Cooking | Refrigerator | Freezer | Dishwasher | Clothes washer | Clothes dryer | Lighting | Computer etc. | Television | TV peripherals | Other electronics | Small apps & Other |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Single Family Detached, Electric Heat | 94% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% |
| Single Family Detached, Non-Electric Heat | 0% | 100% | 99% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% |
| Attached, Electric Heat | 94% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% |
| Attached, Non-Electric Heat | 0% | 100% | 99% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% |
| Apartment, Electric Heat | 94% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% |
| Apartment, Non-Electric Heat | 0% | 100% | 99% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% |
| Other | 100% | 100% | 99% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% |

## 2.8 AVERAGE ELECTRICITY USE PER UNIT

Exhibits 2.16 and 2.17 combine the building stock, efficiency, saturation and fuel share data presented in the preceding exhibits and show the resulting electricity use, by end use, for each dwelling type in, respectively, the Island and Isolated and Labrador Interconnected service regions.

**Exhibit 2.16: Average Electricity Use per Dwelling Unit for the Island and Isolated Service Region in 2006, (kWh/yr.)**

| Dwelling Type | Space Heating | Ventilation | DHW | Cooking | Refrigerator | Freezer | Dishwasher | Clothes washer | Clothes dryer | Lighting | Computer etc. | Television | TV peripherals | Other electronics | Small apps & Other | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Single Family Detached, Electric Heat | 11,956 | 121 | 3,301 | 634 | 985 | 703 | 36 | 64 | 787 | 1,515 | 305 | 430 | 358 | 235 | 902 | **22,330** |
| Single Family Detached, Non-Electric Heat | 621 | 800 | 2,085 | 622 | 985 | 703 | 36 | 64 | 787 | 1,515 | 305 | 430 | 358 | 235 | 902 | **10,446** |
| Attached, Electric Heat | 10,835 | 110 | 2,991 | 539 | 1,006 | 482 | 23 | 46 | 564 | 1,373 | 328 | 417 | 346 | 227 | 428 | **19,716** |
| Attached, Non-Electric Heat | 563 | 725 | 743 | 529 | 1,006 | 482 | 23 | 46 | 564 | 1,373 | 328 | 417 | 346 | 227 | 428 | **7,800** |
| Apartment, Electric Heat | 5,469 | 55 | 2,239 | 378 | 567 | 185 | 7 | 23 | 263 | 693 | 226 | 296 | 246 | 161 | 135 | **10,944** |
| Apartment, Non-Electric Heat | 214 | 275 | 1,258 | 370 | 567 | 185 | 7 | 23 | 263 | 693 | 226 | 296 | 246 | 161 | 135 | **4,920** |
| Isolated | 615 | 118 | 2,740 | 778 | 541 | 958 | 17 | 54 | 697 | 1,483 | 132 | 274 | 227 | 149 | 883 | **9,666** |
| Other | 4,215 | 48 | 264 | 0 | 33 | 26 | 0 | 3 | 33 | 1,211 | 0 | 7 | 6 | 4 | 2,884 | **8,734** |

**Exhibit 2.17: Average Electricity Use per Dwelling Unit for Labrador Interconnected Service Region in 2006, (kWh/yr.)**

| Dwelling Type | Space Heating | Ventilation | DHW | Cooking | Refrigerator | Freezer | Dishwasher | Clothes washer | Clothes dryer | Lighting | Computer etc. | Television | TV peripherals | Other electronics | Small apps & Other | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Single Family Detached, Electric Heat | 27,616 | 121 | 3,961 | 633 | 824 | 680 | 46 | 60 | 770 | 1,818 | 236 | 314 | 261 | 171 | 902 | **38,412** |
| Single Family Detached, Non-Electric Heat | 1,954 | 800 | 3,921 | 633 | 824 | 680 | 46 | 60 | 770 | 1,818 | 236 | 314 | 261 | 171 | 902 | **13,389** |
| Attached, Electric Heat | 25,656 | 112 | 3,680 | 488 | 736 | 635 | 38 | 47 | 601 | 1,689 | 250 | 303 | 252 | 165 | 428 | **35,082** |
| Attached, Non-Electric Heat | 1,815 | 743 | 3,643 | 488 | 736 | 635 | 38 | 47 | 601 | 1,689 | 250 | 303 | 252 | 165 | 428 | **11,835** |
| Apartment, Electric Heat | 8,220 | 36 | 2,687 | 378 | 420 | 216 | 8 | 24 | 286 | 832 | 66 | 252 | 209 | 137 | 135 | **13,907** |
| Apartment, Non-Electric Heat | 437 | 179 | 2,660 | 378 | 420 | 216 | 8 | 24 | 286 | 832 | 66 | 252 | 209 | 137 | 135 | **6,240** |
| Other | 5,411 | 11 | 144 | 0 | 8 | 6 | 0 | 1 | 8 | 335 | 0 | 2 | 1 | 1 | 747 | **6,675** |

## 2.9 SUMMARY OF MODEL RESULTS

This section presents the results of the model runs for the Base Year 2006. The results are measured at the customer's point-of-use and do not include line losses; they are presented in four separate exhibits:

- Exhibits 2.18 and 2.19 present the model results for the Island and Isolated service region. The results are broken out by dwelling type and end use.
- Exhibits 2.20 and 2.21 present the model results for the Labrador Interconnected service region. The results are broken out by dwelling type and end use.

### ❑ By Dwelling Type

Single detached dwellings account for the overwhelming majority of residential electricity use in both service regions: approximately 81% of residential electricity consumed in the Island and Isolated service region and 73% in the Labrador Interconnected service region.

In the Island and Isolated service region, the remaining electricity use is in attached dwellings (11%) followed by apartments (6%). Isolated and other residential buildings each account for about 1%.

In the Labrador Interconnected service region, the remaining electricity use is in attached dwellings (22%) followed by apartments (2%). Other residential buildings account for the remaining electricity use (2%).

### ❑ By End Use

Space heating accounts for the largest share of residential electricity use in both service regions: approximately 41% of residential electricity consumed in the Island and Isolated service region and 71% in the Labrador Interconnected service region. The larger space heating share in the Labrador Interconnected service region is due to the colder climate and the very high share of heating load met by electricity. The large electric space heating share reflects the low electricity prices in that region.

DHW is the second largest electricity end use in both service regions: approximately 17% of residential electricity consumed in the Island and Isolated service region and 11% in the Labrador Interconnected service region.

In the Island and Isolated service region, other significant end uses include lighting (9%) and refrigerators (6%). The electronic end uses (computers, televisions and peripherals, other electronics) combined account for approximately 8% of residential electricity use.

In the Labrador Interconnected service region, other significant end uses include lighting (5%), refrigerators (2%), freezers (2%) and cooking (2%). The electronic end uses (computers, televisions and peripherals, other electronics) combined account for approximately 3% of residential electricity use.

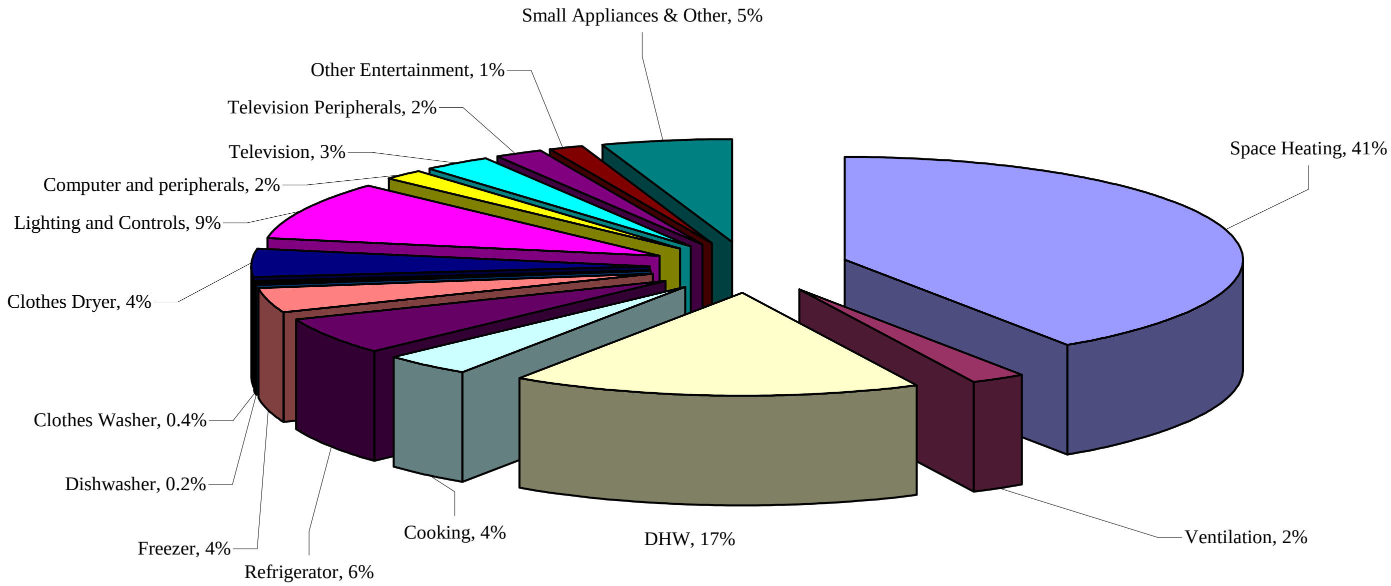
**Exhibit 2.18: Electricity Consumption for the Island and Isolated Service Region, Modelled by End Use and Segment in the Base Year (2006), (GWh/yr.)[18]**

| Dwelling Type | Milestone Year | Residential | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Total | Space Heating | Ventilation | DHW | Cooking | Refrigerator | Freezer | Dishwasher | Clothes Washer | Clothes Dryer | Lighting and Controls | Computer and peripherals | Television | Television Peripherals | Other Entertainment | Small Appliances & Other |
| Single-Family | 2006 | 2,569 | 1,006 | 69 | 420 | 97 | 152 | 109 | 6 | 10 | 122 | 234 | 47 | 67 | 55 | 36 | 139 |
| Attached | 2006 | 340 | 168 | 5 | 49 | 11 | 20 | 10 | 0.5 | 1 | 11 | 28 | 7 | 8 | 7 | 5 | 9 |
| Apartment | 2006 | 193 | 90 | 2 | 40 | 7 | 11 | 4 | 0.1 | 0 | 5 | 13 | 4 | 6 | 5 | 3 | 3 |
| Isolated | 2006 | 34 | 2 | 0.4 | 10 | 3 | 2 | 3 | 0.1 | 0 | 2 | 5 | 0.5 | 1 | 1 | 1 | 3 |
| Other | 2006 | 31 | 15 | 0.2 | 1 | 0.0 | 0.1 | 0.1 | 0.00 | 0.01 | 0.1 | 4 | 0 | 0.02 | 0.02 | 0.01 | 10 |
| TOTAL | 2006 | 3,166 | 1,281 | 77 | 520 | 118 | 186 | 125 | 6 | 11 | 141 | 285 | 59 | 82 | 68 | 44 | 164 |

*Note: Any differences in totals are due to rounding.*

[18] Electricity consumption in this exhibit does not include the "vacant and partially occupied" category of dwellings. Consumption data for the vacant and partial group must be added to these figures to obtain a total that matches the Utilities' forecast data.

**Exhibit 2.19: Distribution of Electricity Consumption, by End Use in the Base Year (2006) for the Island and Isolated Service Region**



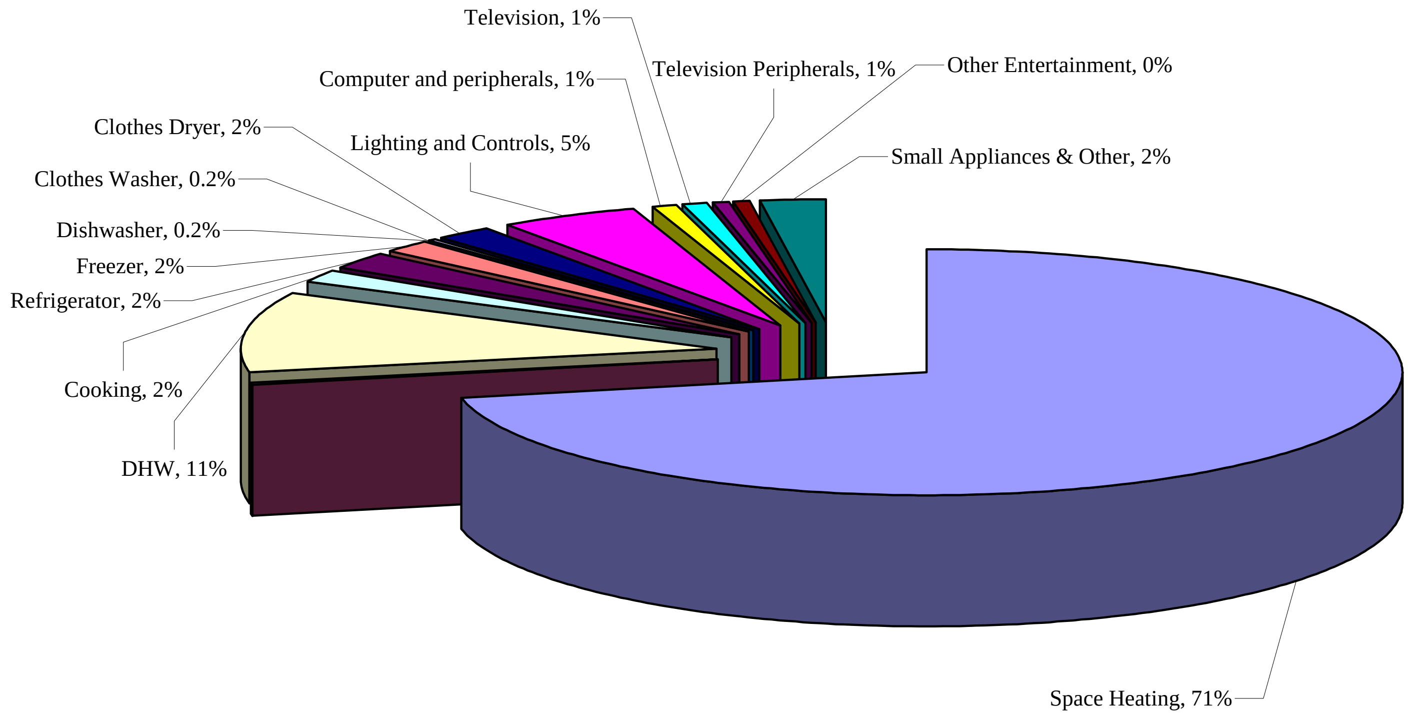

*Totals may not add to 100% due to rounding.*

**Exhibit 2.20: Electricity Consumption for the Labrador Interconnected Service Region, Modelled by End Use and Segment in the Base Year (2006), (GWh/yr.)**

| Dwelling Type | Milestone Year | Residential | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Total | Space Heating | Ventilation | DHW | Cooking | Refrigerator | Freezer | Dishwasher | Clothes Washer | Clothes Dryer | Lighting and Controls | Computer and peripherals | Television | Television Peripherals | Other Entertainment | Small Appliances & Other |
| Single-Family | 2006 | 195 | 139 | 1 | 20 | 3 | 4 | 3 | 0.2 | 0.3 | 4 | 9 | 1 | 2 | 1 | 1 | 5 |
| Attached | 2006 | 59 | 43 | 0.2 | 6 | 1 | 1 | 1 | 0.1 | 0.1 | 1 | 3 | 0.4 | 1 | 0.4 | 0.3 | 1 |
| Apartment | 2006 | 6 | 4 | 0.02 | 1 | 0.2 | 0.2 | 0.1 | 0.004 | 0.01 | 0.1 | 0.4 | 0.03 | 0.1 | 0.1 | 0.1 | 0.1 |
| Other | 2006 | 4.0 | 3.3 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.5 |
| TOTAL | 2006 | 264 | 189 | 1 | 28 | 4 | 6 | 5 | 0.3 | 0.4 | 5 | 13 | 2 | 2 | 2 | 1 | 6 |

*Note: Any differences in totals are due to rounding.*

**Exhibit 2.21: Distribution of Electricity Consumption, by End Use in the Base Year (2006) for the Labrador Interconnected Service Region**




*Totals may not add to 100% due to rounding.*

# 3. REFERENCE CASE ELECTRICITY USE

## 3.1 INTRODUCTION

This section presents the Residential sector Reference Case for the study period (2006 to 2026). The Reference Case estimates the expected level of electricity consumption that would occur over the study period in the absence of new utility-based CDM initiatives. The forecast data provided were based on a set of assumptions that include future rate changes. The Reference Case includes the same assumption and it becomes part of the environment in which conservation potential will be evaluated. The Reference Case, therefore, provides the point of comparison for the calculation of electricity-savings opportunities associated with each of the scenarios that are assessed within this study.

The Reference Case discussion is presented within the following sub sections:

- Estimation of Net Space Heating Loads—New Dwellings
- "Natural" Changes to Space Heating Loads—Existing Dwellings
- "Natural" Changes to Electric Appliance UECs
- Appliance Saturation Trends
- Stock Growth
- Fuel Shares
- Summary of Model Results.

## 3.2 ESTIMATION OF NET SPACE HEATING LOADS—NEW DWELLINGS

The first task in building the Reference Case involved the development of estimates of the net space heating loads for new dwellings to be built over the study period. As was the case with the existing building stock, the study relied on several sources to prepare these estimates, including:

- Estimated household electricity consumption levels contained in the NLH Long Term Planning Review Forecast, Summer/Fall 2006
- Consultation with housing experts in Newfoundland and Labrador
- Review of experience in other jurisdictions.

Based on consideration of the best available data from the above sources, this study assumes that the net space heating loads in new dwellings remain the same as for the existing dwellings. This conclusion recognizes that while thermal efficiencies are improving in new dwellings, they are being partially, or wholly, offset by changing construction practices.

Examples of these off-setting trends include:

- Overall, window, wall and roofing thermal efficiency levels have increased in new residential buildings and air leakage rates have been reduced by more than 40% compared to typical existing dwellings.

- The amount of window area in new houses has increased by up to 20% compared to typical existing homes.

- The new stock tends to have floor areas that are 15%-20% larger, on average.

- Buildings also feature an increase in exterior wall surface area of between 5%-20%. This reflects both the increased floor area and a tendency for homes to include architectural features with more corners and details that diverge from the standard rectangular shapes.

Exhibit 3.1 summarizes the resulting new net space heating loads.

**Exhibit 3.1: New Residential Units—Net Space Heating Loads[19] by Dwelling Type and Service Region, (kWh/yr.)[20]**

| Dwelling Type | Island and Isolated | Labrador Interconnected |
|---|---|---|
| Single Family Detached, Electric Heat | 12,554 | 29,966 |
| Single Family Detached, Non-Electric Heat | 16,700 | 39,863 |
| Attached, Electric Heat | 11,377 | 27,840 |
| Attached, Non-Electric Heat | 15,134 | 37,035 |
| Apartment, Electric Heat | 5,742 | 8,920 |
| Apartment, Non-Electric Heat | 5,742 | 8,920 |
| Isolated | 12,293 | N/A |
| Other | 10,036 | 5,630 |

### 3.2.1 Development of Thermal Archetypes – New Stock

Although the study assumes that the net space heating loads remain approximately the same for both new and existing dwellings, the physical and thermal specifications of the new dwellings differ from the existing dwellings. Thus, as in the Base Year discussion, a thermal archetype for each of the major new dwelling types was developed using HOT2000.

For the new housing stock, archetypes were created for the two primary dwelling types in each service region: single-family detached and attached. A brief description of each housing archetype is provided below.

- ❑ **Single-family Dwellings**

For the Island and Isolated service region, a "typical" existing, single-detached dwelling can be defined as a single-story bungalow of approximately 110 $m^2$ (1184 $ft^2$) with an unheated basement. This home has 9.6 $m^2$ (103 ft2) of windows, defined as double-glazed, mostly with vinyl frames. Walls are represented by RSI-3.0 (R-17) insulation values, ceilings RSI-5.5 (R-31) and no basement insulation. The houses are reasonably

[19] Net space heating load is the space heating load of a building that must be met by the space heating system over a full year. This is equal to the total heat loss through the building envelope minus solar and internal gains. Values shown for non-electrically heated dwellings are shown in kilowatt hours for format consistency.
[20] Vacant and partially-occupied dwelling units are not shown in this exhibit.

airtight with about 2.87 air changes per hour (ac/h) at 50 Pascal (Pa) depressurization. Typically, there is no central ventilation system.

For the Labrador Interconnected service region, a "typical" existing, single-detached dwelling can be defined as a single-story bungalow of approximately 110 $m^2$ (1184 $ft^2$) with a heated basement. This home has 9.6 $m^2$ (103 $ft^2$) of windows, defined as double-glazed, mostly with wood or vinyl frames. Walls are represented by RSI-3.0 (R-17) insulation values, ceilings RSI-5.5 (R-31) and there is no insulation in the basement. The houses are typically not very airtight with about 4.55 air changes per hour (ac/h) at 50 Pascal (Pa) depressurization. Typically, there is no central ventilation system.

- **Attached Dwellings**

For the Island and Isolated service region, a "typical" existing attached dwelling can be defined as a two-story home of approximately 130 $m^2$ (1400 $ft^2$) with an unheated basement. This home has 9.6 $m^2$ (103 $ft^2$) of windows, defined as double-glazed, mostly with vinyl frames. Walls are represented by RSI-3.0 (R-17) insulation values, ceilings RSI-5.5 (R-31) and there is no basement insulation. The houses are average in terms of air tightness with about 3.57 air changes per hour (ac/h) at 50 Pascal (Pa) depressurization. Typically, there is no central ventilation system.

For the Labrador Interconnected service region, a "typical" existing single-detached dwelling can be defined as a single-story bungalow of approximately 130 $m^2$ (1400 $ft^2$) with a heated basement. This home has 9.6 $m^2$ (103 $ft^2$) of windows, defined as double-glazed, mostly with wood or vinyl frames. Walls are represented by RSI-2.5 (R-14) insulation values, ceilings RSI-5.0 (R-28) and there is no insulation in the basement. The houses are typically not very airtight with about 4.55 air changes per hour (ac/h) at 50 Pascal (Pa) depressurization. Typically, there is no central ventilation system.

## 3.3 "NATURAL" CHANGES TO SPACE HEATING LOADS – EXISTING DWELLINGS

In addition to new dwellings, space heating loads in existing dwellings are also expected to change over the study period. However, no specific data are available and, as outlined in the preceding discussion of new dwellings, contrary trends[21] are occurring. Consequently, this analysis assumes that net space heating loads in existing buildings remain unchanged in the reference case.

Examples of trends that tend to decrease the net space heating loads include:

- Insulation and other improvements that occur when renovation projects are undertaken
- Replacement of old windows with new models that provide comfort and aesthetic benefits as well as improved energy efficiency
- Installation of more efficient thermostatic controls.

[21] Replacement of the heating equipment itself is not one of these factors, first, because it does not actually change the net heating load and second, because electric space heating in Newfoundland and Labrador is mainly done with baseboard strip, already at 100% efficiency.

Examples of trends that tend to increase net space heating loads include:

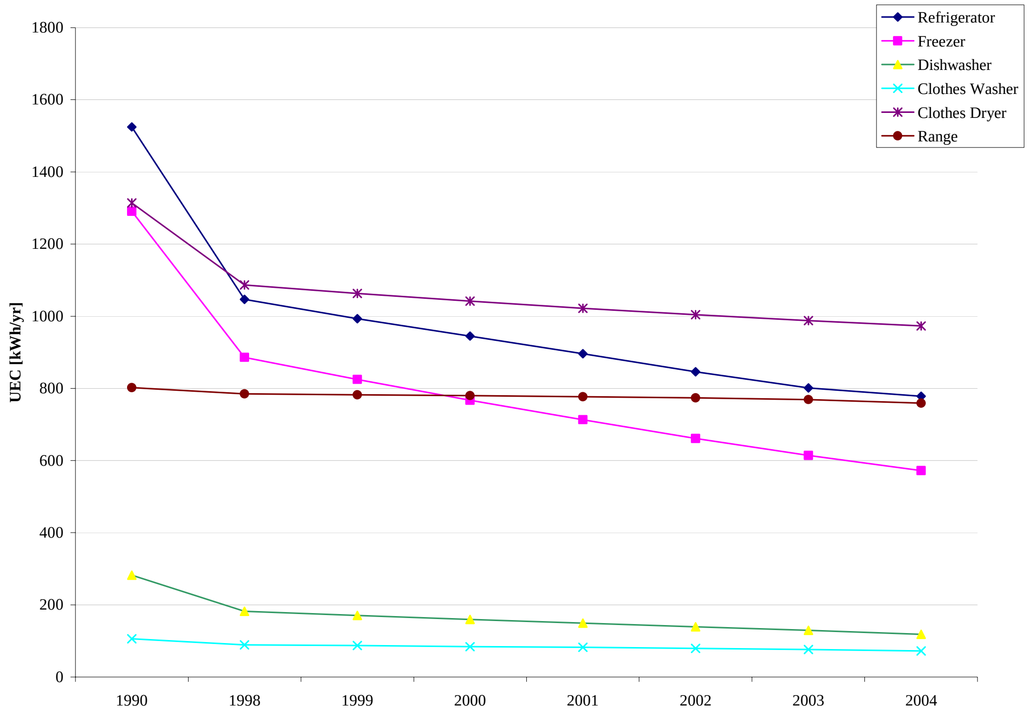
- Enlargement of houses with additions
- Reductions in internal gains due to more efficient appliances and lights.

## 3.4 "NATURAL" CHANGES TO ELECTRIC APPLIANCE UECS

This section identifies the annual unit electricity consumption (UEC) for the major household appliances and equipment for both "stock in place" and new sales for the period 2006 to 2026.

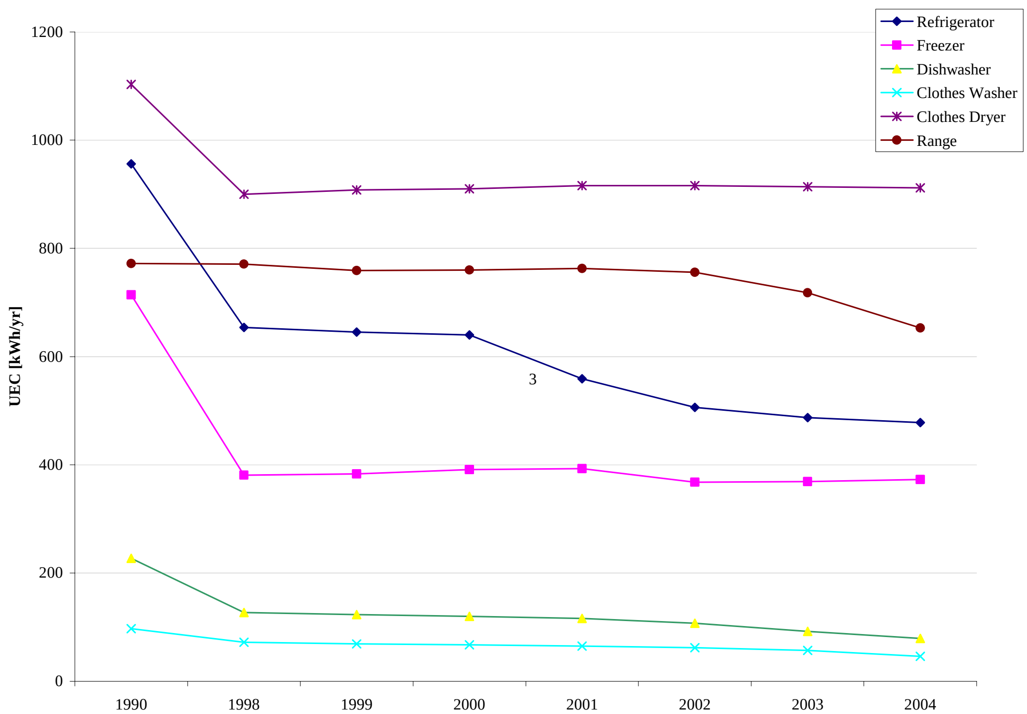
Exhibits 3.2 and 3.3 show Canadian trend information for both the existing stock and new sales of white goods for the period 1990 to 2004.

## Exhibit 3.2: Canadian White Goods UECs for Existing Stock




*Source: NRCan, Energy Efficiency Trends in Canada 1990 and 1998–2004, August 2006.*

## Exhibit 3.3: Canadian White Goods UECs for New Sales




*Source: NRCan, Energy Efficiency Trends in Canada 1990 and 1998–2004, August 2006.*

As shown in Exhibit 3.2, the annual UEC for major household white good type appliances in existing stock declined steadily between 1990 and 2000, due to stock turnover and to continuing improvements in new stock. However, as shown in Exhibit 3.3, the majority of efficiency improvements to large electrical appliances took place in the early to mid 1990s with the trend line levelling off after that for most appliances (except refrigerators and ranges, which show further improvement post 2000). In the future, federal energy-efficiency regulations will continue to regulate additional appliances and to revise existing regulations, suggesting that additional minor improvements in the UECs for new white goods will take place.

Further discussion of the modelled assumptions applied to each of the major appliances follows.

*Note: Assumptions for cooking appliances, refrigerators, freezers, dishwashers, clothes washers and clothes dryers are based on appliance energy use trend data compiled by Natural Resources Canada and reported in Energy Efficiency Trends in Canada 1990 and 1998–2004 (NRCan, August 2006) and Marbek's Appliance Replacement Model.*

- **Cooking**

A UEC, which includes both ranges and microwave ovens, of 770 kWh/yr. is assumed in the Base Year, adjusted for occupancy and region declining to 730 kWh/yr. in the final milestone year. In new stock, the UEC was assumed to decrease from 750 kWh/yr. to 700 kWh/yr.

- **Refrigerator**

A UEC of 830 kWh/yr. is assumed in the Base Year, adjusted for occupancy and service region declining to 510 kWh/yr. in the final milestone year. In new stock, the UEC was assumed to decrease from 680 kWh/yr. to 450 kWh/yr.

- **Freezer**

A UEC of 650 kWh/yr. is assumed in the Base Year, adjusted for occupancy and service region declining to 480 kWh/yr. in the final milestone year. In new stock, the UEC was assumed to decrease from 560 kWh/yr. to 420 kWh/yr.

- **Dishwasher**

A UEC of 92 kWh/yr. is assumed in the Base Year, adjusted for occupancy and region declining to 83 kWh/yr. in the final milestone year. In new stock, the UEC was assumed to decrease from 88 kWh/yr. to 81 kWh/yr.

The values shown are for mechanical energy only; hot water use is included with the DHW UEC.

- **Clothes Washer**

A UEC of 78 kWh/yr. is assumed in the Base Year, adjusted for occupancy and region declining to 71 kWh/yr. in the final milestone year. In new stock, the UEC was assumed to decrease from 75 kWh/yr. to 68kWh/yr.

The values shown are for mechanical energy only; hot water use is included with the DHW UEC.

- **Clothes Dryer**

A UEC of 1,000 kWh/yr. is assumed in the Base Year, adjusted for occupancy and region declining to 850 kWh/yr. in the final milestone year. In new stock, the UEC was assumed to decrease from 940 kWh/yr. to 800 kWh/yr.

- **Ventilation**

Ventilation energy in existing stock is assumed to remain constant. This assumption recognizes that there are a number of competing trends that remain unresolved at this time. On the one hand, there is a trend towards manufacturers' use of larger fan motors (1/2-HP versus 1/3-HP) in new oil and propane furnaces. This means that furnaces replaced in the study period may have a larger furnace fan motor. However, the trend towards larger fan motors is at least partially offset by efficiency improvements. For example, an earlier study for the Canadian Electricity Association (CEA) noted that improved fan design, combined with the use of permanent split capacitor fan motors, had improved furnace fan efficiency by between 13% and 19%.[22]

In new stock, average ventilation energy was assumed to increase to around 450 kWh/yr. from the current average of approximately 340 kWh/yr. This value was based on the HOT2000 modelled results and assumes compliance with municipal building codes. Building codes in Newfoundland and Labrador are based on the National Building Code (for example, the St. John's building bylaw references the 2005 edition of the National Building Code).

- **Domestic Hot Water**

Exhibit 3.4 summarizes DHW UECs by end use for new dwellings. A comparison with the values presented previously for existing dwellings (see Section 2) shows significant reductions for hot water use in dishwashing and clothes washing; however, slightly more modest changes have been assumed for personal consumption.

DHW electricity for new and existing appliances is obtained from NRCan (NRCan, 2005), augmented by results from conditional demand analysis and customer survey work done by both NP and NLH in the 1990s. For existing and retrofitted buildings, the DHW UEC is assumed to

[22] Phillips, B. Blower. *Efficiency in Domestic Heating Systems*, CEA Report No. 9202-U-921, 1995 and *Optimizing Heat and Air Distribution Systems when Retrofitting Houses with Energy Efficient Equipment*, Canada Mortgage and Housing Corporation, 2002. Ventilation UECs will be higher in dwellings that have air conditioning and/or continuous ventilation.

decrease by 0.2% per year based on data from NRCan.[23] The UEC for DHW in new buildings is assumed to be constant.

**Exhibit 3.4: Distribution of DHW Electricity Use by End Use in New Stock, (kWh/yr.)**

| End Use | Sample Electricity Use Single Family Detached (kWh/yr.) | % |
|---|---|---|
| Personal Use | 1,075 | 38 |
| Dishwashing | 600 | 21 |
| Clothes Washing | 750 | 26 |
| Standby Losses | 425 | 15 |
| Total | 2,850 | 100 |

## ❑ Lighting

The lighting UEC was assumed to decrease at a rate of 0.2% per year. This value is based on the results of analysis undertaken by Natural Resources Canada and reported in their *Energy End Use Data Handbook* (NRCan, June 2005).

## ❑ Televisions

The North American television industry has announced its commitment to convert all analog television to digital broadcasting within the next five years. These broadcast changes are occurring at a time when television technology and programming options are also rapidly changing. Some television technology changes, such as the introduction of liquid crystal display (LCD) and plasma models, may also have significant impacts on household electricity consumption. It is also possible that these changes will result in an increased rate of turnover in the current stock of televisions to models that are better able to take advantage of the high definition (HD) digital signal.

LCD is expected to become the dominant television technology by 2010, capturing approximately 57% of sales in that year. Although LCD screens typically use less electricity on a per inch basis, consumers typically choose screens that are larger when purchasing an LCD screen compared to cathode ray tube screens (CRTs). The most popular television on the market today is the 27” CRT but this is expected to shift within the next five years to the 32” LCD television. This trend has the effect of reducing the electricity advantage that would be gained from a direct switch to the new LCD technology.

In addition to the increase in screen size, HD television models typically consume more power than equivalent standard definition televisions for all technology types. Since the trend with televisions is towards HD sets with greater resolution, television unit electricity use is expected to increase in the future.

[23] Natural Resources Canada. *Energy Efficiency Trends in Canada*, 1990–2000, June 2002.

The growing popularity of larger and higher resolution screens means that, by 2010, national television electricity consumption is expected to grow by 40% to 45%.

In light of these changes, UECs for televisions are assumed to increase from 178 kWh/yr. to 250 kWh/yr. over the study period. These assumptions are based on market and energy use data collected as part of a 2006 study *Technology and Market Profile: Consumer Electronics.*[24]

❑ **Television Peripherals**

One implication of the pending changes towards digital television broadcasting is that new signal adaptors, commonly referred to as set-top boxes (STBs), will need to be added to nearly two-thirds of Canadian households to receive a television signal.

Industry representatives estimate that each Canadian subscriber household has, on average, 1.5 set-top boxes.[25] They also note that the trend is towards a greater number of STBs per household and, by 2010, the industry estimates that the average will have increased to approximately two STBs per subscriber household.

When complete, the switch to digital broadcasting is expected to increase national STB electricity consumption by up to four times its current level due to the added requirement for STBs among those televisions currently operating on analog cable or over-the-air broadcast signals. Moreover, within these STBs, the most significant trend is towards greater functionality, which is directly associated with further increases in unit electricity consumption.

In light of these changes, UECs for television peripherals are assumed to increase from 220 kWh/yr. to 310 kWh/yr. over the study period.[26]

❑ **Computers and Peripherals**

Electricity consumption for personal computers is expected to increase despite the move to more energy-efficient flat screen technology. This is due in part to the growing preference for larger screens but mainly due to a trend towards longer operating hours both in full operating mode and in idle mode. There is also a move towards increasing numbers and functionality of computer peripherals, further increasing consumption.

UECs for personal computers and their peripherals are assumed to increase from 390 kWh/yr. to 560 kWh/yr. over the study period.

❑ **Other Electronics**

As functionality increases, other entertainment devices, such as computer games and music systems are becoming more powerful. For example, the new PlayStation 3 games console uses 360 Watts compared to its predecessor, which uses only 45 Watts. One of the selling features of

[24] Marbek Resource Consultants. *Technology and Market Profile: Consumer Electronics*, September 2006.
[25] Ibid.
[26] Ibid.

the Nintendo Wii and other next generation products is that they can be left on-line for 24 hours a day.

UECs for other electronics are assumed to increase from 160 kWh/yr. to 190 kWh/yr. over the study period.

❑ **Small Appliances and Other**

The UECs for the small appliances and other categories increase over the study period in anticipation of new end uses, but there is considerable uncertainty in the amount of this increase.

Based on the changes observed in previous studies, new end uses are constantly emerging, some of which are substantial consumers of electricity. One example is electric vehicle charging. Electric cars and plug-in hybrids could achieve substantial penetration by the end of the study period; charging of a typical electric vehicle would require approximately 7,000 kWh/yr.[27]

## 3.5 APPLIANCE SATURATION TRENDS

To develop estimates of the future saturation of residential equipment, references from NLH were reviewed along with data on trends in the increasing use of entertainment-based electronics.

The saturation of most end-use appliances has remained relatively constant in recent years, suggesting that further changes to saturations are unlikely within the study period. There are two main exceptions:[28] computers and television peripherals. Based on current trends and industry data,[29] the following assumptions have been incorporated into the Reference Case.

- Computer saturation levels increase by approximately 60% over the study period
- Television peripherals saturation levels increase by more than 100%.

## 3.6 STOCK GROWTH

The next step in developing the Reference Case involved the development and application of estimated levels of growth in each dwelling type and service region over the study period. The number of dwelling units, by type and service region were provided by NLH and match exactly those contained in NLH Long Term Planning (PLF) Review Forecast, Summer/Fall 2006.

Exhibit 3.5 presents a summary of the resulting percentage stock growth, by year and dwelling type in each service region.

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[27] California EPA, Air Resources Board. *Fact Sheet: Battery Electric Vehicles*, Sacramento, CA, 2003, http://www.arb.ca.gov/msprog/zevprog/factsheets/evinformation.pdf.

[28] Some increase in space cooling saturation levels may also occur over the 20-year period and it may become material by the end of the period; however, based on client discussions it was agreed that residential space cooling consumption would experience minimal predicted growth with considerable uncertainty in that growth, and therefore it has not been addressed separately.

[29] Op. cit. *Technology and Market Profile: Consumer Electronics.*

### Exhibit 3.5: Residential Stock Growth Rates by Service Region, 2011 to 2026,

| Region and Period | Electric Accounts | | | | | Non-Electric Accounts | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Single Family | Attached | Apart ment | Isolated | Other | Single Family | Attached | Apart ment | Isolated | Other |
| **Island and Isolated** | | | | | | | | | | |
| 2006-2011 | 1.5% | 1.5% | 1.5% | 0.6% | 0.4% | 0.1% | 0.1% | 0.1% | 0.6% | 0.4% |
| 2011-2016 | 1.2% | 1.2% | 1.2% | 0.5% | 0.3% | 0.1% | 0.1% | 0.1% | 0.5% | 0.3% |
| 2016-2021 | 1.1% | 1.1% | 1.1% | 0.5% | 0.2% | -0.1% | -0.1% | -0.1% | 0.5% | 0.2% |
| 2021-2026 | 1.1% | 1.1% | 1.1% | 0.5% | 0.1% | -0.2% | -0.2% | -0.2% | 0.5% | 0.1% |
| **Labrador Interconnected** | | | | | | | | | | |
| 2006-2011 | 0.7% | 0.7% | 0.7% | N/A | 0.7% | 0.0% | 0.0% | 0.0% | N/A | 0.0% |
| 2011-2016 | 0.5% | 0.5% | 0.5% | N/A | 0.5% | 0.0% | 0.0% | 0.0% | N/A | 0.0% |
| 2016-2021 | 0.5% | 0.5% | 0.5% | N/A | 0.5% | 0.6% | 0.6% | 0.0% | N/A | 0.0% |
| 2021-2026 | 0.5% | 0.5% | 0.5% | N/A | 0.5% | 0.6% | 0.6% | 0.0% | N/A | 0.0% |

## 3.7 FUEL SHARES

The only change in fuel shares assumed in the study period is the relative growth in electrically heated versus non-electrically heated dwellings. No changes are assumed in the fuel shares for any of the other end uses.

## 3.8 SUMMARY OF MODEL RESULTS

This section presents the results of the model runs for the entire study period. The results are measured at the customer's point-of-use and do not include line losses. They are presented in two exhibits:

- Exhibits 3.6 and 3.7 present the model results for the Island and Isolated service region. The results are broken out by dwelling type, end use and milestone year.
- Exhibits 3.8 and 3.9 present the model results for the Labrador Interconnected service region. The results are broken out by dwelling type, end use and milestone year.

Selected highlights of electricity use in 2026 are provided below.

❑ **By Dwelling Type**

Single-family detached dwellings continue to account for the overwhelming majority of total residential electricity consumption in both the Island and Isolated (79%) and the Labrador Interconnected (74%) service regions.

❑ **By End Use**

Space heating continues to account for the largest share of residential electricity use in both service regions (41% in Island and Isolated and 71% in Labrador Interconnected), followed by DHW (15% in Island and Isolated and 9% in Labrador Interconnected).

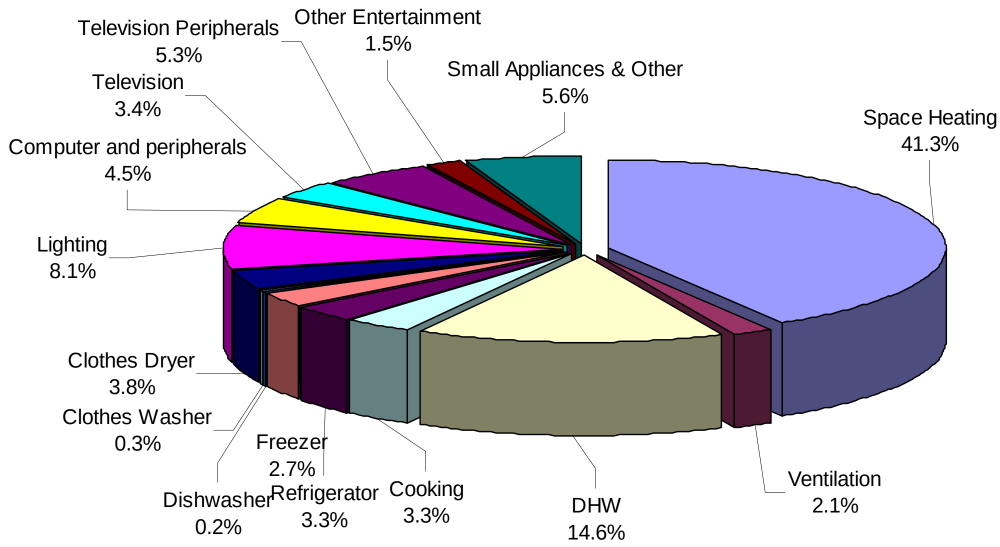
The most notable increase in electricity consumption occurs in the group of electronic end uses represented by televisions, television peripherals, computers and other entertainment. By 2026, these combined end uses are expected to account for approximately 15% of residential electricity use in the Island and Isolated service region and 6% in the Labrador Interconnected service region.

**Exhibit 3.6: Reference Case Electricity Consumption for the Island and Isolated Service Region, Modelled by End Use, Dwelling Type and Milestone Year (GWh/yr.)**

| Dwelling Type | Milestone Year | Residential | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Total | Space Heating | Ventilation | DHW | Cooking | Refrigerator | Freezer | Dishwasher | Clothes Washer | Clothes Dryer | Lighting | Computer and peripherals | Television | Television Peripherals | Other Entertainment | Small Appliances & Other |
| Single Family | 2006 | 2,569 | 1,006 | 69 | 420 | 97 | 152 | 109 | 6 | 10 | 122 | 234 | 47 | 67 | 55 | 36 | 139 |
| | 2011 | 2,757 | 1,076 | 70 | 431 | 99 | 136 | 104 | 6 | 10 | 123 | 241 | 69 | 87 | 112 | 39 | 152 |
| | 2016 | 2,873 | 1,139 | 72 | 439 | 101 | 125 | 100 | 6 | 10 | 125 | 247 | 91 | 94 | 119 | 42 | 166 |
| | 2021 | 3,016 | 1,211 | 72 | 446 | 103 | 114 | 95 | 6 | 10 | 125 | 252 | 114 | 100 | 144 | 45 | 179 |
| | 2026 | 3,125 | 1,264 | 73 | 452 | 104 | 103 | 90 | 6 | 10 | 126 | 256 | 141 | 108 | 152 | 48 | 193 |
| Attached | 2006 | 340 | 168 | 5 | 49 | 11 | 20 | 10 | 0 | 1 | 11 | 28 | 7 | 8 | 7 | 5 | 9 |
| | 2011 | 377 | 180 | 6 | 52 | 11 | 18 | 10 | 0 | 1 | 12 | 29 | 10 | 11 | 23 | 5 | 10 |
| | 2016 | 398 | 191 | 6 | 53 | 12 | 17 | 9 | 0 | 1 | 12 | 30 | 13 | 12 | 25 | 6 | 11 |
| | 2021 | 420 | 201 | 6 | 55 | 12 | 16 | 9 | 1 | 1 | 12 | 31 | 17 | 13 | 28 | 6 | 12 |
| | 2026 | 441 | 212 | 6 | 57 | 12 | 15 | 9 | 1 | 1 | 12 | 32 | 21 | 15 | 30 | 7 | 13 |
| Apartment | 2006 | 193 | 90 | 2 | 40 | 7 | 11 | 4 | 0 | 0 | 5 | 13 | 4 | 6 | 5 | 3 | 3 |
| | 2011 | 218 | 97 | 2 | 42 | 8 | 11 | 4 | 0 | 0 | 5 | 14 | 6 | 8 | 15 | 3 | 3 |
| | 2016 | 233 | 103 | 2 | 43 | 8 | 11 | 4 | 0 | 0 | 5 | 15 | 9 | 8 | 18 | 4 | 3 |
| | 2021 | 250 | 109 | 2 | 45 | 8 | 11 | 4 | 0 | 0 | 6 | 15 | 11 | 9 | 22 | 4 | 4 |
| | 2026 | 264 | 115 | 2 | 46 | 8 | 11 | 3 | 0 | 0 | 6 | 16 | 14 | 10 | 24 | 4 | 4 |
| Isolated | 2006 | 34 | 2 | 0 | 10 | 3 | 2 | 3 | 0 | 0 | 2 | 5 | 0 | 1 | 1 | 1 | 3 |
| | 2011 | 35 | 2 | 0 | 10 | 3 | 2 | 3 | 0 | 0 | 2 | 5 | 1 | 1 | 2 | 1 | 3 |
| | 2016 | 36 | 2 | 0 | 10 | 3 | 2 | 3 | 0 | 0 | 2 | 5 | 1 | 1 | 2 | 1 | 4 |
| | 2021 | 37 | 2 | 0 | 10 | 3 | 1 | 3 | 0 | 0 | 2 | 5 | 1 | 1 | 2 | 1 | 4 |
| | 2026 | 38 | 2 | 0 | 10 | 3 | 1 | 3 | 0 | 0 | 2 | 6 | 1 | 2 | 2 | 1 | 4 |
| Other | 2006 | 31 | 15 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 0 | 0 | 0 | 0 | 10 |
| | 2011 | 32 | 15 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 0 | 0 | 0 | 0 | 11 |
| | 2016 | 33 | 15 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 0 | 0 | 0 | 0 | 12 |
| | 2021 | 34 | 15 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 0 | 0 | 0 | 0 | 12 |
| | 2026 | 34 | 16 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 0 | 0 | 0 | 0 | 13 |
| TOTAL | 2006 | 3,228 | 1,298 | 77 | 530 | 120 | 189 | 128 | 6 | 12 | 144 | 291 | 60 | 83 | 69 | 45 | 175 |
| | 2011 | 3,483 | 1,388 | 79 | 545 | 124 | 170 | 123 | 6 | 12 | 146 | 300 | 87 | 109 | 154 | 49 | 191 |
| | 2016 | 3,637 | 1,467 | 80 | 556 | 126 | 157 | 118 | 7 | 12 | 147 | 307 | 115 | 118 | 167 | 53 | 207 |
| | 2021 | 3,821 | 1,557 | 81 | 566 | 128 | 144 | 112 | 7 | 12 | 149 | 314 | 146 | 126 | 200 | 57 | 224 |
| | 2026 | 3,968 | 1,626 | 82 | 575 | 130 | 132 | 107 | 7 | 12 | 149 | 320 | 180 | 136 | 211 | 61 | 241 |

*Notes: 1) Results are measured at the customer's point-of-use and do not include line losses. 2) Any differences in totals are due to rounding. 3) Rounding reduces many non-zero values in this table to apparent zeroes.*

**Exhibit 3.7: Distribution of Electricity Consumption, by End Use in 2026 for the Island and Isolated Service Region**



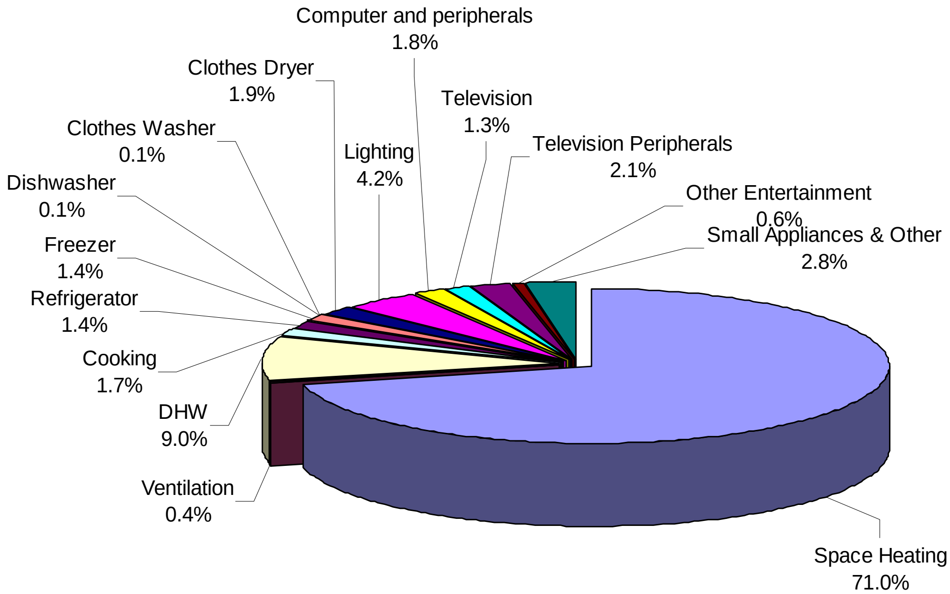

*Totals may not add to 100% due to rounding.*

**Exhibit 3.8: Reference Case Electricity Consumption for the Labrador Interconnected Service Region, Modelled by End Use, Dwelling Type and Milestone Year (GWh/yr.)**

| | | Residential | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Dwelling Type** | **Milestone Year** | **Total** | **Space Heating** | **Ventilation** | **DHW** | **Cooking** | **Refrigerator** | **Freezer** | **Dishwasher** | **Clothes Washer** | **Clothes Dryer** | **Lighting** | **Computer and peripherals** | **Television** | **Television Peripherals** | **Other Entertainment** | **Small Appliances & Other** |
| Single Family | 2006 | 195 | 139 | 1 | 20 | 3 | 4 | 3 | 0 | 0 | 4 | 9 | 1 | 2 | 1 | 1 | 5 |
| | 2011 | 205 | 147 | 1 | 21 | 3 | 4 | 3 | 0 | 0 | 4 | 10 | 2 | 2 | 3 | 1 | 5 |
| | 2016 | 210 | 150 | 1 | 21 | 3 | 3 | 3 | 0 | 0 | 4 | 10 | 2 | 2 | 3 | 1 | 5 |
| | 2021 | 215 | 154 | 1 | 21 | 3 | 3 | 3 | 0 | 0 | 4 | 10 | 3 | 2 | 3 | 1 | 6 |
| | 2026 | 220 | 158 | 1 | 21 | 3 | 3 | 3 | 0 | 0 | 4 | 10 | 4 | 3 | 4 | 1 | 6 |
| | | | | | | | | | | | | | | | | | |
| Attached | 2006 | 59 | 43 | 0 | 6 | 1 | 1 | 1 | 0 | 0 | 1 | 3 | 0 | 1 | 0 | 0 | 1 |
| | 2011 | 62 | 45 | 0 | 6 | 1 | 1 | 1 | 0 | 0 | 1 | 3 | 1 | 1 | 1 | 0 | 1 |
| | 2016 | 64 | 46 | 0 | 6 | 1 | 1 | 1 | 0 | 0 | 1 | 3 | 1 | 1 | 1 | 0 | 1 |
| | 2021 | 65 | 47 | 0 | 6 | 1 | 1 | 1 | 0 | 0 | 1 | 3 | 1 | 1 | 2 | 0 | 1 |
| | 2026 | 67 | 49 | 0 | 6 | 1 | 1 | 1 | 0 | 0 | 1 | 3 | 1 | 1 | 2 | 0 | 1 |
| | | | | | | | | | | | | | | | | | |
| Apartment | 2006 | 6 | 4 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 2011 | 7 | 4 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 2016 | 7 | 4 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 2021 | 7 | 4 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 2026 | 8 | 4 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | | | | | | | | | | | | | | | | |
| Other | 2006 | 4 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 2011 | 4 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 2016 | 4 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| | 2021 | 5 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| | 2026 | 5 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| | | | | | | | | | | | | | | | | | |
| TOTAL | 2006 | 264 | 189 | 1 | 28 | 4 | 6 | 5 | 0 | 0 | 5 | 13 | 2 | 2 | 2 | 1 | 6 |
| | 2011 | 279 | 199 | 1 | 28 | 4 | 5 | 4 | 0 | 0 | 5 | 13 | 2 | 3 | 4 | 1 | 6 |
| | 2016 | 285 | 204 | 1 | 28 | 4 | 5 | 4 | 0 | 0 | 5 | 13 | 3 | 3 | 5 | 1 | 7 |
| | 2021 | 292 | 209 | 1 | 28 | 4 | 4 | 4 | 0 | 0 | 5 | 13 | 4 | 3 | 5 | 1 | 7 |
| | 2026 | 300 | 215 | 1 | 29 | 4 | 4 | 4 | 0 | 0 | 5 | 14 | 5 | 4 | 6 | 2 | 8 |
| | | | | | | | | | | | | | | | | | |

*Notes: 1) Results are measured at the customer's point-of-use and do not include line losses. 2) Any differences in totals are due to rounding. 3) Rounding reduces many non-zero values in this table to apparent zeroes.*

**Exhibit 3.9: Distribution of Electricity Consumption, by End Use in 2026 for the Labrador Interconnected Service Region**




*Totals may not add to 100% due to rounding.*

# 4. CONSERVATION & DEMAND MANAGEMENT (CDM) MEASURES

## 4.1 INTRODUCTION

This section identifies and assesses selected energy-efficiency, fuel switching and peak load reduction measures for the Residential sector. The discussion is organized and presented as follows:

- Methodology for Assessment of Energy-efficiency Measures
- Description of Energy-efficiency Technologies
- Summary of Energy-efficiency Results
- Peak Load Reduction Measures.

## 4.2 METHODOLOGY FOR ASSESSMENT OF ENERGY-EFFICIENCY MEASURES

The following steps were employed to assess the energy-efficiency measures:

- Select candidate energy-efficiency measures
- Establish technical performance for each option within a range of applicable load sizes and/or service region conditions (e.g., degree days)
- Establish the capital, installation and operating costs for each option
- Calculate the cost of conserved energy (CCE) for each technology and O&M measure.

***Step 1 Select Candidate Measures***

The candidate measures were selected in collaboration with the Utilities and from a literature review and previous study team experience. The selected measures are all considered to be technically proven and commercially available, even if only at an early stage of market entry. Technology costs, which will be addressed in this section, were not a factor in the initial selection of candidate technologies.

***Step 2 Establish Technical Performance***

Information on the performance improvements provided by each measure was compiled from available secondary sources, including the experience and on-going research work of study team members.

***Step 3 Establish Capital, Installation and Operating Costs for Each Measure***

Information on the cost of implementing each measure was also compiled from secondary sources, including the experience and on-going research work of study team members.

The incremental cost is applicable when a measure is installed in a new facility, or at the end of its useful life in an existing facility; in this case, incremental cost is defined as the cost difference for the energy-efficiency measure relative to the "baseline" technology. The full cost is applicable when an operating piece of equipment is replaced with a more efficient model prior to the end of its useful life.

In both cases, the costs and savings are annualized, based on the number of years of equipment life and the discount rate, and the costs incorporate applicable changes in annual O&M costs. All costs are expressed in constant (2007) dollars.

***Step 4 Calculate CCE for Each Measure***

One of the important sets of information provided in this section is the CCE associated with each energy-efficiency measure. The CCE for an energy-efficient measure is defined as the annualized incremental cost of the upgrade measure divided by the annual energy savings achieved, excluding any administrative or program costs required to achieve full use of the technology or measure. All cost information presented in this section and in the accompanying tables (see Appendix A) are expressed in constant (2007) dollars.

The CCE provides a basis for the subsequent selection of measures to be included in the Economic Potential Forecast. The CCE is calculated according to the following formula:

$$\frac{C_A + M}{S}$$

Where:

$C_A$ is the annualized installed cost
$M$ is the incremental annual cost of O&M
$S$ is the annual kWh energy savings.

And $A$ is the annualization factor.

Where: $$A = \frac{i(1+i)^n}{(1+i)^n - 1}$$ $i$ is the discount rate
$n$ is the life of the measure.

The detailed CCE tables (see Appendix A) show both “incremental” and “full” installed costs for the energy-efficiency measures, as applicable. If the measure or technology is installed in a new facility or at the point of natural replacement in an existing facility, then the “incremental” cost of the measure versus the cost of the baseline technology is used. If, prior to the end of its life, an operating piece of equipment is replaced with a more efficient model, then the “full” cost of the efficient measure is used.

The annual saving associated with the efficiency measure is the difference in annual electricity consumption with and without the measure.

The CCE calculation is sensitive to the chosen discount rate. In the CCE calculations that accompany this document, three discount rates are shown: 4%, 6% and 8%. The 6% real discount rate was used for the primary CCE calculation. The CCE was also calculated using the 4% and 8% real discount rates to provide sensitivity analysis.

Selection of the appropriate discount rate to be used in this analysis was guided by the intended use of the study results. This study seeks to identify the economic potential for DSM in Newfoundland and Labrador from a provincial perspective. Therefore, the appropriate discount rate is the social opportunity cost of capital, which is the estimated average pre-tax rate of return on public and private investments in the provincial economy.[30]

## 4.3 DESCRIPTION OF ENERGY-EFFICIENCY TECHNOLOGIES

This subsection provides a brief description of each of the energy-efficiency technologies and measures that are included in this study, as listed in Exhibit 4.1.

**Exhibit 4.1: Energy-efficiency Technologies and Measures - Residential Sector**

**Existing Building Envelope**
- High- & super high-performance windows
- Air leakage Sealing
- Attic insulation
- Wall insulation
- Foundation insulation
- Crawl space insulation

**New Building Design**
- R-2000 Home
- EnerGuide for Housing 80
- Energy-efficient new apartment building construction

**Space Heating and Ventilation Equipment**
- Programmable thermostat
- Electronic and high-efficiency thermostats
- Air source heat pump for homes
- Ground source heat pump for homes
- Low-temperature heat pump for apartments
- Ground source heat pump for apartments
- Integrated heating and DHW heat pumps
- High-efficiency heat recovery ventilator
- Electronically commutated permanent magnet (ECPM) motors for furnace fans
- Premium motors for apartment building ventilation systems
- Building recommissioning – apartment buildings
- Oil-fired central forced air heating system

**Domestic Hot Water**
- Low-flow shower heads and faucets
- Water tank insulation
- Pipe insulation

**Major Appliances**
- Microwave/convection oven
- ENERGY STAR refrigerator
- ENERGY STAR freezer
- ENERGY STAR dishwasher
- ENERGY STAR front loading clothes washer
- ENERGY STAR top loading clothes washer

**Household Electronics**
- Reduction in standby losses
- ENERGY STAR compliant computer
- ENERGY STAR television
- LCD television

**Lighting**
- CFLs
- Replacement of T12s with T8s
- LED holiday Lighting
- Lighting timers
- Motion sensors

[30] This discount rate allows for analytic consistency with the earlier NERA Marginal Cost Study, which used a nominal discount rate of 8.4% (approximately 6% real, i.e. net of inflation). NLH lowered its nominal discount rate in the summer of 2007 to 7.75%; however, this change has no material impact on the results of this study.

The discussion is organized by major end use and is presented in the following subsections:

- Existing building envelope
- New building design
- Space heating and ventilation equipment
- Domestic hot water
- Major appliances
- Household electronics
- Lighting.

Each energy-efficiency improvement opportunity is discussed below, with a brief description of the technology, savings relative to the baseline with respect to detached homes in the Island and Isolated service region (with savings ranges provided for other dwelling types and climate regions), typical installed costs, applicability and co-benefits.[31]

### 4.3.1 Existing Building Envelope

Building envelope measures improve the thermal performance of the building's walls, roof and/or windows. These measures also provide significant co-benefits, such as increased occupant comfort, improved resale value, etc. Ten energy-efficiency upgrade options were identified and assessed for this end use. They are:

- High-performance (ENERGY STAR) windows
- Super high-performance windows
- Air leakage sealing
- Attic insulation
- Wall insulation
- Foundation insulation
- Crawl space insulation
- High-performance glazing systems for apartment buildings
- Upgrade wall insulation for apartment buildings
- Upgrade roof insulation for apartment buildings.

❑ **High-Performance (ENERGY STAR) Windows**

| **Measure Profile** | |
|---|---|
| Applicable Dwelling Type(s) | Single detached and attached |
| Vintage | Existing and new |
| Costs | $4 per square foot incremental cost in existing<br>$2 per square foot incremental cost in new |
| Savings | 3%-7% HVAC energy, depending on dwelling type, vintage, and region |
| Useful Life | 25 years |

[31] Measure inputs not otherwise sourced are based on the consultants' recent work with BC Hydro and other utility clients.

High-performance windows are double glazed with a ½-inch air space; they incorporate a number of additional energy-saving features including low-e (soft coating), insulating spacers, argon fill and low conductivity frames (a mix of sliders, hinged and picture). The more efficient windows reduce heat loss through the window by 20% or more, compared to the average low- or mid-efficiency replacement window depending on dwelling type and region. High-performance windows have an RSI value of 0.5 (R-2.8) or higher, compared to standard double glazed windows, which are clear with no gas filling and typically have an RSI value of 0.34 (R-1.9) or less. High-performance windows also provide occupant co-benefits, such as reduced interior noise, reduced air leakage, greater thermal comfort and fewer condensation problems.

This analysis employs an incremental cost of $4 per square foot[32] to renovate an attached or detached dwelling to high-performance windows as opposed to standard windows; the corresponding savings are approximately 3%-7% of space heating, depending on housing type and climate.

If the upgrade is chosen as part of a new construction, the incremental cost is $2 per square foot[33] and the potential savings are higher because new homes tend to have more and larger windows. They are also a larger proportion of the heating energy consumption; because the other building shell components are better in a new home, windows account for a larger fraction of the heat loss than they do in an older home. The product lifetime for windows is approximately 25 years.[34]

- ❑ **Super High-Performance Windows**

| **Measure Profile** | |
|---|---|
| Applicable Dwelling Type(s) | Single detached and attached |
| Vintage | Existing and new |
| Costs | $8 per square foot |
| Savings | 5%-11% HVAC energy, depending on dwelling type, vintage and region |
| Useful Life | 25 years |

Super high-performance windows incorporate additional features such as triple glazing, transparent insulating films or fibreglass frames as well as the low-e coating, argon fill and insulating spacers, giving them an equivalent R-value of up to R-11. These windows are approximately twice the cost of the high-performance windows; incremental costs would be approximately $8 per square foot and the corresponding savings are approximately 5%-11% of space heating, depending on housing type and climate. Triple glazed units are considerably heavier and present fastening issues for existing vinyl window frame extrusions.

[32] Cost data from product review undertaken for Terasen Gas, 2006.
[33] Incremental costs are generally lower for windows installed in new homes, because tract builders are able to purchase windows in the wholesale market where the incremental cost of efficient windows is usually smaller than it is in the retail marketplace.
[34] BC Hydro Power Smart. *QA STANDARD Technology: Effective Measure Life*. September 11, 2006.

## ❑ Air Leakage Sealing

| Measure Profile | |
|---|---|
| Applicable Dwelling Type(s) | Single detached and attached |
| Vintage | Existing and new |
| Costs | $900 incremental cost in existing<br>$600 incremental cost in new |
| Savings | 8%-26% HVAC energy, depending on dwelling type, vintage and region |
| Useful Life | 25 years |

Air sealing of building envelopes includes completion of a blower door test to quantify leakage levels and to identify the location of air leaks. Generally, major leakage occurs at window-to-wall interfaces, around doors, through electrical and plumbing penetrations, at the top of foundation walls and around chimneys and fireplaces.[35] Installation of sealant and gaskets are generally accepted methods for reducing air leakage in buildings.

Air sealing also provides important co-benefits, including reduced drafts, increased occupant comfort and greater control over ventilation capability. In addition, reduced air leakage around windows and attic penetrations eliminates one of the key contributors to water ingress into exterior envelope assemblies.

HOT2000 simulations for Newfoundland showed significant HVAC savings in the range of 8% to 26% due to air leakage sealing, depending on housing type and climate. Electricity savings from ventilation fans, if applicable, would be approximately the same percentage. The cost of leakage control is approximately $900 per existing single-family dwelling if undertaken by an air sealing contractor who can perform an air test as part of the work. If homeowners undertake the air sealing work, significant cost savings can be achieved, but the resulting energy savings would be substantially reduced as well.

The incremental cost of improved air sealing in a new construction project used in this analysis is $600. The life of this measure is approximately 25 years; however, some elements of air leakage sealing, such as weather stripping, will require more frequent replacement and an annual O&M cost of $50 has been added in to account for this.[36]

[35] Fireplaces are particularly challenging to seal around, because of the difficulty of obtaining high-temperature sealants. Selection of fireplaces and woodstoves with outside air intake and proper air sealing built into them avoids this problem.
[36] Energy impacts are from HOT2000 simulations; cost data are based on discussions with installation contractors.

### ❑ Attic Insulation

| Measure Profile | |
|---|---|
| Applicable Dwelling Type(s) | Single detached and attached |
| Vintage | Existing and new |
| Costs | $600 incremental cost |
| Savings | 2%-6% HVAC energy, depending on dwelling type, vintage and region |
| Useful Life | 25 years |

Insulation levels can be increased in attics by blowing insulation into the attic spaces to fill and cover the space within the roof frame. One technique is to make sure loose-fill or batt insulation fills the attic floor joists fully, then add an additional layer of unfaced fibreglass batt insulation across the joists. This analysis assumed attic insulation is improved to RSI-7.0.

This analysis estimates the incremental cost of this measure to be about $600, with a resulting savings of approximately 2%-6% of the space heating costs depending on housing type and climate. Electricity savings from ventilation fans, if applicable, would be approximately the same percentage. The life of this measure is estimated at 25 years.[37]

### ❑ Wall Insulation

| Measure Profile | |
|---|---|
| Applicable Dwelling Type(s) | Single detached and attached |
| Vintage | Existing and new |
| Costs | $750-$2,400 |
| Savings | 3%-11% HVAC energy, depending on dwelling type, vintage and region |
| Useful Life | 25 years |

Wall insulation is usually challenging to retrofit in an existing house because the inside surfaces of the exterior walls are already finished and in place. Adding insulation is only possible by blowing insulating materials into the wall cavity, if sufficient space exists, or by adding insulation to the exterior of the building under the siding. Insulation levels are assumed to increase to RSI-3.5.

The incremental cost of adding the exterior insulation (as not all walls have sufficient space for blown-in insulation) used in this analysis is $750-$2,400 depending on dwelling vintage.[38] Savings are estimated to be 3%-11% of space heating costs depending on housing type and climate. Electricity savings from ventilation fans, if applicable, would

[37] Energy impacts are from HOT2000 simulations; cost data are based on discussions with retailers and installation contractors.
[38] Cost does not include siding. If insulation cannot be blown in, the rigid foam is assumed to be added in conjunction with an already-planned project to replace the siding. The insulation cost is incremental to the siding job.

be approximately the same percentage. The life of this measure is approximately 25 years.[39]

### ❑ Foundation Insulation

| Measure Profile | |
|---|---|
| Applicable Dwelling Type(s) | Single detached and attached |
| Vintage | Existing and new |
| Costs | $40 per square meter |
| Savings | 18%-43% HVAC energy, depending on dwelling type, vintage and region |
| Useful Life | 25 years |

In older homes the basement is often under insulated or even left uninsulated. Increasing the insulation level in basements can be achieved in a number of ways including: constructing a new insulated frame wall or moving the existing frame wall to increase the insulation level, adding extra insulation to the existing frame wall, adding rigid board insulation to the exterior of the foundation or using a combination of interior and exterior rigid board insulation. For the purposes of this report, increased basement insulation was assumed to be either moving an existing frame wall or constructing a new frame wall with an upgrade to RSI-4 insulation. The cost of adding insulation to the foundation, including labour and finishing, is approximately $40 per square meter ($3.70 per square foot) of basement wall area.[40]

HOT2000 simulations for Newfoundland showed significant HVAC savings in the range of 18% to 43% depending on housing type and climate. Electricity savings from ventilation fans, if applicable, would be approximately the same percentage. This measure has a life of approximately 25 years.[41]

### ❑ Crawl Space Insulation

| Measure Profile | |
|---|---|
| Applicable Dwelling Type(s) | Single detached and attached |
| Vintage | Existing |
| Costs | $1,000 incremental cost in existing |
| Savings | 10%-25% HVAC energy, depending on dwelling type, vintage and region |
| Useful Life | 25 years |

Insulation levels may be inadequate in some homes that include a crawl space as part of the basement design. Co-benefits of improved crawl space insulation include improved thermal comfort, fewer drafts and less condensation.

[39] Op. cit., footnote 36.
[40] Cost does not include adding or rebuilding the basement interior walls. The insulation is assumed to be added in conjunction with an already planned basement renovation. The insulation cost is incremental to the renovation cost.
[41] Op. cit., footnote 36.

The addition of crawl space insulation in existing houses to bring the thermal resistance values up to existing code levels of RSI-2.1 provides annual energy savings of approximately 10%-25% of HVAC energy use. Electricity savings from furnace fans, if applicable, would be approximately the same percentage. This measure has a life of approximately 25 years.[42] Typical installed costs are approximately $1,000.

- **High-performance Glazing Systems for Apartment Buildings**

| **Measure Profile** | |
|---|---|
| Applicable Building Types | All |
| Vintage | Existing and new |
| Costs | $2.00/ft$^2$ (floor area) incremental cost |
| Savings | 28% to 34% of heating and cooling energy |
| Useful Life | 20 years |

High-performance glazing systems consist of low-e coated films suspended inside an insulating glass unit. These units can be incorporated into both window and curtain wall systems. In addition to superior insulating performance and lower energy costs, the co-benefits include enhanced comfort, noise reduction, the elimination of perimeter heating and reduced HVAC equipment costs.

Visionwall window and curtain wall systems manufactured by Visionwall Corporation[43] have thermal resistance R-values ranging from 3 to 7 hr.ft$^2$.$^o$F/Btu, low shading coefficients and high visible light transmission. The highest performing product on the market is Superglass Quad (R-value 12.5 hr.ft$^2$.$^o$F/Btu) manufactured by Southwall Technologies.[44] It features two films suspended inside an insulating glass unit creating three krypton-filled air spaces. A tape system is used for gas retention and a thermally broken insolating spacer stops the conduction through the edge of the glass.

This upgrade is a high-performance glazing system with an overall U-value of 0.25 Btu/hr.ft$^2$.$^o$F (R-4). It is applicable to both existing buildings (at end of window life cycle) and new construction. The baseline is an electrically heated commercial building with standard double-glazed windows with an overall U-value of 0.45 Btu/hr.ft$^2$.$^o$F (R-2.2). The incremental cost is $2.00 per square foot of floor area, the savings range from 28% to 34% of the heating and cooling energy and the service life is 20 years.

- **Upgrade Wall Insulation for Apartment Buildings**

| **Measure Profile** | |
|---|---|
| Applicable Building Types | All |
| Vintage | Existing and new |
| Costs | $1.38/ft$^2$ (floor area) incremental cost |
| Savings | 18% of heating energy |
| Useful Life | 25 years |

[42] Op. cit., footnote 36.
[43] http://www.visionwall.com.
[44] http://www.southwall.com.

Various insulating materials and methods can be used to upgrade wall insulation including applying rigid polystyrene board to the exterior of a building or installing fibreglass batts between interior wall studs.

This measure involves upgrading wall insulation to R-24. It is applicable to both existing buildings (at time of recladding) and new construction. The baseline is an electrically heated commercial building with R-12 wall insulation. The incremental cost is $1.38 per square foot of floor area, the savings are 18% of heating energy and the service life is 25 years.

- ❑ **Upgrade Roof Insulation for Apartment Buildings**

| **Measure Profile** | |
|---|---|
| Applicable Building Types | All |
| Vintage | Existing and new |
| Costs | $1.00/ft$^2$ (floor area) incremental cost |
| Savings | 13% of heating energy |
| Useful Life | 25 years |

Upgrading insulation on a built-up roofing system typically involves adding additional layers of rigid insulation at the time of re-roofing.

This measure involves upgrading roof insulation to R-30. It is applicable to both existing buildings (at time of re-roofing) and new construction. The baseline is an electrically heated commercial building with R-20 roof insulation. The incremental cost is $1.00 per square foot of floor area, the savings are 13% of heating energy and the service life is 25 years.

### 4.3.2 New Building Design

New building design integrates advances in both building envelope and space/water conditioning technologies. Three energy-efficiency upgrades were addressed:

- R-2000 Home
- Construction of new homes to achieve an EnerGuide rating of 80 (EG80)
- Energy-efficient new apartment construction.

- ❑ **R-2000 Home**

| **Measure Profile** | |
|---|---|
| Applicable Dwelling Type(s) | Single detached and attached |
| Vintage | New |
| Costs | $7,500 incremental cost for bungalow<br>$9,000 incremental cost for 2-story |
| Savings | 30% to 50% of HVAC |
| Useful Life | 30 years |

R-2000 homes are required to achieve a stringent energy budget that is determined by a combination of factors related to heating fuel, house size and climatic data. In addition, R-2000 homes are required to achieve an air tightness level of 1.5 ac/h at 50 Pa. A number of co-benefits are associated with R-2000 construction, such as improved occupant comfort, improved air quality due to the mandatory use of heat recovery ventilators, higher resale value and reduced environmental impact.

This analysis estimates that annual space heating savings are 30%[45] relative to standard, electrically heated new houses. Actual performance verification performed by an R-2000 builder in Newfoundland showed energy savings of between 30% and 50%[46] relative to standard practice. Fuel savings for non-electrically heated homes would be approximately the same percentage. Typical incremental construction costs for an R-2000 home are assumed to be $7,500 to $9,000.[47]

- ❑ **EnerGuide 80 Home**

| **Measure Profile** | |
|---|---|
| Applicable Dwelling Type(s) | Single detached and attached |
| Vintage | New |
| Costs | $7,500 incremental cost for bungalow<br>$9,000 incremental cost for 2-story |
| Savings | 30% to 50% of space heating energy |
| Useful Life | 30 years |

An EnerGuide for Houses rating is a standard measure of a home's energy performance, calculated by a professional EnerGuide for Houses advisor. The rating is based on information on the construction of the home and the results of a blower door test performed once the house has been built. A blower door test measures air leakage when the air pressure within the house is lowered a specified amount below the air pressure outside. EnerGuide ratings for new houses fall within the following ranges:

- Typical new houses: 72 to 74
- Energy-efficient new houses: 77 to 82
- R-2000 houses: 80 minimum
- Highly energy-efficient new houses: 80 to 90
- Advanced houses using little or no purchased energy: 91 to 100.

The key difference between the R-2000 standard and the more flexible requirement to meet the EG80 rating is that builders do not need to install a heat recovery ventilator to achieve a rating of EG80, nor meet other environmental requirements of the R-2000 program. This substantially reduces the cost of the measure. However, in St. John's where electric heating is in the majority of homes, heat recovery ventilation is standard

[45] Energy impacts are from HOT2000 simulations; cost data are based on information from a paper by Anil Parekh of NRCan, *Cost Impact of the New R-2000 Technical Standard – Summary Report*, March 2000. Supplemented by discussions with installation contractors.
[46] Discussion with Greg Hussey of Karwood Contracting, an R-2000 builder in Newfoundland, August, 2007.
[47] Ibid.

practice,[48] meaning there will be no cost difference between a home achieving EG80 and an R-2000 home.

This analysis estimates that annual space heating savings are 30% to 50% relative to standard electrically heated new houses. Fuel savings in non-electrically heated homes would be approximately the same percentage. Typical incremental construction costs for an EG80 home are assumed to be $7,500 to $9,000.[49]

❑ **Energy-efficient New Apartment Construction**

New construction refers to new high-efficiency buildings designed using the integrated design process that achieve substantial improvements over conventional new buildings through the application and integration of energy-efficiency technologies and design approaches.

Baseline new construction is assumed to follow the MNECB and ASHRAE 90.1 - 1999 standards.

Two energy-efficiency upgrade options were evaluated for new construction:

- New apartment building - 25% more efficient than current standards
- New apartment building - 40% more efficient than current standards.

❑ **New Apartment Building - 25% More Efficient Than Current Standards**

| **Measure Profile** | |
|---|---|
| Applicable Dwelling Type(s) | Apartment buildings |
| Vintage | New |
| Costs | $1.00/ft$^2$ incremental cost |
| Savings | 25% |
| Useful Life | 30 years |

The integrated design approach (IDA) to new building design is predicated on a systematic application of energy measures to all end uses at the design stage. This includes targeting the building envelope, lighting, HVAC equipment (fans and pumps) and, finally, the heating and cooling plants. Savings of 25% are achievable at an average incremental cost of $1/ft$^2$. The 25% measure is a subset of the 40% measure and is, therefore, not considered separately in cases where the 40% measure passes the CCE test. If the 40% measure fails the CCE test for a particular region or dwelling type, the analysis falls back to the 25% improvement. If the latter passes the CCE test, it would be included in the potential.

[48] Ibid.
[49] Cost is based on R-2000 incremental cost, less the cost of installing an HRV.

❑ **New Apartment Building - 40% More Efficient Than Current Standards**

| **Measure Profile** | |
|---|---|
| Applicable Dwelling Type(s) | Apartment buildings |
| Vintage | New |
| Costs | $4.50/ft$^2$ incremental cost |
| Savings | 40% |
| Useful Life | 30 years |

A new apartment building that is 40% more efficient than current design practice will require a very high-performance design, equivalent to C-2000 levels. This requires a full IDA that takes advantage of costs trade-offs from equipment downsizing. The design will require the most energy-efficient technologies, extremely efficient lighting designs and heating/cooling plants with very high part-load efficiencies. Savings of 40% are achievable at an average incremental cost of $4.50/ft$^2$.

### 4.3.3 Space Heating and Ventilation Equipment

Space heating and ventilation equipment refers to the equipment and controls used to heat and ventilate residential dwellings. The following energy-efficiency upgrade options were identified and assessed for this end use.[50]

- Programmable thermostat
- High-efficiency thermostat
- Low-temperature air source heat pumps for new homes
- Ground source heat pump for new homes
- Low-temperature heat pumps for apartments
- Ground source heat pump for apartments
- Integrated heating and DHW heat pumps
- High-efficiency heat recovery ventilator
- Electronically commutated permanent magnet (ECPM) motors for furnace fans
- Oil-fired central forced air heating system.
- Premium motors for apartment building ventilation systems
- Building recommissioning—apartment buildings.

[50] Duct sealing is not included due to the negligible number of homes with ducted electric heating systems in Newfoundland and Labrador. It should be noted that 27% of the electrically heated homes in the Labrador Interconnected service region do have ducts. Including both detached and attached dwellings, this would total approximately 1,800 dwellings. In a dwelling where the ducts run within the conditioned space (as is typical of Canadian homes), duct sealing saves approximately 5%. It costs approximately $1,000 per home, mostly in labour, and would not pass the CCE test in Labrador.

### ❑ Programmable Thermostat

| Measure Profile | |
|---|---|
| Applicable Dwelling Type(s) | Single detached and attached |
| Vintage | New and existing |
| Costs | $70 incremental cost |
| Savings | 6% of HVAC energy |
| Useful Life | 18 years |

Digital programmable thermostats provide improved temperature setting accuracy and are capable of multiple time settings. When combined with an assumed 4ºC temperature setback during night and unoccupied periods, typical space heat savings are in the range of 10% to 15%[51] relative to the baseline, depending on the dwelling's vintage and type of dwelling. Other utility studies[52] have indicated that a lower savings percentage should be used, to reflect the fact that the thermostat's setback capabilities do not completely reflect how they are used, e.g., some home occupants reliably set back manual thermostats, and some home occupants do not use the setback features on their electronic thermostats. Accordingly a value of 6% savings has been used in this study.

These thermostats can be installed in both new and existing dwellings. The typical incremental installed cost for a programmable versus non-programmable thermostat is about $70[53] per thermostat and the units have an expected life of 15-20[54] years.

### ❑ High-efficiency Thermostat

| Measure Profile | |
|---|---|
| Applicable Dwelling Type(s) | Single detached and attached |
| Vintage | New and existing |
| Costs | $30 incremental cost |
| Savings | 3% of HVAC energy |
| Useful Life | 18 years |

Digital programmable thermostats are, in general known for their increased accuracy and energy savings potential due to setback features. Recently, less expensive thermostats with the same accuracy, but without the programming functions, have become available. These improved electronic thermostats help reduce temperature fluctuations to less than 0.5-1$^{o}$C, whereas fluctuations usually range on an average from 1.5-2$^{o}$C. This increased sensitivity helps to ensure that electric furnaces or baseboard heaters start up as close as possible to the desired temperature set point. One model used with baseboard electric heaters will switch the heater on and off to maintain an ambient temperature within +/-

[51] Canadian ENERGY STAR Calculator.
[52] Enbridge Gas Distribution, Inc., consumer awareness campaign literature, supported by unpublished internal studies.
[53] From retail outlets e.g., Home Hardware and Canadian Tire.
[54] Canadian ENERGY STAR Calculator.

0.5°C of the set point. It could save around 3%[55] of energy use while improving comfort considerably. This model, however, is not recommended for fuel fired furnaces or wherever short cycling is not desirable.

It should be noted that increased temperature sensing precision may not have any significant impact on energy savings since the temperature setting in a home is generally linked to homeowner comfort and preference, not to the number displayed on the thermostat. The assumption would also need to be made that the less precise thermostat allows homes to overheat by 1 degree, not be under heated by 1 degree. Based on the NRCan 3% savings information, the assumption used in the analysis will be that this type of thermostat saves 3% compared to a regular thermostat. It is assumed to cost approximately $30.

- ❑ **Low-temperature Air Source Heat Pumps for New Homes**

| **Measure Profile** | |
|---|---|
| Applicable Dwelling Type(s) | Single detached and attached |
| Vintage | New |
| Costs | $8,000 incremental cost |
| Savings | 50% of space heating energy in Island houses<br>43% of space heating energy in Labrador houses |
| Useful Life | 20 years |

When outdoor air temperatures drop below freezing, standard air source heat pump (ASHPs) systems switch to auxiliary electric resistance heaters to meet the space heating requirements. This limitation has served to minimize the penetration of ASHPs in cold climates. However, a low-temperature air source heat pump (LTHP) developed by Hallowell International[56] is capable of operating at 0°F with a coefficient of performance (COP) of greater than two. At this temperature, standard ASHPs operate less efficiently, produce less than half their rated capacity, and rely primarily on backup electric resistance heaters to maintain comfort.

The LTHP features a two-speed, two-cylinder compressor for efficient operation, a back-up booster compressor that allows the system to operate efficiently down to 15ºF and a plate heat exchanger called an "economizer" that further extends the performance of the heat pump to well below 0ºF.

LTHPs were considered as an alternative for new dwellings only.[57] In new dwellings, LTHPs can provide increased efficiency compared to the more common electric baseboard heaters.[58] Energy savings in the Island and Isolated service region were

[55] NRCan Office of Energy Efficiency, *Heating with Electricity*, March 2003, http://oee.nrcan.gc.ca/publications/infosource/pub/home/Heating_With_Electricity_Chapter2.cfm?attr=4.
[56] www.gotohallowell.com
[57] In existing homes, it would be practical to install an ASHP only in electrically heated homes that already have ducts. The number of such homes in Newfoundland and Labrador is so small that the potential from this measure in existing homes was deemed negligible.
[58] It is assumed that the additional duct work required to install an ASHP in an existing home with electric baseboard heaters is prohibitive.

estimated to be 50% relative to baseboard heaters. In the Labrador Interconnected region, the more severe winters reduced the savings estimate to 43% relative to baseboard heaters. LTHPs can also provide space cooling in summer months at no incremental capital cost, which can improve the CCE slightly.

Typical installed costs in new dwellings are approximately $8,000 to $12,000, including duct work (the lower number has been used in the model, as more representative of a mature market price), and units can last from 15-25 years.[59]

- **Ground Source Heat Pumps for New Homes**

| **Measure Profile** | |
|---|---|
| Applicable Dwelling Type(s) | Single detached |
| Vintage | New |
| Costs | $18,200 incremental cost |
| Savings | 65% of space heating energy in Island houses<br>62% of space heating energy in Labrador houses |
| Useful Life | 20 years |

Ground source heat pumps (GSHP) utilize the relatively constant temperature properties of the earth or ground water to provide heating and cooling to homes. Although they offer further savings relative to other heat pump types, they are expensive and cannot be used in many urban applications.[60]

Typical HSPF values for regions in Canada experiencing a winter similar to St John's are 8.9-10.6, which equates to energy savings of 65% relative to baseboard heaters in new homes. Typical HSPF values for regions in Canada experiencing a more severe winter such as in Labrador are 8-10, which equates to energy savings of 62% relative to baseboard heaters.[61] In both regions GSHP save approximately 30% to 45% compared to ASHP in new buildings.

Installed costs are approximately $20,000 for a closed loop system in a typical dwelling, or $18,200 more than a conventional system.[62]

Again, the addition of cooling at no incremental cost can improve the savings relative to the baseline.

[59] Heating seasonal performance factors (HSPF), savings, costs and lifetimes from NRCan Office of Energy Efficiency, *Heating and Cooling with a Heat Pump*. Data checked with manufacturers and contractors.

[60] In most urban locations, there is insufficient room for trenching to install horizontal ground loops for GSHPs. At best, there may be room to drill the vertical holes for vertical ground loops. In many locations, there is no space even for that. In some cases where there is room, it is impossible to gain access with the drilling rig because of surrounding structures.

[61] Ibid.

[62] Earth Energy Society of Canada. http://www.earthenergy.ca/saving.html.

## ❑ Low-temperature Air Source Heat Pumps for Apartments

| **Measure Profile** | |
|---|---|
| Applicable Dwelling Type(s) | Apartments |
| Vintage | Existing and new |
| Costs | \$1.80 to \$2.50/ft$^2$ incremental cost |
| Savings | 56% to 59% of space heating and cooling energy |
| Useful Life | 15 years |

When outdoor air temperatures drop below freezing, standard air source heat pump systems switch to auxiliary electric resistance heaters to meet the space heating requirements. This limitation has served to minimize the penetration of air source heat pumps in cold climates. However, as indicated earlier, Hallowell International's low-temperature air source heat pump is capable of operating at 0°F with a COP of greater than two. At this temperature, standard air source heat pumps operate less efficiently, produce less than half their rated capacity and rely primarily on backup electric resistance heaters to maintain comfort.

The LTHP features a two-speed, two-cylinder compressor for efficient operation, a backup booster compressor that allows the system to operate efficiently down to 15ºF and a plate heat exchanger called an "economizer" that further extends the performance of the heat pump to well below 0ºF.

This measure involves upgrading a standard HVAC system with an equivalent LTHP system. This could include, for example, replacing a standard ASHP system with a LTHP system. The target market is both residential and small commercial buildings and the baseline is electric resistance heating and direct expansion cooling.  This technology is applicable to existing buildings (at the end of HVAC life cycle) and new construction. The incremental cost ranges between \$1.80 and \$2.50 per square foot, the savings range between 56% and 59% of space heating and cooling energy and the service life is 15 years.

Currently, the LTHP is available only as a 3.0 and 3.5 ton split system, however Hallowell International expects to launch an expanded product line targeting the commercial market including a packaged rooftop heat pump and a packaged terminal heat pump (PTHP) as early as 2008.[63]

[63] Conversation with James Bryant of Hallowell International, [September, 2007]

## ❑ Ground Source Heat Pumps for Apartments

| **Measure Profile** | |
|---|---|
| Applicable Dwelling Type(s) | All |
| Vintage | Existing & new |
| Costs | $4.90/ft$^2$ incremental cost |
| Savings | 61% to 64% of space heating & cooling energy |
| Useful Life | 20 years |

Ground source heat pump (GSHP) systems are more efficient than conventional heat pump systems, with higher COPs and energy-efficiency ratios (EERs). GSHPs also replace the need for a boiler in winter by utilizing heat stored in the ground; this heat is upgraded by a vapour-compressor refrigeration cycle. In summer, heat from a building is rejected to the ground, eliminating the need for a cooling tower or a heat rejector. They also lower operating costs because the ground is cooler than the outdoor air.

Water-to-air heat pumps are typically installed throughout a building with duct work serving only the immediate zone; a two-pipe water distribution system conveys water to and from the ground source heat exchanger. The heat exchanger field consists of a grid of vertical boreholes with plastic u-tube heat exchangers connected in parallel.

This measure involves upgrading a standard HVAC system with a GSHP system and is applicable to existing building (at the end of HVAC life cycle) and new construction. The baseline is a commercial building with standard electric resistance heating and direct expansion cooling. The incremental cost is $4.90 per square foot, the savings range between 61% and 64% of heating and cooling energy and the service life is 20 years.

## ❑ Integrated Heating and Hot Water (Heat Pump)

| **Measure Profile** | |
|---|---|
| Applicable Dwelling Type(s) | Single detached |
| Vintage | New and existing |
| Costs | $1,000 incremental on top of GSHP costs |
| Savings | 35% DHW plus heating savings as above |
| Useful Life | 20 years |

GSHP can also reduce DHW energy consumption through the addition of a desuperheater. A desuperheater is a small, refrigerant/water heat exchanger that transfers superheated gases from the heat pump's compressor to a water pipe that runs to a home's hot water storage tank. In the cooling season, the desuperheater uses excess heat extracted from the home and in the heating season it uses any excess heat that is not needed for space heating. At peak heating times a conventional water heater can meet additional needs.

A desuperheater can purportedly result in DHW energy savings of 25%-50%[64] (35% has been used in the model, as an approximate midpoint) and costs approximately $1,000.[65]

- **High-efficiency Heat Recovery Ventilators (HRV)**

| Measure Profile | |
|---|---|
| Applicable Dwelling Type(s) | Single detached and attached |
| Vintage | New |
| Costs | $650 incremental cost |
| Savings | 7% of HVAC energy |
| Useful Life | 15 years |

Heat recovery ventilators (HRV) are installed to recover wasted heat energy from centralized exhausts. Such units typically result in a 13% reduction in space heating costs.[66] New, high-efficiency HRV units recover approximately 50% more of the energy escaping in ventilation air, resulting in an additional 7%[67] reduction in space heating costs.

This analysis assumes that a high-efficiency HRV costs approximately $3,150[68] compared to a standard unit, which costs $2,500. The technology has an estimated life of 15 years. New HRV also have an energy-efficiency option, utilizing a variable speed DC motor instead of the less efficient PSC motor, cutting consumption from 150 Watts to less than 50 Watts on low speed.

- **Electronically Commutated Permanent Magnet (ECPM) Furnace Fan Motor**

| Measure Profile | |
|---|---|
| Applicable Dwelling Type(s) | Single detached and attached |
| Vintage | New and existing |
| Costs | $140 incremental cost |
| Savings | 40% of ventilation energy |
| Useful Life | 20 years |

Furnace fan motors are typically designed with permanent split capacitors (PSC) and achieve efficiencies in the range of 50%-60%. In contrast, ECPM motors have operating efficiencies in the range of 80%. Furnace fan motors are used in houses with central,

[64] NRCan Office of Energy Efficiency, *Heating and Cooling with a Heat Pump*.
[65] Earth Energy Society of Canada http://www.earthenergy.ca/saving.html.
[66] The standard HRV is not a separate measure in this analysis. Based on discussions with local contractors, installing HRVs is becoming standard practice in electrically heated new homes in Newfoundland and Labrador. It should be noted, however, that, for the existing vintage, with an installed cost of $2,500 (nearly four times the incremental cost of the above measure) and savings of 13% (only double the savings of the above measure), the standard HRV would not pass the CCE test.
[67] E Source Heating Technology Atlas.
[68] Cost based on discussions with contractors.

forced air heating systems. When operated exclusively in space heating mode, ECPM motors reduce fan motor electricity use[69] by approximately 40%.[70]

Typical installed costs are approximately $140[71] more than for a standard fan motor. ECPM motors also reduce fan noise.

- **Oil-fired Forced Air Heating System for New Homes[72]**

| **Measure Profile** | |
|---|---|
| Target Segments | All |
| Vintage | New |
| Costs | $4,300 incremental cost |
| Electricity Savings | Approximately 95%[73] |
| Useful Life | 15 years |

Space heating in new homes can be provided by an ENERGY STAR (83% efficiency) oil-fired furnace instead of electric baseboard heating. The installed cost of a direct vent forced air furnace with oil tank and duct work in a new single family home is in the range of $6,500 to $7,000. This compares with an estimated installed cost of up to $2,700 for electric baseboard heating, which includes the cost of a larger electrical panel, wiring, heaters and thermostats. The oil-fired system also uses approximately 420 kWh of fan electricity (in this analysis, assumed to be powered by an ECPM motor).

- **Premium Motors for Apartment Building Ventilation systems**

| **Measure Profile** | |
|---|---|
| Applicable Dwelling Type(s) | Apartment buildings |
| Vintage | Existing & new |
| Costs | 20% incremental cost |
| Savings | 1.4% of ventilation energy |
| Useful Life | 10 years |

Premium efficiency motors typically have reduced losses of 10%-40%, thereby increasing motor efficiency by 1%-10%.[74] In a retrofit situation it is considered best

[69] As noted in earlier sections, this end use is currently the focus of extensive research efforts. Recent end-use metering results suggest that, in heating mode, ECPM motor savings are fully offset by increased space heating fuel consumption. This is because waste heat generated by the fan motor is captured in the distributed hot air. Therefore, if the fan motor's waste heat is reduced due to increased efficiency, the primary heating fuel must make up the difference. If used to distribute cooled air, the increased fan motor efficiency (i.e., reduced waste heat) would reduce both motor consumption and the total cooling load.
[70] Canadian Centre For Housing Technology, *Effects of ECM Furnace Motors on Electricity and Gas Use*.
[71] Canadian Centre for Housing Technology, *Effects of ECM Furnace Motors on Electricity and Gas Use*, and discussion with retailers.
[72] This measure has been included as it may offer a net benefit to the NLH system. This is because a portion of the electricity generated will be from thermal sources if the Island and Isolated service region remains an isolated grid.
[73] Electricity savings require use of another fuel, assumed to be oil in this case; residual electricity use is for circulation fan operation.
[74] BC Hydro. *Power Smart Tips & Practices*.

practice to replace failed motors with new premium efficiency motors rather than rewind them since motor rewinding often degrades motor efficiency by 1%-3%.

This measure involves upgrading an induction motor with an equivalent premium efficiency motor. It is applicable to both existing buildings (at end of motor life cycle) and new construction. The baseline is a standard efficiency induction motor. The incremental cost is estimated to be 20% relative to a standard efficiency motor, the savings are 1.4% and the service life is 10 years.

❑ **Building Recommissioning – Apartment Buildings**

| **Measure Profile** | |
|---|---|
| Applicable Dwelling Type(s) | Apartment buildings |
| Vintage | Existing |
| Costs | $0.60 per ft$^2$ |
| Savings | 20% of HVAC energy use |
| Useful Life | 5 years |

Recommissioning is a quality assurance process for ensuring that a building's complex array of mechanical and electrical systems is operated to perform according to the design intent and current operational needs of the building. The process generally involves monitoring and simulation of building systems to gain a thorough understanding of current operation and possibilities for optimization. Energy savings generally result from equipment repairs, air and water rebalancing and control optimization.

Recommissioning is applicable to existing buildings only. The baseline is a typical office building with an electricity intensity of 26 kWh/ft$^2$yr. The full cost is estimated to be $0.60/ft$^2$, the savings are 20% of HVAC energy use and the service life is 5 years.

### 4.3.4 Domestic Hot Water

Domestic hot water (DHW) refers to the heated water used for showers, baths, hand washing and clothes and dishwashing (DHW savings for clothes and dishwashers are treated separately in Section 4.3.5). Four[75] energy-efficiency upgrade options were identified and assessed for this end use, of which three are discussed below:

- Low-flow shower heads and faucets
- Water tank insulation
- Pipe insulation.

[75] The potential for heat traps was deemed negligible in the context of this study due to the relatively high replacement rate of DHW tanks in the Newfoundland residential marketplace (often after 6 years). The discussion was removed accordingly.

### ❑ Low-flow Showers and Faucets

| Measure Profile | |
|---|---|
| Applicable Dwelling Type(s) | Single detached and attached |
| Vintage | Existing |
| Costs | $25 incremental cost |
| Savings | 11% of DHW energy in existing |
| Useful Life | 12 years |

Energy-efficient showers and faucets have aerators and flow restrictors to reduce water use. DHW used for general use (including showers and faucets) is assumed to account for approximately 35% of total DHW energy.

This analysis estimates that reductions in hot water usage are in the range of 30% relative to traditional models, or 11% of total DHW use. Installed costs are approximately $25 for a single-family dwelling. This measure has an expected life of 12 years.[76]

### ❑ Hot Water Tank Insulation

| Measure Profile | |
|---|---|
| Applicable Dwelling Type(s) | Single detached and attached |
| Vintage | Existing |
| Costs | $30 full cost |
| Savings | 6% of DHW energy |
| Useful Life | 10 years |

Very energy-efficient water heater storage tanks will have an insulation value of at least RSI-4.2. Adding insulation to an existing hot water tank, purchased before 2004, can reduce standby heat losses resulting in energy savings of 4%–9% (6% has been used in the model as an approximately midpoint).[77]

Pre-cut tank jackets (blankets) are readily available and cost around $15-20[78] in central Canada but are more expensive in Newfoundland and Labrador (approximately $30). They last for 10-15 years. Space limitations restrict the applicability of this measure in some cases. The potential is rapidly eroding as tanks are replaced.

[76] Data used in the BC Hydro 2007 Conservation Potential Review, and in the 2006 Terasen Gas CPR Study. Similar assumptions are used in the American Council for an Energy-Efficient Economy (ACEEE) and Energy Efficiency and Renewable Energy (EERE) *Consumer Tip Sheets* and have been confirmed for 2007.
[77] U.S. Department of Energy. http://www.eere.energy.gov/consumer/your_home/water_heating/index.cfm/mytopic=13070.
[78] From Canadian retailers.

### ❑ Hot Water Pipe Insulation

| Measure Profile | |
|---|---|
| Applicable Dwelling Type(s) | Single detached and attached |
| Vintage | Existing |
| Costs | $4 incremental cost |
| Savings | 3% of DHW energy |
| Useful Life | 6 years |

Hot water pipe insulation reduces the distribution losses for DHW, which account for approximately 5%-10% of the total water heater electricity consumption.

This analysis estimates that hot water pipe insulation reduces total DHW energy consumption by 3%. The materials cost an average of $4 per house and are assumed to be installed by the homeowner. The measure has an expected life of 6 years.[79]

## 4.3.5 Major Appliances

- Microwave/convection oven
- ENERGY STAR refrigerator
- High-efficiency freezer
- ENERGY STAR dishwasher
- ENERGY STAR front loading clothes washer
- ENERGY STAR top loading clothes washer
- Switch to propane gas for cooking.

### ❑ Microwave/Convection Oven

| Measure Profile | |
|---|---|
| Applicable Dwelling Type(s) | All |
| Vintage | New and existing |
| Costs | $1,400 incremental |
| Savings | 25% |
| Useful Life | 20 years |

New stove models combine conventional, microwave and convection ovens into a single appliance. Relative to a conventional oven, these designs provide electricity savings of about 25% and faster cooking times. Typical incremental costs are about $1,400 relative to conventional models and the units have a life of approximately 20 years.

[79] Savings data based on earlier analysis conducted for Terasen Gas. Cost data gathered from retailer scan.

### ❑ ENERGY STAR Refrigerator

| Measure Profile | |
|---|---|
| Applicable Dwelling Type(s) | All |
| Vintage | New and existing |
| Costs | Incremental cost $50-$100 |
| Savings | 15% -20% |
| Useful Life | 17 years |

ENERGY STAR refrigerators achieve substantial savings in electricity consumption through improved insulation and compressor efficiency, as well as better quality door seals and load sensors.[80] ENERGY STAR refrigerators must use 15% less energy than current standards dictate for an upright model, and 20% less energy for a compact design. Incremental cost for an ENERGY STAR fridge is $50-$100.[81]

### ❑ ENERGY STAR Freezer

| Measure Profile | |
|---|---|
| Applicable Dwelling Type(s) | All |
| Vintage | New and existing |
| Costs | Incremental cost $50-$100 |
| Savings | 10% |
| Useful Life | 17 years |

The performance efficiency of freezers has increased significantly over the last 10 years through improved insulation and compressor efficiency. ENERGY STAR freezers must use 10% less energy than current standards dictate. Incremental cost for an ENERGY STAR freezer is $50-$100.[82]

### ❑ Manual Defrost Freezer

| Measure Profile | |
|---|---|
| Applicable Dwelling Type(s) | All |
| Vintage | New and existing |
| Costs | Incremental cost $0 |
| Savings | 30% |
| Useful Life | 17 years |

Freezers without an automatic defrost cycle use approximately 30%[83] less electricity than comparable freezers with the defrost cycle; they also cost the same or less. Chest freezers

[80] A potential pitfall with refrigerator replacement initiatives is that some customers will retain the old refrigerator. For example, it may get moved to the basement and used as a beer fridge. This phenomenon may also affect freezer initiatives. Other utilities have addressed this issue through programs that offer a “bounty” to customers who surrender old second refrigerators and freezers.
[81] Based on scan of retailers.
[82] Based on scan of retailers.
[83] Canadian ENERGY STAR Calculator.

experience only limited amount of frost build up over time and rarely require defrosting and, therefore, for the purposes of this study, the level of service provided is assumed to remain virtually unchanged.

- **ENERGY STAR Dishwasher**

| **Measure Profile** | |
|---|---|
| Applicable Dwelling Type(s) | Single detached and attached |
| Vintage | Existing and new |
| Costs | Incremental cost $50 |
| Savings | 41% of DHW and mechanical dishwasher energy |
| Useful Life | 10 years |

ENERGY STAR dishwashers save energy by using improved technology for the primary wash cycle and by using less hot water to clean. Construction includes more effective washing action, energy-efficient motors and other advanced technologies, such as sensors, that determine the length of the wash cycle and the temperature of the water necessary to clean the dishes. In addition, some advanced dishwashers can sense and adjust for the amount of soil on dishes, using only as much water as necessary.

As of January 1, 2007 the ENERGY STAR level for dishwashers was changed with a corresponding increase in energy efficiency from 26% better than standard to 41% better. These savings affect both the mechanical energy of the dishwasher and the energy used for heating the water. The incremental cost of a unit meeting these new criteria is assumed to be $50.[84] The estimated life of a dishwasher is 10 years.[85]

- **ENERGY STAR Front Loading Clothes Washer**

| **Measure Profile** | |
|---|---|
| Applicable Dwelling Type(s) | Single detached and attached |
| Vintage | Existing and new |
| Costs | Incremental cost $550 |
| Savings | 70% of DHW used for clothes washing<br>50% of mechanical energy<br>35% of dryer energy |
| Useful Life | 15 years |

Compared to standard models, front loading (horizontal axis) washing machines reduce hot water use by 60%-80% (70% has been used in the model, as an approximate midpoint). Mechanical energy use is also reduced by about 50% and, due to their faster spin speed, they also reduce dryer energy by about 35%.[86]

This analysis assumes the energy savings outlined above. Incremental costs are assumed to be about $550 more than a standard vertical axis machine, although some high-end

[84] Based on discussion with retailers.
[85] Canadian ENERGY STAR Calculator.
[86] Savings data based on earlier analysis conducted for Terasen Gas.

models have incremental costs of about $1,000.[87] They are assumed to have a life of 15 years.

- **ENERGY STAR Top Loading Clothes Washer**

| Measure Profile | |
|---|---|
| Applicable Dwelling Type(s) | Single detached and attached |
| Vintage | Existing and new |
| Costs | Incremental cost $250 |
| Savings | 60% of DHW used for clothes washing<br>50% of mechanical energy<br>35% of dryer energy |
| Useful Life | 15 years |

ENERGY STAR clothes washers use approximately 60%[88] less hot water and 50% less mechanical energy per load than standard models. Because ENERGY STAR clothes washers spin faster, there are additional savings in dryer energy of approximately 35%. In January 2007, the ENERGY STAR standard for clothes washers was increased. However, the base regulation was also increased and the savings above the baseline, therefore, remain the same.

The change in standards has, however, resulted in a reduction of the number of qualifying models to only top of the range units and the incremental cost has therefore increased to about $250.[89] The estimated life of a clothes washer is 15 years.

- **Switch to Propane Gas for Cooking[90]**

| Measure Profile | |
|---|---|
| Target Segments | All |
| Vintage | New |
| Costs | $245 installed cost for a tank plus $105/yr. rental<br>$400 installed cost for piping |
| Electricity Savings | 100% of on-site cooking electricity [91] |
| Useful Life | 15 years |

Propane cooking stoves offer the same perceived advantages in cooking convenience offered by natural gas stoves. Typical installed cost is $645 more than an electric stove due to piping costs (typically $400-500) and the cost of installing a propane tank ($245). The propane tank is typically a rental, costing an additional $105 per year.

[87] Cost data based on retailer scan.
[88] Canadian and U.S. ENERGY STAR Calculator.
[89] From retailer scan.
[90] This measure is not an efficiency measure but has been included for the same reasons as outlined previously in footnote 72, Section 4.3.3, for oil-fired space heating.
[91] Electricity savings require use of another fuel, assumed to be propane in this case.

### 4.3.6 Household Electronics

Improvements to household electronics enhance the efficacy of entertainment items such as TVs and computers, while maintaining service levels. Four[92] energy-efficiency upgrade options were identified and assessed for this end use as follows:

- Reduction in standby losses
- ENERGY STAR compliant computer
- ENERGY STAR television
- LCD television.

❑ **Standby Losses**

| **Measure Profile** | |
|---|---|
| Applicable Dwelling Type(s) | All |
| Vintage | New and existing |
| Costs | $40 per dwelling |
| Savings | 16% for computers, 8% for TVs and other electronics, 73% for TV peripherals |
| Useful Life | 10 years |

Standby losses, consumed by electrical appliances when they are turned off or not in use, represent a significant component of residential electricity consumption. They account for 16% of computer energy use, 8% of the electricity used by TV and other electronics such as games consoles, and 73% of the electricity use of TV peripherals such as set-top boxes.[93] Technically, these standby losses can be reduced to zero by use of a power bar to completely remove power to the appliance.

In practice, the interaction between the power bar and the electronic device will often need to be more sophisticated than a simple shut-off. Some TVs need fan runtime after the screen is shut off, to avoid heat damage. Some set-top boxes require time to boot up and reconnect to their network before use, suggesting that to avoid user inconvenience they should be turned on in advance of prime viewing hours with a timer. Smart power bars with these capabilities are now making inroads in the marketplace. Over the study period, technical advances will improve these features and, in some cases, may move them from the power bar into the electronic appliance itself.

[92] LCD monitors have become the standard technology and the measure was dropped accordingly.
[93] Alan Fung, Adam Aulenback, Alex Ferguson and V Ismet Ugurssal. *Standby Power Requirements of Household Appliances in Canada*, April 2002.

## ❑ ENERGY STAR Compliant Computer

| Measure Profile | |
|---|---|
| Applicable Dwelling Type(s) | All |
| Vintage | New and existing |
| Costs | Incremental cost negligible |
| Savings | 60% |
| Useful Life | 8 years |

The ENERGY STAR specification for computers was revised in October 2006 and came into effect in July 2007. The previous specification only addressed energy use during a computer's sleep mode and was not demanding even in this respect with approximately 98% of available computers carrying the ENERGY STAR label. The energy savings were also dependent on the operating mode set by the user. The requirements have been seriously revised in an attempt to offer greater differentiation for innovative, truly energy-efficient models and now address all modes of operation in order to have automatic savings that are not dependent on user behaviour. It is estimated that the new specification will mean that ENERGY STAR computers and computer peripherals use, on average, 60% less energy than conventional models.[94] This premium performance comes at a price that remains comparable to conventional computer models.

## ❑ ENERGY STAR Television

| Measure Profile | |
|---|---|
| Applicable Dwelling Type(s) | All |
| Vintage | New and existing |
| Costs | Incremental cost $50 |
| Savings | 30% |
| Useful Life | 20 years |

ENERGY STAR qualified televisions must use one Watt or less in standby mode, which equates to approximately 30% less energy use annually[95] than a non-qualifying product. An ENERGY STAR TV may be CRT, LCD or plasma technology. The incremental cost of a 32" LCD ENERGY STAR qualified TV compared to its standard counterpart was found to be $20-$100 ($50 has been used in the model, as an approximate midpoint).[96]

[94] ENERGY STAR Press Release, 2006.
[95] Canadian and U.S. ENERGY STAR Calculator.
[96] From retailer scan.

### ❑ LCD Television

| Measure Profile | |
|---|---|
| Applicable Dwelling Type(s) | All |
| Vintage | New and existing |
| Costs | $400 incremental cost |
| Savings | 40% |
| Useful Life | 20 years |

Like LCD computer monitors, LCD TVs typically use less energy than CRTs, both when running and when in standby mode. A 27” LCD TV uses approximately 80-100 Watts[97] of power in “on” mode compared to an equivalent CRT monitor, which uses 150 Watts. Energy savings are thus in the order of 40%. LCD TVs are $300-$500[98] more expensive than the CRT equivalents ($400 has been used, as an approximate midpoint). One aspect of consumer behaviour that may complicate analysis of this measure is that people tend to buy larger LCD TVs than CRTs, potentially reducing the savings. We have not included this effect at this stage of the analysis.

## 4.3.7 Lighting

Lighting improvements enhance the efficacy of lighting fixtures, while maintaining service levels. Seven energy-efficiency upgrade options were identified and assessed for this end use as follows:

- Replacement of incandescent lamps with compact fluorescent lights (CFLs)
- White LED lamp
- Replacement of T12s with T8s (mainly in apartment building common areas)
- Redesign with high-performance T8 lighting systems
- LED holiday lighting
- Lighting timers
- Motion sensors.

### ❑ Replacement of Incandescent Lamps with Compact Fluorescent Lights[99]

| Measure Profile | |
|---|---|
| Applicable Dwelling Type(s) | All |
| Vintage | New and existing |
| Costs | Incremental cost $3 |
| Savings | 75% |
| Useful Life | 9 years |

[97] Marbek Resources Consultants Ltd. *Consumer Electronics Report*.
[98] From review of retailers.
[99] This measure is the replacement of incandescent lamps in standard applications with relatively long hours of use and no requirement for special shapes or dimming capability. A second compact fluorescent measure was added to the model, to address specialty applications where the lamp is more expensive or the hours of use are shorter. Incremental cost for the specialty CFL measure is $9. All other profile assumptions remain the same.

Compact fluorescent lights (CFLs) can be used to replace incandescent bulbs in most applications. A 13-Watt CFL provides a light output similar to that of a 60-Watt incandescent lamp and consumes approximately 75% less electricity. CFLs have come down a lot in price in recent years with the top end of the price range now being about $3-$10[100] for one CFL compared to no more than $1 for an incandescent bulb ($3 has been used as an incremental cost in the model, as representative of the majority of standard, low-cost applications). A CFL lasts approximately eight to ten times longer.

- **White LED Lamp**

| Measure Profile | |
|---|---|
| Applicable Building Types | All |
| Vintage | Existing and new |
| Costs | Full $43/lamp; incremental $38/lamp |
| Savings | 75% of lighting energy |
| Useful Life | 12 years |

This upgrade is a white light-emitting diode (LED) array that displays 800 lumens at 50 lumens per Watt and has a full cost of $43. Relamping a 65-Watt incandescent reflector lamp with this upgrade results in savings of 75% while producing an equivalent amount of light. In addition, white LEDs currently have a life of 35,000 hours compared to the shorter life of incandescent lamps; this provides additional benefits in the form of lower maintenance and lamp replacement costs. However, this technology is in the early stages of market entry and therefore improvements to the technology in terms of cost and efficacy should be expected in the coming years.

- **Replacement of Existing T12 Lamps and Magnetic Ballasts with T8 Fluorescent Lamps and Electronic Ballasts**

| Measure Profile | |
|---|---|
| Applicable Dwelling Type(s) | Detached, attached and apartment |
| Vintage | New and existing |
| Costs | Standard: Full $41/fixture; incremental $0<br>High-performance: Full $50/fixture; incremental $9/fixture |
| Savings | Standard T8 lamp and ballast: 26%<br>High-performance T8 lamp and ballast: 39% |
| Useful Life | 16 years |

T12 fluorescent lamps and magnetic ballasts can be replaced with standard 32-Watt T8 fluorescent lamps and electronic ballasts or the newer so called “high-performance” T8 lamps and ballasts. T12s still remain in limited applications in detached and attached homes, and in apartment building lobbies and corridors. Standard T8 lighting systems provide savings of approximately 26% relative to the conventional T12 systems in existing buildings. High-performance systems have even greater savings (39%) resulting

[100] From a retailer scan. $10 is now quite expensive for a singe CFL and might be paid only for a “daylight” model. Lowest prices were in the range of $3 for one lamp.

from a possible reduction in the number of lamps used due to the superior lumen output of this lighting. In new apartment buildings and other residential applications, the choice of high-performance T8s over standard T8s can save up to 17%.

Typical installed cost can be as little as nothing, when considering the incremental cost of a standard T8 system compared to a T12 system, or $41 per fixture if considering the full cost of a standard T8 system. Typical installed cost can be as little as $9 per fixture when considering the incremental cost of a high-performance T8 system compared to a T12 system, or $50 per fixture if considering the full cost of a high-performance T8 system.

- **Redesign with High-performance T8 Lighting Systems**

| Measure Profile | |
|---|---|
| Applicable Building Types | All |
| Vintage | Existing |
| Costs | Full $1.72/ft^2$; incremental $0.48/ft^2$ |
| Savings | 62% of lighting energy |
| Useful Life | 16 years |

The combination of lighting redesign to lower light levels and next generation T8 lighting systems results in savings of 62% and a lower incremental cost (due to fewer fixtures) relative to baseline T12 systems.

| Measure Profile | |
|---|---|
| Applicable Building Types | All |
| Vintage | New |
| Costs | Full $1.72/ft^2$; incremental $0.01/ft^2$ |
| Savings | 48% of lighting energy |
| Useful Life | 16 years |

This technology upgrade is the same as previously described in the T12 upgrades discussion above. However, in this case the savings are 48% relative to the baseline standard T8 systems.

- **Replacement of Incandescent Holiday Lights with LED Holiday Lights**

| Measure Profile | |
|---|---|
| Applicable Dwelling Type(s) | All |
| Vintage | New and existing |
| Costs | $2 incremental cost |
| Savings | 91% |
| Useful Life | 20 years |

LED seasonal decorative lights (including Christmas lights) can replace existing incandescent light strings. A string of LED holiday lights uses 14 Watts on average compared to a string of incandescent lights, which uses 150 Watts on average. LED strings thus consume less than 10% of the electricity used by a comparable string of incandescent holiday lights.

LED holiday lights are now available in most hardware stores at an incremental cost of about $1 to $3 ($2 has been used in the model, as an approximate midpoint). LED holiday lights can also last up to 10 times longer than incandescent holiday lights.

- **Lighting Timers**

| **Measure Profile** | |
|---|---|
| Applicable Dwelling Type(s) | All |
| Vintage | New and existing |
| Costs | Full cost $20 |
| Savings | 60% |
| Useful Life | 10 years |

Outdoor security lights or aesthetic lights are often fitted with a photo-sensor to run from dusk until dawn. However, if exterior lighting is only required until a certain hour (e.g., 11 pm), a timer can be installed to turn the light off automatically.

This analysis assumes that in the base case an outdoor light operates from dusk to dawn (on average 10 hours a night over the course of the year[101]) and a timer reduces this to an average of 4 hours a night. Energy savings are, therefore, in the range of 60%. Outdoor light timers cost approximately $20.[102]

- **Motion Sensors**

| **Measure Profile** | |
|---|---|
| Applicable Dwelling Type(s) | All |
| Vintage | New and existing |
| Costs | Full cost $50 |
| Savings | 95% |
| Useful Life | 10 years |

Motion sensors for residential security lighting are designed to switch on the light only if there is movement. This reduces the time that the light is actually on to 30-60 minutes per night on average and results in energy savings of approximately 95%. Motion sensors cost approximately $50.[103]

[101] Marbek Resource Consultants Ltd., *Dusk to Dawn Luminaires*.
[102] From retailer scan.
[103] From retailer scan.

## 4.4 SUMMARY OF ENERGY-EFFICIENCY RESULTS

The energy-efficiency measures and associated CCEs are summarized in Exhibit 4.2. Note that the negative values shown for selected lighting upgrades indicate that the annualized capital cost of the energy-efficiency measure is less expensive than the baseline technology.

The building-level measures for apartment buildings and their associated CCEs were derived from the results found for the Commercial sector. These are presented in Exhibit 4.3 (numbered Exhibit 4.2 in the Commercial sector report). Note that some measures in this table are not applicable to residential buildings. Measures that apply within the apartment suites are included in Exhibit 4.2 below.

## Exhibit 4.2: Residential Energy-efficiency Technologies and Measures – Cost of Conserved Energy

**Summary of CCE's - Residential Sector**

| End Use | | Technology | Dwelling Type | Vintage | Sp heating fuel | CCEs (¢/kWh) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 4.0% DR | | 6.0% DR | | 8.0% DR | |
| | | | | | | Full | Incr. | Full | Incr. | Full | Incr. |
| Lighting | Upgrade 1 | Replace incandescent with CFL | All Detachments | New & Exist. | Elec. & Non-elec. | 0.7 | -2.3 | 0.8 | -2.3 | 0.9 | -2.3 |
| | Upgrade 2 | Replace incandescent with CFL - Specialized applications | All Detachments | New & Exist. | Elec. & Non-elec. | 6.3 | -3.8 | 6.9 | -3.3 | 7.5 | -2.9 |
| | Upgrade 3 | Replace incandescent with white LED | All Detachments | New & Exist. | Elec. & Non-elec. | 16.6 | 16.5 | 19.0 | 18.8 | 21.5 | 21.2 |
| | Upgrade 4 | Replace T12 with T8 | Detached/Attached | New & Exist. | Elec. & Non-elec. | 4.2 | | 4.8 | | 5.5 | |
| | Upgrade 5 | Replace T12 with T8 | Apartment | New & Exist. | Elec. & Non-elec. | 0.6 | | 0.7 | | 0.8 | |
| | Upgrade 6 | Replace porchlight with CFL | Detached/Attached | New & Exist. | Elec. & Non-elec. | 0.2 | -0.7 | 0.2 | -0.7 | 0.3 | -0.7 |
| | Upgrade 7 | Replace porchlight with white LED | Detached/Attached | New & Exist. | Elec. & Non-elec. | 5.0 | 4.9 | 5.7 | 5.6 | 6.5 | 6.4 |
| | Upgrade 8 | Exterior and holiday lights | All Detachments | New & Exist. | Elec. & Non-elec. | 5.6 | -9.7 | 6.6 | -9.1 | 7.7 | -8.5 |
| | Upgrade 9 | Motion Sensor | All Detachments | New & Exist. | Elec. & Non-elec. | 3.0 | | 3.3 | | 3.6 | |
| | Upgrade 10 | Lighting Timer | All Detachments | New & Exist. | Elec. & Non-elec. | 1.9 | | 2.1 | | 2.3 | |
| Existing Building Envelope - Island & Isolated | Upgrade 1 | High-performance glazings | Detached | New | Elec | | 4.2 | | 5.2 | | 6.2 |
| | Upgrade 1 | High-performance glazings | Row | New | Elec | | 3.7 | | 4.5 | | 5.4 |
| | Upgrade 1 | High-performance glazings | Detached | Exist. | Elec | | 3.4 | | 4.2 | | 5.0 |
| | Upgrade 1 | High-performance glazings | Row | Exist. | Elec | | 3.9 | | 4.7 | | 5.7 |
| | Upgrade 2 | ENERGYSTAR glazings | Detached | New | Elec | | 1.6 | | 2.0 | | 2.3 |
| | Upgrade 2 | ENERGYSTAR glazings | Row | New | Elec | | 1.5 | | 1.8 | | 2.1 |
| | Upgrade 2 | ENERGYSTAR glazings | Detached | Exist. | Elec | | 2.4 | | 3.0 | | 3.6 |
| | Upgrade 2 | ENERGYSTAR glazings | Row | Exist. | Elec | | 2.9 | | 3.6 | | 4.3 |
| | Upgrade 3 | Wall Insulation | Detached | New | Elec | | 14.7 | | 18.0 | | 21.5 |
| | Upgrade 3 | Wall Insulation | Row | New | Elec | | 16.1 | | 19.6 | | 23.5 |
| | Upgrade 3 | Wall Insulation | Detached | Exist. | Elec | | 11.7 | | 14.2 | | 17.1 |
| | Upgrade 3 | Wall Insulation | Row | Exist. | Elec | | 15.3 | | 18.8 | | 22.5 |
| | Upgrade 4 | Attic Insulation | Detached | New | Elec | | 10.2 | | 12.5 | | 14.9 |
| | Upgrade 4 | Attic Insulation | Row | New | Elec | | 11.7 | | 14.3 | | 17.2 |
| | Upgrade 4 | Attic Insulation | Detached | Exist. | Elec | | 5.7 | | 6.9 | | 8.3 |
| | Upgrade 4 | Attic Insulation | Row | Exist. | Elec | | 7.6 | | 9.3 | | 11.1 |
| | Upgrade 5 | Foundation Insulation | Detached | New | Elec | | 5.9 | | 7.2 | | 8.6 |
| | Upgrade 5 | Foundation Insulation | Row | New | Elec | | 3.7 | | 4.5 | | 5.4 |
| | Upgrade 5 | Foundation Insulation | Detached | Exist. | Elec | | 6.9 | | 8.4 | | 10.1 |
| | Upgrade 5 | Foundation Insulation | Row | Exist. | Elec | | 4.7 | | 5.7 | | 6.8 |
| | Upgrade 5 | Crawlspace Insulation | Detached | New | Elec | | 2.0 | | 2.5 | | 3.0 |
| | Upgrade 5 | Crawlspace Insulation | Row | New | Elec | | 3.5 | | 4.3 | | 5.1 |
| | Upgrade 5 | Crawlspace Insulation | Detached | Exist. | Elec | | 2.2 | | 2.7 | | 3.2 |
| | Upgrade 5 | Crawlspace Insulation | Row | Exist. | Elec | | 4.0 | | 4.9 | | 5.9 |
| | Upgrade 6 | Air leakage sealing | Detached | New | Elec | | 8.9 | | 9.8 | | 10.7 |
| | Upgrade 6 | Air leakage sealing | Row | New | Elec | | 9.8 | | 10.8 | | 11.8 |
| | Upgrade 6 | Air leakage sealing | Detached | Exist. | Elec | | 9.1 | | 10.2 | | 11.4 |
| | Upgrade 6 | Air leakage sealing | Row | Exist. | Elec | | 10.1 | | 11.3 | | 12.6 |

**Exhibit 4.2: Residential Energy-efficiency Technologies and Measures – Cost of Conserved Energy (cont'd)**

| End Use | | Technology | Dwelling Type | Vintage | Sp heating fuel | CCEs (¢/kWh) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 4.0% DR | | 6.0% DR | | 8.0% DR | |
| | | | | | | Full | Incr. | Full | Incr. | Full | Incr. |
| Existing Building Envelope - Labrador Interconnected | Upgrade 1 | High-performance glazings | Detached | New | Elec | | 2.6 | | 3.2 | | 3.8 |
| | Upgrade 1 | High-performance glazings | Row | New | Elec | | 2.4 | | 2.9 | | 3.5 |
| | Upgrade 1 | High-performance glazings | Detached | Exist. | Elec | | 2.5 | | 3.1 | | 3.7 |
| | Upgrade 1 | High-performance glazings | Row | Exist. | Elec | | 2.4 | | 3.0 | | 3.5 |
| | Upgrade 2 | ENERGYSTAR glazings | Detached | New | Elec | | 1.0 | | 1.2 | | 1.4 |
| | Upgrade 2 | ENERGYSTAR glazings | Row | New | Elec | | 0.9 | | 1.1 | | 1.4 |
| | Upgrade 2 | ENERGYSTAR glazings | Detached | Exist. | Elec | | 1.7 | | 2.1 | | 2.5 |
| | Upgrade 2 | ENERGYSTAR glazings | Row | Exist. | Elec | | 1.9 | | 2.3 | | 2.7 |
| | Upgrade 3 | Wall Insulation | Detached | New | Elec | | 12.8 | | 15.7 | | 18.8 |
| | Upgrade 3 | Wall Insulation | Row | New | Elec | | 9.2 | | 11.2 | | 13.5 |
| | Upgrade 3 | Wall Insulation | Detached | Exist. | Elec | | 4.4 | | 5.3 | | 6.4 |
| | Upgrade 3 | Wall Insulation | Row | Exist. | Elec | | 5.5 | | 6.7 | | 8.1 |
| | Upgrade 4 | Attic Insulation | Detached | New | Elec | | 6.8 | | 8.3 | | 9.9 |
| | Upgrade 4 | Attic Insulation | Row | New | Elec | | 6.0 | | 7.3 | | 8.8 |
| | Upgrade 4 | Attic Insulation | Detached | Exist. | Elec | | 2.5 | | 3.1 | | 3.7 |
| | Upgrade 4 | Attic Insulation | Row | Exist. | Elec | | 3.1 | | 3.8 | | 4.6 |
| | Upgrade 5 | Foundation Insulation | Detached | New | Elec | | 1.6 | | 2.0 | | 2.3 |
| | Upgrade 5 | Foundation Insulation | Row | New | Elec | | 1.0 | | 1.2 | | 1.4 |
| | Upgrade 5 | Foundation Insulation | Detached | Exist. | Elec | | 2.0 | | 2.4 | | 2.9 |
| | Upgrade 5 | Foundation Insulation | Row | Exist. | Elec | | 1.5 | | 1.9 | | 2.2 |
| | Upgrade 5 | Crawlspace Insulation | Detached | New | Elec | | 1.0 | | 1.2 | | 1.4 |
| | Upgrade 5 | Crawlspace Insulation | Row | New | Elec | | 1.8 | | 2.2 | | 2.6 |
| | Upgrade 5 | Crawlspace Insulation | Detached | Exist. | Elec | | 1.3 | | 1.6 | | 1.9 |
| | Upgrade 5 | Crawlspace Insulation | Row | Exist. | Elec | | 2.3 | | 2.9 | | 3.4 |
| | Upgrade 6 | Air leakage sealing | Detached | New | Elec | | 3.0 | | 3.2 | | 3.5 |
| | Upgrade 6 | Air leakage sealing | Row | New | Elec | | 3.2 | | 3.5 | | 3.8 |
| | Upgrade 6 | Air leakage sealing | Detached | Exist. | Elec | | 3.7 | | 4.1 | | 4.6 |
| | Upgrade 6 | Air leakage sealing | Row | Exist. | Elec | | 3.9 | | 4.4 | | 4.9 |
| Space Heating and Ventilation Equipment | Upgrade 1 | Prog. Tstat - High Cons. | All Detachments | New & Exist. | Elec | 0.5 | | 0.6 | | 0.6 | |
| | Upgrade 1 | Prog. Tstat - Med Cons. | All Detachments | New & Exist. | Elec | 1.0 | | 1.2 | | 1.3 | |
| | Upgrade 1 | Prog. Tstat - Low Cons. | All Detachments | New & Exist. | Elec | 1.6 | | 1.7 | | 1.9 | |
| | Upgrade 1 | Eff. Tstat - High Cons. | All Detachments | New & Exist. | Elec | 0.4 | | 0.5 | | 0.5 | |
| | Upgrade 1 | Eff. Tstat - Med Cons. | All Detachments | New & Exist. | Elec | 0.9 | | 1.0 | | 1.1 | |
| | Upgrade 1 | Eff. Tstat - Low Cons. | All Detachments | New & Exist. | Elec | 1.3 | | 1.5 | | 1.7 | |
| | Upgrade 1 | Air source heat pump | All Detachments - Island | New | Elec | 11.7 | 9.6 | 13.9 | 11.4 | 16.2 | 13.3 |
| | Upgrade 2 | Air source heat pump | All Detachments - Lab | New | Elec | 4.7 | 3.9 | 5.6 | 4.6 | 6.6 | 5.4 |
| | Upgrade 3 | Ground source heat pump | All Detachments - Island | New | Elec | 18.0 | 16.4 | 21.4 | 19.4 | 25.0 | 22.7 |
| | Upgrade 1 | Ground source heat pump | All Detachments - Lab | New | Elec | 7.3 | 6.6 | 8.6 | 7.9 | 10.1 | 9.2 |
| | Upgrade 3 | Integrated Space/DHW heating | All Detachments - Island | New | Elec | 15.7 | 14.4 | 18.6 | 17.0 | 21.8 | 19.9 |
| | Upgrade 1 | Integrated Space/DHW heating | All Detachments - Lab | New | Elec | 7.1 | 6.5 | 8.4 | 7.7 | 9.8 | 9.0 |

## Exhibit 4.2: Residential Energy-efficiency Technologies and Measures – Cost of Conserved Energy (cont'd)

| End Use | | Technology | Dwelling Type | Vintage | Sp heating fuel | CCEs (¢/kWh) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 4.0% DR | | 6.0% DR | | 8.0% DR | |
| | | | | | | Full | Incr. | Full | Incr. | Full | Incr. |
| Space Heating and Ventilation Equipment | Upgrade1 | Electronically commutated permanent magnet motors (ECPM) - High Cons | Detached/Attached | New/Existing | Elec. & Non-elec. | | 3.7 | | 4.4 | | 5.1 |
| | Upgrade1 | Electronically commutated permanent magnet motors (ECPM) - Low Cons | Detached/Attached | New/Existing | Elec. & Non-elec. | | 7.4 | | 8.7 | | 10.2 |
| | Upgrade1 | Electronically commutated permanent magnet motors (ECPM) - Continuous | Detached/Attached | New/Existing | Elec. & Non-elec. | | 0.9 | | 1.1 | | 1.3 |
| | Upgrade2 | Heat Recovery Ventilator - High Cons | Detached/Attached | New & Exist. | Elec. & Non-elec. | 15.2 | 3.1 | 17.4 | 3.6 | 19.7 | 4.1 |
| | Upgrade2 | Heat Recovery Ventilator - Med Cons | Detached/Attached | New & Exist. | Elec. & Non-elec. | 35.1 | 7.2 | 40.2 | 8.3 | 45.6 | 9.4 |
| | Upgrade2 | Heat Recovery Ventilator - Low Cons | Detached/Attached | New & Exist. | Elec. & Non-elec. | 39.7 | 8.2 | 45.4 | 9.4 | 51.5 | 10.6 |
| Domestic Hot Water | Upgrade1 | Efficient shower/faucet | All Detachments | Exist. | Elec DHW | 0.9 | | 1.0 | | 1.1 | |
| | Upgrade2 | DHW tank insulation | Detached | New & Exist. | Elec DHW | 1.9 | 1.9 | 2.1 | 2.1 | 2.3 | 2.3 |
| | Upgrade2 | DHW tank insulation | Attached | New & Exist. | Elec DHW | 4.1 | 4.1 | 4.5 | 4.5 | 5.0 | 5.0 |
| | Upgrade 3 | Heat trap | All Detachments | New & Exist. | Elec DHW | 18.4 | 18.4 | 19.2 | 19.2 | 20.1 | 20.1 |
| | Upgrade 4 | Pipe Insulation | Detached/Attached | New & Exist. | Elec DHW | 0.4 | 0.4 | 0.4 | 0.4 | 0.5 | 0.5 |
| Major Appliances | Upgrade 1 | Energy Star top-loading clothes washer + Dryer energy | All Detachments | New & Exist. | Elec DHW | | 7.5 | | 8.6 | | 9.8 |
| | Upgrade 2 | Horizontal axis clothes washer + Dryer Energy | All Detachments | New & Exist. | Elec DHW | | 16.6 | | 19.0 | | 21.5 |
| | Upgrade 3 | New Energy Star dishwasher | All Detachments | New & Exist. | Elec DHW | | 17.4 | | 19.6 | | 21.9 |
| | Upgrade 4 | Highest efficiency dishwasher | All Detachments | New & Exist. | Elec DHW | | 1.5 | | 1.7 | | 1.9 |
| | Upgrade 5 | Energy Star 18 Cu Ft New | Detached/Attached | New & Exist. | Elec. & Non-elec. | | 4.5 | | 5.2 | | 6.1 |
| | Upgrade 6 | Highest efficiency refrigerator | Detached/Attached | New & Exist. | Elec. & Non-elec. | | 74.1 | | 88.1 | | 103.2 |
| | Upgrade 7 | Energy Star compact | Apartment | New & Exist. | Elec. & Non-elec. | | 4.3 | | 5.1 | | 5.9 |
| | Upgrade 8 | High efficiency freezer | Detached/Attached | New & Exist. | Elec. & Non-elec. | | 7.6 | | 8.9 | | 10.3 |
| | Upgrade 9 | High efficiency freezer | Apartment | New & Exist. | Elec. & Non-elec. | | 12.5 | | 14.6 | | 16.9 |
| | Upgrade 10 | Microwave/convection oven | All Detachments | | | | 50.6 | | 59.9 | | 70.0 |
| Household Electronics | Upgrade 1 | ENERGY STAR Computer | All Detachments | New & Exist. | Elec. & Non-elec. | | 0.0 | | 0.0 | | 0.0 |
| | Upgrade 2 | LCD monitors | All Detachments | New & Exist. | Elec. & Non-elec. | | -0.8 | | 0.1 | | 1.0 |
| | Upgrade 3 | ENERGY STAR television | All Detachments | New & Exist. | Elec. | | 4.9 | | 5.8 | | 6.8 |
| | Upgrade 3 | LCD Television | All Detachments | New & Exist. | Elec. | | 29.0 | | 34.3 | | 40.1 |
| | Upgrade 4 | Miscellaneous reduced standby | All Detachments | New & Exist. | Elec. & Non-elec. | | 1.4 | | 1.6 | | 1.9 |
| New Building Design | Upgrade 1 | R2000 housing | Detached | New | Elec. | 252.4 | 6.8 | 317.1 | 8.5 | 387.8 | 10.4 |
| | Upgrade 2 | EGH 80 | Detached | New | Elec. | 249.4 | 3.7 | 313.3 | 4.6 | 383.0 | 5.7 |
| Fuel Switching | Upgrade 1 | Oil Furnace, New Island Detached | Detached | New | Elec. | | 13.6 | | 14.1 | | 14.6 |
| | Upgrade 1 | Oil Furnace, New Labrador Detached | Detached | New | Elec. | | 10.8 | | 11.0 | | 11.2 |
| | Upgrade 1 | Oil Furnace, New Island Attached | Attached | New | Elec. | | 12.8 | | 13.2 | | 13.7 |
| | Upgrade 1 | Oil Furnace, New Labrador Attached | Attached | New | Elec. | | 10.2 | | 10.4 | | 10.6 |
| | Upgrade 2 | Propane Cooking Range | All Detachments | New & Exist. | Elec. | | 49.0 | | 50.3 | | 51.8 |

## Exhibit 4.3: Commercial (Apartment Buildings) Energy-efficiency Technologies and Measures – Cost of Conserved Energy[104]

| Measure/Technology | | | Vintage | CCEs (¢/kWh) | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | 4.0% DR | | 6.0% DR | | 8.0% DR | |
| | | | | Full | Incr. | Full | Incr. | Full | Incr. |
| Lighting | T12 | Standard T8s | Existing | 5.4 | 0.0 | 6.3 | 0.0 | 7.2 | 0.0 |
| | | Low BF T8s | Existing | 3.9 | 0.0 | 4.6 | 0.0 | 5.2 | 0.0 |
| | | High-performance T8s | Existing | 4.2 | 0.5 | 4.9 | 0.7 | 5.7 | 0.8 |
| | | Redesign with standard T8s | Existing | 5.1 | -2.0 | 5.9 | -2.3 | 6.8 | -2.6 |
| | | Redesign with high-performance T8s | Existing | 4.9 | -1.3 | 5.6 | -1.6 | 6.4 | -1.8 |
| | T8 | High-performance T8s | Existing & New | 13.1 | 1.7 | 15.3 | 2.1 | 17.6 | 2.5 |
| | | Redesign with high-performance T8s | Existing & New | 8.4 | 0.0 | 9.8 | 0.0 | 11.2 | 0.0 |
| | | Fully integrated lighting and controls | Existing & New | 29.6 | 22.0 | 34.3 | 25.4 | 39.3 | 29.2 |
| | | Occupancy sensors | Existing & New | 6.0 | 4.3 | 6.6 | 4.7 | 7.2 | 5.1 |
| | Inc | Compact fluorescent lamps | Existing & New | 2.7 | -1.1 | 2.9 | -1.0 | 3.2 | -0.8 |
| | | Induction lighting | Existing & New | 4.5 | 0.4 | 4.9 | 0.7 | 5.4 | 1.1 |
| | | White LEDs | Existing & New | 0.1 | -3.5 | 0.4 | -3.2 | 0.8 | -2.8 |
| | | Halogen IR | Existing & New | 10.1 | -4.8 | 10.5 | -4.7 | 10.8 | -4.6 |
| | | Ceramic metal halide | Existing & New | 4.7 | -4.6 | 5.1 | -4.4 | 5.6 | -4.1 |
| | | LED exit signs | Existing | 1.7 | na | 2.0 | na | 2.4 | na |
| | HID | Pulse-start metal halide | Existing & New | 9.5 | 0.3 | 10.9 | 0.3 | 12.5 | 0.4 |
| | | High intensity fluorescents | Existing & New | 4.1 | 0.4 | 4.8 | 0.5 | 5.4 | 0.5 |
| HVAC | | Low temperature heat pumps - Island | Existing & New | na | 5.5 | na | 6.0 | na | 6.6 |
| | | Low temperature heat pumps - Labrador | Existing & New | na | 4.8 | na | 5.3 | na | 5.8 |
| | | Ground source heat pumps - Island | Existing & New | na | 6.2 | na | 7.3 | na | 8.6 |
| | | Ground source heat pumps - Labrador | Existing & New | na | 4.5 | na | 5.4 | na | 6.3 |
| | | Infrared heaters - Island | Existing & New | 6.7 | 6.7 | 7.4 | 7.4 | 8.1 | 8.1 |
| | | Infrared heaters - Labrador | Existing & New | 4.8 | 4.8 | 5.3 | 5.3 | 5.8 | 5.8 |
| | | High-efficiency chillers - Island | Existing & New | na | 6.1 | na | 7.4 | na | 8.9 |
| | | High-efficiency chillers - Labrador | Existing & New | na | 8.1 | na | 9.9 | na | 11.8 |
| | | High-efficiency AC units - Island | Existing & New | na | 11.3 | na | 12.9 | na | 14.7 |
| | | High-efficiency AC units - Labrador | Existing & New | na | 18.7 | na | 21.5 | na | 24.3 |
| | | Adjustable speed drives | Existing & New | 5.0 | 5.0 | 5.6 | 5.6 | 6.1 | 6.1 |
| | | Premium efficiency motors | Existing & New | 19.5 | 2.9 | 21.5 | 3.2 | 23.5 | 3.6 |
| | | Building recommissioning | Existing | 4.0 | na | 4.3 | na | 4.5 | na |
| | | Advanced BAS | Existing & New | 4.3 | na | 4.7 | na | 5.1 | na |
| | | Programmable thermostats - Island | Existing & New | 1.8 | 0.9 | 2.0 | 1.0 | 2.2 | 1.1 |
| | | Programmable thermostats - Labrador | Existing & New | 1.6 | 0.8 | 1.8 | 0.9 | 1.9 | 1.0 |
| DHW | | Low-flow aerators & shower heads | Existing & New | 2.6 | na | 2.8 | na | 2.9 | na |
| | | Tankless water heaters | Existing & New | na | 37.4 | na | 41.2 | na | 45.2 |
| Building Envelope | | High-performance glazings - Island | Existing & New | na | 5.5 | na | 6.5 | na | 7.5 |
| | | High-performance glazings - Labrador | Existing & New | na | 3.3 | na | 4.0 | na | 4.6 |
| | | Wall insulation - Island | Existing & New | na | 6.0 | na | 7.4 | na | 8.8 |
| | | Wall insulation - Labrador | Existing & New | na | 4.2 | na | 5.1 | na | 6.1 |
| | | Roof insulation - Island | Existing & New | na | 6.9 | na | 8.5 | na | 10.1 |
| | | Roof insulation - Labrador | Existing & New | na | 4.4 | na | 5.3 | na | 6.4 |
| | | Air curtains - Island | Existing & New | 5.1 | 5.1 | 5.8 | 5.8 | 6.6 | 6.6 |
| | | Air curtains - Labrador | Existing & New | 3.3 | 3.3 | 3.8 | 3.8 | 4.3 | 4.3 |
| New Construction | | New buildings - 25% more efficient | New | na | 0.9 | na | 1.1 | na | 1.4 |
| | | New buildings - 40% more efficient | New | na | 2.5 | na | 3.1 | na | 3.8 |

[104] This exhibit is produced from the measure summary in the Commercial report.

## 4.5 PEAK LOAD REDUCTION MEASURES

### 4.5.1 Overview

Electric utilities are typically interested in peak load reduction measures as a means to avoid or defer the costs of capacity expansion. Capacity costs refer to a wide range of capital-based investments, including generating stations (new and upgraded), transmission lines, distribution lines, substations, transformers and other infrastructure required to deliver power.

From the customer's perspective, adoption of peak load reduction measures is typically dependent on the overall benefits to them, such as direct incentive payments or rate benefits. Under most current rate structures, residential customers are billed only for electricity (kWh) regardless of when it is used, and not for "demand." Consequently, in the absence of specific peak-based rate structures, peak load reduction measures that do not also reduce overall energy consumption do not provide financial benefits to customers.

The current trend throughout much of the North American utility industry is towards more specific pricing, such as time-of-use and even hourly pricing, or peak incentives that pass along some of the utility benefits to customers on a performance basis. These new pricing structures provide incentive for even residential customers to implement measures or to participate in utility peak load reduction programs, as long as the differential between peak and off-peak prices is sufficient to provide a noticeable financial benefit to the customer. To date, effective implementation of many of the potential peak load reduction options has been limited by the availability and cost of suitable metering and data communications technology.

Currently, several Canadian jurisdictions[105] are in the early stages of implementing pilot Residential sector load reduction initiatives. These initiatives are designed to test:

- New metering technologies, such as advanced meters (also referred to as "smart meters")
- New rate structures, such as real-time feedback, pay-as-you-go billing and critical peak pricing
- Direct load control.

Most conventional meters monitor electricity consumption (kWh) but do not track *when* the electricity is used. Instead, conventional meters are occasionally read and reported to electric utilities, which then bill customers every one or two months. As a result, customers only find out their electricity usage after the fact.

In contrast, advanced meters (known in some industry circles as "smart meters") record how much electricity is used and when. Advanced meters, through their interval metering

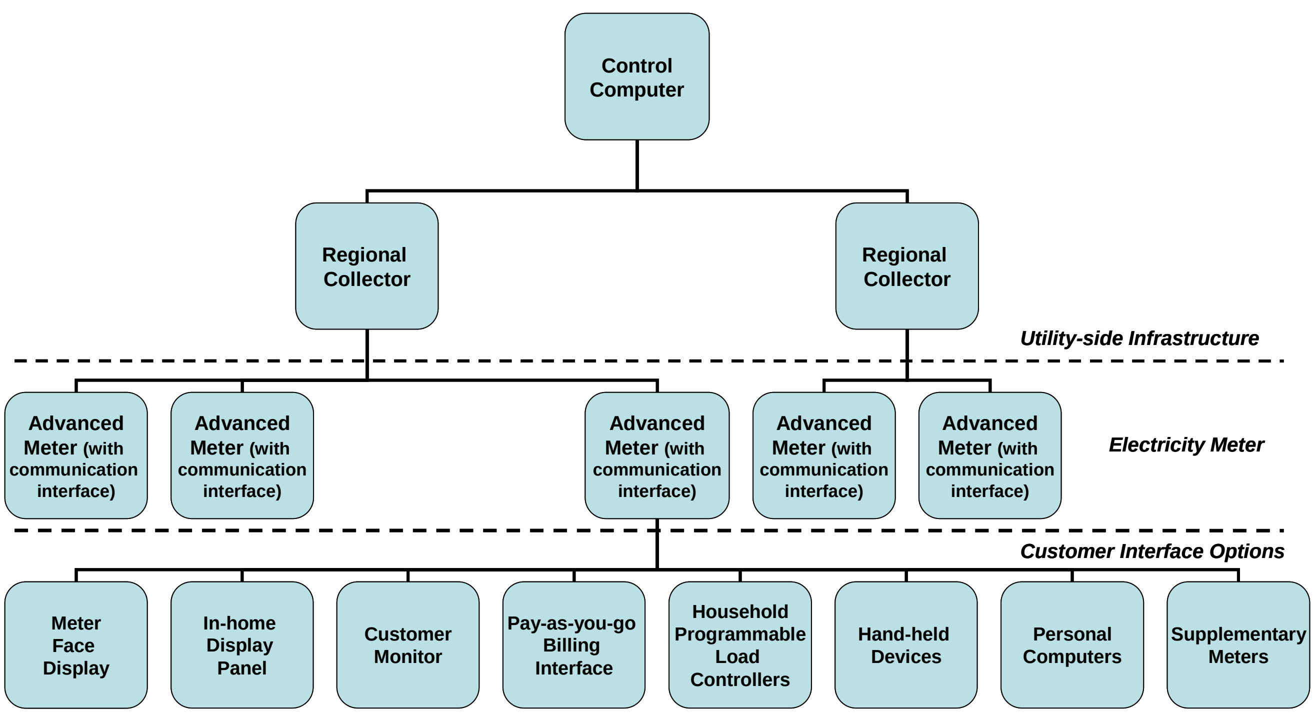
[105] Marbek Resource Consultants; *Technology & Market Assessment of Residential Electricity Advanced Metering In Canada*. Prepared for Natural Resources Canada, November 2006.

and two-way communications, allow the implementation of numerous utility programs and services that encourage customers to reduce or shift (i.e., change the time of) their electricity consumption, particularly away from peak times when the cost of supply is becoming increasingly more expensive.

Exhibit 4.4 presents an illustrative schematic of an advanced metering system. As illustrated, there are three major levels of system components:

- **Customer Interface Options** — The hardware interfaces that can be used for the advanced meter to communicate with the customer and, to a certain extent, any applicable electrical load controllers in the customer's household.
- **Electricity Meter** — The advanced meter itself, equipped with a communication interface to facilitate communication to other devices and the utility.
- **Utility-side Infrastructure** — The infrastructure required for two-way communication between the utility and the advanced meter.[106]

**Exhibit 4.4: Illustrative Schematic of an Advanced Metering System**




[106] Ibid, *Technology & Market Assessment of Residential Electricity Advanced Metering In Canada*. page 4

As illustrated in Exhibit 4.4, there is wide range of technical options available at each level in a typical advanced metering system. This is particularly the case at the customer interface level where there is a growing number of devices that can be used to provide real-time feedback to customers in a convenient and understandable manner. Typically, these devices provide a numerical or graphical display that is either wired into the same room as the meter, wired next to the main thermostat, or is a wireless panel that can be placed anywhere in the home. Alone, none of these devices save energy per se, though the information provided may enable consumer behaviour change.

In summary, new electric metering and customer interface technologies, when combined with the applicable utility infrastructure, have the potential to support a wide range of utility-sponsored peak load reduction and load shifting initiatives via pricing and promotional initiatives. Within the agreed study scope, it is not feasible to provide further specific rate design or system infrastructure specifications. However, further information is provided below on selected direct load control options.

### 4.5.2 Peak Load Reduction Measures – Direct Load Control

Consistent with the agreed study scope, the information provided below is based on existing secondary data sources and does not include a detailed analysis of specific peak load conditions of the Utilities. Much of the information provided draws from work that the consultant team recently completed for BC Hydro.[107] To that end, the material presented is intended to be indicative of general trends and costs but would also need to be adjusted for specific application to NLH/NP peak load conditions.[108]

The remainder of this subsection provides an overview of the following Residential sector peak load reduction measures:

- Utility control of space heating equipment using remote thermostat or switch
- Utility control of DHW heater using remote switch.

#### ❑ Utility-Based Control of Space Heating Equipment

Utility-based control of space heating equipment can be thermostat-based or switch-based. Thermostat-based control typically applies to those applications where there is one thermostat that controls a central furnace (or air conditioner) that provides space conditioning for the entire home. Switch-based control, on the other hand, applies to those applications where space heating is provided by baseboard heaters with individual (or multiple) thermostats. As virtually all of the residential electric space heating in Newfoundland and Labrador is baseboard heating, the remainder of this discussion focuses on switch-based space heating load control.

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[107] Marbek Resource Consultants and Applied Energy Group. *BC Hydro Conservation Potential Review – 2007*. Prepared for BC Hydro, 2007.

[108] As both BC Hydro and NLH/NP are winter peaking utilities and both are hydro-based with fossil fuel plants serving peak load conditions, the information provided is expected to be generally applicable to the NLH/NP context.

Switch-based space heating load control is accomplished by the installation of a remote control switch on either the heating unit itself or on the circuits controlling the heating unit. This measure primarily addresses units where temperature control is on each room unit, without a central thermostat capability. Typically this would include baseboard units with individual controls or where one or more units are controlled from an electrical circuit. Typically, units are not shut off for the entire control period but rather “cycled” to limit the on time to a predetermined number of minutes per control cycle. Installations are also equipped with an owner-operated override to ensure that the customer’s comfort is not adversely impacted.

The control technology is commercially available and has been implemented in millions of sites in the U.S. However, in the overwhelming majority of applications, this control technology has been applied to air conditioning loads, not space heating loads.

The research conducted for the BC Hydro study[109] noted that switches cost approximately $285 ($170 device plus $115 installation), plus 10% annual equipment maintenance ($12/year). The installation cost is higher for the switch because it involves a high voltage connection and would thus require a higher skilled installer (in many locales this would be a licensed electrician). Installation costs are the same in both new and existing homes.

Actual peak load reduction is difficult to predict due to the impacts of customer override to mitigate adverse comfort impacts, which depend heavily on the degree of over- or under-sizing of the units as well as the overall thermal characteristics of the home. Override control is critical to ensure that customers with undersized systems, poor insulation or low tolerance for cold would not be too adversely affected.

On a household basis, the BC Hydro study concluded that the potential peak load reduction (during the 8 am to 1 pm period on a typical winter peak day) would be in the range of 0.74-0.92 kW per single-family dwelling (annual space heat load of about 13,000 kWh), assuming a comparable level of overrides and system failures to current thermostat programs. Previous experience has also shown that reductions may erode over time due to a number of factors, including signal strength losses and customer overrides.

Based on a one-time cost of approximately $285 ($170 device plus $115 installation), plus 10% annual equipment maintenance ($12/year), and estimated annual impacts of 0.74-0.92 kW per household, the BC Hydro study estimated that the cost would be in the range of about $30-$40[110] per kW/year when applied to single-family dwellings with 100% electric fuel use. Utility infrastructure costs as well as program promotion or incentive costs are in addition.

***Caveat***

The experience in this technology has primarily been for central air conditioning and water heater load control. As there are no customer benefits inherent in the technology, a

[109] Op. cit., BC Hydro Conservation Potential Review – 2007, p. 140.
[110] Assumes 15-year life, 6% discount rate.

cash incentive would typically be expected for each season that the measure was needed, payable either by season or by event (or both).

- **Utility Control of Domestic Hot Water Heater Using Remote Switch**

Switch-based water heater load control is accomplished by the installation of a remote control switch on either the water heater itself or on the circuits controlling the water heater. In older systems, this type of control has been accomplished via radio frequency (RF) control, which allows remote shut off of the water heater under specific capacity-constrained conditions during a limited number of pre-specified hours during winter peak months. In the systems that are currently offered, pager-based communications is used. An even more economic solution is to piggyback off an existing communications system. For example, if space heat control already exists, water heat control can be added via a hard-wired or wireless connection. This can reduce the total cost of the water heater control by up to 40%.

Depending upon the length of the control and the size of the water heater tank, units can be shut off for the entire control period or “cycled” to limit the on time to a predetermined number of minutes per control cycle. Water heat control is commercially available and implemented in hundreds of thousands of sites in the U.S.

Applicable dwelling types should have a water heater that has at least a 40-gallon tank. The size of the tank is important because it provides hot water during times when the control is in effect. The larger the water heater tank, the longer the control can be in place without disrupting the customer’s comfort.

Switches cost about $100 per unit, plus $150 for installation, plus maintenance. Costs are reduced to $150 (i.e., $50 incremental installation) if the control switch can be added to an existing control system at the same time, including one-way/two-way thermostats and switches for space heating. Installation costs are the same in both new and existing homes.[111]

On a household basis, the BC Hydro study concluded that the potential peak load reduction (during the 8 am to 1 pm period on a typical winter peak day) would be about 0.66 kW. This assumes annual DHW electricity consumption of about 3,300 kWh/yr. per household.

Based on a one-time cost of approximately $250, ongoing maintenance of 5% (about $12/year) and estimated annual impacts of 0.63-0.70 kW, the BC Hydro study estimated that the cost would be in the range of about $49-$55[112] per kW/year when applied to single-family dwellings. As an incremental option to space heating load control, the installation costs would be reduced by $100 and the resulting cost of electric peak reduction (CEPR) would be $35-$39 per kW. Utility infrastructure costs as well as program promotion or incentive costs are in addition.

[111] Op. cit., BC Hydro Conservation Potential Review – 2007, p. 146.
[112] Assumes 15-year life, 6% discount rate.

Because there are no customer benefits inherent in the technology, a cash incentive would typically be expected for each season that the measure was needed, payable either by season or by event (or both). Additional work would be required to maintain, verify and evaluate the system performance to the same degree of accuracy as two-way thermostat systems due to the lack of confirmation and higher incidence of removals and failures.

***Caveat***

This water heater control measure would not provide customers with any ancillary benefits and thus the only incentive for their participation would be monetary, likely on a per annum or per control event basis.

# 5. ECONOMIC POTENTIAL ELECTRICITY FORECAST

## 5.1 INTRODUCTION

This section presents the Residential sector Economic Potential Forecast for the study period 2006 to 2026. The Economic Potential Forecast estimates the level of electricity consumption that would occur if all equipment and building envelopes were upgraded to the level that is cost effective against the long run avoided cost of electricity in the Newfoundland Labrador service area. In this study, "cost effective" means that the technology upgrade cost, referred to as the cost of conserved energy (CCE) in the preceding section, is equal to, or less than, the economic screen.[113]

The discussion in this section is organized according to the following sub sections:

- Avoided Cost Used for Screening
- Major Modelling Tasks
- Technologies Included in Economic Potential Forecast
- Summary of Results
- CDM Measure Supply Curves.

## 5.2 AVOIDED COST USED FOR SCREENING

NLH has determined that the primary avoided costs of new electricity supply to be used for this analysis are $0.0980/kWh for the Island and Isolated service region and $0.0432/kWh for the Labrador Interconnected service region. These avoided costs represent a future in which the Lower Churchill project is not built and there is no DC link from Labrador to the Island.[114]

Therefore, the Economic Potential Forecast incorporates all the CDM measures reviewed in Section 4 that have a CCE equal to or less than the avoided costs.

NLH is currently studying the Lower Churchill/DC Link project. However, a decision on whether to proceed is not expected until 2009 and, even if the project proceeds, the earliest completion date would be in late 2014. This means that, regardless of the decision, the avoided cost values shown above will be in effect until the approximate mid point of the study period.

If the Lower Churchill/DC Link project does proceed, the avoided costs presented above are expected to change. To provide insight into the potential impacts of the Lower Churchill/DC Link project on this study, it was agreed that the consultants would provide a high-level sensitivity analysis.

[113] Costs related to program design and implementation are not yet included.
[114] The avoided costs draw on the results of the earlier study conducted by NERA Economic Consulting, which is entitled: Newfoundland and Labrador Hydro. *Marginal Costs of Generation and Transmission*. May 2006. The avoided costs used in this study include generation, transmission and distribution.

## 5.3 MAJOR MODELLING TASKS

By comparing the results of the Residential sector Economic Potential Electricity Forecast with the Reference Case, it is possible to determine the aggregate level of potential electricity savings within the Residential sector, as well as identify which specific dwelling and end uses provide the most significant opportunities for savings.

To develop the Residential sector Economic Potential Forecast, the following tasks were completed:

- The CCE for each of the energy-efficient upgrades presented in Exhibits 4.2 and 4.3 were reviewed, using the 6% (real) discount rate. [115]

- Technology upgrades that had a CCE equal to, or less than, the avoided cost threshold were selected for inclusion in the economic potential scenario, either on a "full cost" or "incremental" basis. It is assumed that technical upgrades having a "full cost" CCE that met the cost threshold were implemented in the first forecast year. It is assumed that those upgrades that only met the cost threshold on an "incremental" basis are being introduced more slowly as the existing stock reaches the end of its useful life.

- Electricity use within each of the dwelling types was modelled with the same energy models used to generate the Reference Case. However, for this forecast, the remaining "baseline" technologies included in the Reference Case forecast were replaced with the most efficient "technology upgrade option" and associated performance efficiency that met the cost threshold of $0.0980/kWh for the Island and Isolated service region and $0.0432/kWh for the Labrador Interconnected service region.

- When more than one upgrade option was applied to a given end use, the first measure selected was the one that reduced the electrical load. For example, measures to reduce the overall DHW load (e.g., low-flow showerheads and more efficient dishwashers) were applied before the heat pump water heater. Similarly, the cost effectiveness of the heat pump water heater was tested at the new, lower annual load and included only if it continued to meet the CCE threshold.

- The economic potential analysis includes full consideration of interaction between measures and interaction between end uses. Measures applied to the same end use are applied sequentially, so that there is no "double-counting" of savings. The second measure applied to an end use takes its savings from the energy consumption remaining after the first measure has been applied. Interaction between end uses affects space heating, because measures that reduce internal loads (lighting, appliances, electronics, etc.) tend to increase the space heating consumption. In extreme cases, where few space heating measures are applied and the savings in other end uses are large, the space heating may actually increase.

[115] See Section 4.2.

- A sensitivity analysis was conducted using preliminary avoided cost values that assume development of the Lower Churchill/DC Link.

## 5.4 TECHNOLOGIES INCLUDED IN ECONOMIC POTENTIAL FORECAST

Exhibits 5.1 and 5.2 provide a listing of the technologies selected for inclusion in this forecast for, respectively, the Island and Isolated and Labrador Interconnected service regions. In each case, the exhibits show the following:

- End use affected
- Upgrade option(s) selected
- Dwelling types to which the upgrade options were applied
- Rate at which the upgrade options were introduced into the stock.

## Exhibit 5.1: Technologies Included in Economic Potential Forecast for the Island and Isolated Service Region

| End Use | Upgrade Option | Applicability of Upgrade Options by Dwelling Type | Rate of Stock Introduction |
|---|---|---|---|
| Existing Building Envelope | ENERGY STAR Windows | Detached and Attached | New construction, immediate<br>Existing homes, at rate of window replacement |
| | Super high-performance windows | Detached and Attached | New construction, immediate<br>Existing homes, at rate of window replacement |
| | Air leakage sealing | Detached and Attached | Immediate |
| | Attic insulation | Detached and Attached | Immediate |
| | Wall insulation | Detached and Attached | Immediate where insulation can be blown in; where rigid foam external insulation is needed, at rate of siding replacement |
| | Foundation insulation | Detached and Attached | At rate of installation or replacement of finished basement walls |
| New Building Design | New house designed to an EG80 rating | Detached and Attached | Immediate |
| | New apartment building designed to 40% better energy consumption than current standard | Apartment | Immediate |
| Space Heating and Ventilation Equipment | Efficient (programmable and highly accurate) thermostats | All Residential | Immediate |
| | High-efficiency HRV | Detached and Attached | New construction, immediate<br>Existing homes, at rate of unit replacement |
| | Cold climate heat pumps | Apartment | Immediate in new construction |
| Domestic Hot Water | DHW pipe wrap | Detached and Attached | Immediate |
| | Low-flow shower heads and faucets | All Residential | Immediate |
| Major Appliances | ENERGY STAR fridge | All Residential | At rate of unit replacement |
| | Energy-efficient freezer | All Residential | At rate of unit replacement |
| | ENERGY STAR top loading clothes washer | All Residential | At rate of unit replacement |
| Lighting | CFLs, including both standard and specialized | All Residential | Immediate |
| | LED holiday lights | All Residential | At rate of unit replacement |
| | Outdoor lighting timer | Detached and Attached | Immediate |
| | Motion sensor | Detached and Attached | Immediate |
| | T8 lighting in common areas | Apartment | New construction, immediate<br>Existing, at rate of renovation |
| Computers & Peripherals | ENERGY STAR computer | All Residential | At rate of unit replacement |
| | Reduce standby losses | All Residential | Immediate |
| Television | ENERGY STAR TV | All Residential | At rate of unit replacement |
| | Reduce standby losses | All Residential | Immediate |

| End Use | Upgrade Option | Applicability of Upgrade Options by Dwelling Type | Rate of Stock Introduction |
|---|---|---|---|
| Television Peripherals | Reduce standby losses | All Residential | Immediate |
| Other Electronics | Reduce standby losses | All Residential | Immediate |

## Exhibit 5.2: Technologies Included in Economic Potential Forecast for the Labrador Interconnected Service Region

| End Use | Upgrade Option | Applicability of Upgrade Options by Dwelling Type | Rate of Stock Introduction |
|---|---|---|---|
| Existing Building Envelope | ENERGY STAR Windows | Detached and Attached | New construction, immediate<br>Existing homes, at rate of window replacement |
| | Super high-performance windows | Detached and Attached | New construction, immediate<br>Existing homes, at rate of window replacement |
| | Air leakage sealing | Detached and Attached | Immediate |
| | Attic insulation | Detached and Attached | Immediate |
| | Wall insulation | Detached and Attached | Immediate where insulation can be blown in; where rigid foam external insulation is needed, at rate of siding replacement |
| | Foundation insulation | Detached and Attached | At rate of installation or replacement of finished basement walls |
| Space Heating and Ventilation Equipment | Efficient (programmable and highly accurate) thermostats | All Residential | Immediate |
| | Cold climate heat pumps | Apartment | Immediate in new construction |
| Domestic Hot Water | DHW pipe wrap | Detached and Attached | Immediate |
| | Low-flow shower heads and faucets | All Residential | Immediate |
| Lighting | CFLs, standard only | All Residential | Immediate |
| | Outdoor lighting timer | Detached and Attached | Immediate |
| | Motion sensor | Detached and Attached | Immediate |
| | T8 lighting in common areas | Apartment | New construction, immediate<br>Existing, at rate of renovation |
| Computers & Peripherals | ENERGY STAR computer | All Residential | At rate of unit replacement |
| | Reduce standby losses | All Residential | Immediate |
| Television | Reduce standby losses | All Residential | Immediate |
| Television Peripherals | Reduce standby losses | All Residential | Immediate |
| Other Electronics | Reduce standby losses | All Residential | Immediate |

## 5.5 SUMMARY OF RESULTS[116]

This section compares the Reference Case and Economic Potential Electricity Forecast levels of residential electricity consumption for the two service regions. In each case, the results are presented as electricity savings that would occur at the customer's point-of-use. The results are presented in the following exhibits:

- Exhibits 5.3 and 5.4 present the results by end use, dwelling type and milestone year for, respectively, the Island and Isolated and Labrador Interconnected service regions.

[116] All results are reported at the customer's point-of-use and do not include line losses.

# Exhibit 5.3: Total Potential Electricity Savings by End Use, Dwelling Type and Milestone Year for the Island and Isolated Service Region (GWh/yr.)

| Dwelling Type | Milestone Year | Residential | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Total | Space Heating | Ventilation | DHW | Cooking | Refrigerator | Freezer | Dishwasher | Clothes Washer | Clothes Dryer | Lighting | Computer and peripherals | Television | Television Peripherals | Other Electronics | Small Appliances & Other |
| Detached | 2011 | 330.28 | 48.79 | 2.50 | 35.97 | | 0.00 | 0.00 | | 0.00 | 0.00 | 138.91 | 23.97 | 4.93 | 73.00 | 2.22 | |
| | 2016 | 440.92 | 98.72 | 2.86 | 40.89 | | 3.23 | 1.70 | | 1.44 | 11.95 | 142.22 | 52.60 | 8.43 | 74.69 | 2.18 | |
| | 2021 | 568.49 | 159.79 | 3.21 | 53.98 | | 6.63 | 3.65 | | 2.90 | 24.04 | 145.00 | 65.73 | 14.34 | 87.11 | 2.11 | |
| | 2026 | 688.16 | 223.58 | 3.23 | 67.62 | | 9.39 | 5.39 | | 4.36 | 36.19 | 147.50 | 80.37 | 21.26 | 87.26 | 2.02 | |
| Attached | 2011 | 40.62 | 0.35 | 0.20 | 4.26 | | 0.00 | 0.00 | | 0.00 | 0.00 | 16.79 | 3.44 | 0.64 | 14.66 | 0.29 | |
| | 2016 | 54.57 | 5.40 | 0.23 | 4.91 | | 0.60 | 0.00 | | 0.14 | 1.16 | 17.41 | 7.65 | 1.11 | 15.69 | 0.28 | |
| | 2021 | 70.22 | 12.49 | 0.26 | 6.61 | | 1.25 | 0.00 | | 0.29 | 2.36 | 17.99 | 9.69 | 1.91 | 17.11 | 0.28 | |
| | 2026 | 86.25 | 20.63 | 0.27 | 8.44 | | 1.78 | 0.00 | | 0.44 | 3.59 | 18.55 | 12.01 | 2.87 | 17.39 | 0.27 | |
| Apartment | 2011 | 27.64 | 3.03 | 0.79 | 2.24 | | 0.00 | 0.00 | | 0.00 | 0.00 | 8.82 | 2.26 | 0.43 | 9.89 | 0.19 | |
| | 2016 | 38.48 | 5.88 | 0.80 | 3.98 | | 0.37 | 0.00 | | 0.07 | 0.52 | 9.26 | 5.04 | 0.75 | 11.62 | 0.19 | |
| | 2021 | 49.82 | 10.03 | 0.81 | 5.80 | | 0.84 | 0.00 | | 0.13 | 1.06 | 9.68 | 6.43 | 1.30 | 13.55 | 0.19 | |
| | 2026 | 58.07 | 12.25 | 0.82 | 7.68 | | 1.30 | 0.00 | | 0.21 | 1.62 | 10.17 | 8.01 | 1.97 | 13.85 | 0.19 | |
| Isolated | 2011 | 5.36 | 0.12 | 0.02 | 0.81 | | 0.00 | 0.00 | | 0.00 | 0.00 | 3.04 | 0.23 | 0.07 | 1.04 | 0.03 | |
| | 2016 | 6.31 | 0.22 | 0.02 | 0.91 | | 0.04 | 0.05 | | 0.03 | 0.24 | 3.09 | 0.51 | 0.12 | 1.05 | 0.03 | |
| | 2021 | 7.49 | 0.33 | 0.02 | 1.19 | | 0.08 | 0.11 | | 0.05 | 0.47 | 3.14 | 0.63 | 0.20 | 1.22 | 0.03 | |
| | 2026 | 8.52 | 0.44 | 0.02 | 1.48 | | 0.11 | 0.16 | | 0.08 | 0.71 | 3.19 | 0.77 | 0.30 | 1.22 | 0.03 | |
| Other | 2011 | 2.16 | -0.10 | 0.01 | 0.00 | | 0.00 | 0.00 | | 0.00 | 0.00 | 2.26 | 0.00 | 0.00 | 0.00 | 0.00 | |
| | 2016 | 2.18 | -0.10 | 0.01 | 0.00 | | 0.00 | 0.00 | | 0.00 | 0.00 | 2.27 | 0.00 | 0.00 | 0.00 | 0.00 | |
| | 2021 | 2.18 | -0.10 | 0.01 | 0.00 | | 0.00 | 0.00 | | 0.00 | 0.00 | 2.27 | 0.00 | 0.00 | 0.00 | 0.00 | |
| | 2026 | 2.18 | -0.09 | 0.01 | 0.00 | | 0.00 | 0.00 | | 0.00 | 0.00 | 2.26 | 0.00 | 0.00 | 0.00 | 0.00 | |
| Vacant and Partial | 2011 | 2.98 | -0.12 | 0.01 | 0.00 | | 0.00 | 0.00 | | 0.00 | 0.00 | 3.09 | 0.00 | 0.00 | 0.00 | 0.00 | |
| | 2016 | 2.96 | -0.11 | 0.01 | 0.00 | | 0.00 | 0.00 | | 0.00 | 0.00 | 3.06 | 0.00 | 0.00 | 0.00 | 0.00 | |
| | 2021 | 2.93 | -0.11 | 0.01 | 0.00 | | 0.00 | 0.00 | | 0.00 | 0.00 | 3.03 | 0.00 | 0.00 | 0.00 | 0.00 | |
| | 2026 | 2.91 | -0.10 | 0.01 | 0.00 | | 0.00 | 0.00 | | 0.00 | 0.00 | 3.00 | 0.00 | 0.00 | 0.00 | 0.00 | |
| TOTAL | 2011 | 409.05 | 52.07 | 3.51 | 43.28 | | 0.00 | 0.00 | | 0.00 | 0.00 | 172.91 | 29.89 | 6.07 | 98.59 | 2.73 | |
| | 2016 | 545.41 | 110.01 | 3.93 | 50.69 | | 4.25 | 1.76 | | 1.67 | 13.86 | 177.31 | 65.80 | 10.40 | 103.04 | 2.69 | |
| | 2021 | 701.13 | 182.43 | 4.32 | 67.57 | | 8.80 | 3.76 | | 3.37 | 27.93 | 181.11 | 82.48 | 17.76 | 118.99 | 2.61 | |
| | 2026 | 846.09 | 256.72 | 4.36 | 85.22 | | 12.58 | 5.55 | | 5.09 | 42.11 | 184.67 | 101.17 | 26.40 | 119.72 | 2.50 | |

*Notes: 1) Savings for dishwasher and clothes washer are for mechanical energy only; hot water savings are reported in DHW. All savings at customer's point-of-use. 2) Any differences in totals are due to rounding. 3) Negative values in the space heating end use for "Other" and "Vacant and Partial" dwellings are a result of interaction between end uses; the reduction in internal heat gains due to lighting measures is greater than the savings from space heating measures.*

## Exhibit 5.4: Total Potential Electricity Savings by End Use, Dwelling Type and Milestone Year for the Labrador Interconnected Service Region (GWh/yr.)

| | | Residential | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Dwelling Type** | **Milestone Year** | **Total** | **Space Heating** | **Ventilation** | **DHW** | **Cooking** | **Refrigerator** | **Freezer** | **Dishwasher** | **Clothes Washer** | **Clothes Dryer** | **Lighting** | **Computer and peripherals** | **Television** | **Television Peripherals** | **Other Electronics** | **Small Appliances & Other** |
| Detached | 2011 | 33.69 | 24.78 | 0.02 | 1.73 | | | | | | | 4.62 | 0.61 | 0.12 | 1.76 | 0.05 | |
| | 2016 | 40.43 | 31.36 | 0.02 | 1.09 | | | | | | | 4.69 | 1.33 | 0.11 | 1.78 | 0.05 | |
| | 2021 | 47.92 | 38.46 | 0.02 | 0.81 | | | | | | | 4.76 | 1.65 | 0.11 | 2.06 | 0.05 | |
| | 2026 | 55.82 | 46.22 | 0.02 | 0.53 | | | | | | | 4.82 | 2.01 | 0.11 | 2.06 | 0.05 | |
| | | | | | | | | | | | | | | | | | |
| Attached | 2011 | 6.39 | 3.29 | 0.01 | 0.53 | | | | | | | 1.42 | 0.21 | 0.04 | 0.87 | 0.02 | |
| | 2016 | 8.05 | 4.84 | 0.01 | 0.33 | | | | | | | 1.44 | 0.47 | 0.04 | 0.91 | 0.02 | |
| | 2021 | 9.87 | 6.55 | 0.01 | 0.25 | | | | | | | 1.46 | 0.58 | 0.04 | 0.97 | 0.02 | |
| | 2026 | 11.80 | 8.42 | 0.01 | 0.16 | | | | | | | 1.48 | 0.71 | 0.03 | 0.97 | 0.02 | |
| | | | | | | | | | | | | | | | | | |
| Apartment | 2011 | 0.60 | 0.11 | 0.01 | 0.06 | | | | | | | 0.20 | 0.02 | 0.01 | 0.20 | 0.00 | |
| | 2016 | 0.72 | 0.19 | 0.01 | 0.05 | | | | | | | 0.20 | 0.03 | 0.01 | 0.23 | 0.00 | |
| | 2021 | 0.84 | 0.27 | 0.01 | 0.04 | | | | | | | 0.21 | 0.04 | 0.01 | 0.26 | 0.00 | |
| | 2026 | 0.93 | 0.36 | 0.01 | 0.03 | | | | | | | 0.22 | 0.05 | 0.01 | 0.26 | 0.00 | |
| | | | | | | | | | | | | | | | | | |
| Other | 2011 | 0.19 | 0.09 | 0.00 | 0.00 | | | | | | | 0.10 | 0.00 | 0.00 | 0.00 | 0.00 | |
| | 2016 | 0.19 | 0.09 | 0.00 | 0.00 | | | | | | | 0.10 | 0.00 | 0.00 | 0.00 | 0.00 | |
| | 2021 | 0.20 | 0.10 | 0.00 | 0.00 | | | | | | | 0.10 | 0.00 | 0.00 | 0.00 | 0.00 | |
| | 2026 | 0.20 | 0.10 | 0.00 | 0.00 | | | | | | | 0.10 | 0.00 | 0.00 | 0.00 | 0.00 | |
| | | | | | | | | | | | | | | | | | |
| TOTAL | 2011 | 40.87 | 28.27 | 0.04 | 2.32 | | | | | | | 6.33 | 0.84 | 0.17 | 2.83 | 0.07 | |
| | 2016 | 49.39 | 36.48 | 0.04 | 1.47 | | | | | | | 6.43 | 1.83 | 0.16 | 2.91 | 0.07 | |
| | 2021 | 58.82 | 45.37 | 0.04 | 1.10 | | | | | | | 6.52 | 2.27 | 0.15 | 3.29 | 0.07 | |
| | 2026 | 68.75 | 55.09 | 0.04 | 0.73 | | | | | | | 6.62 | 2.77 | 0.15 | 3.29 | 0.07 | |

*Notes: 1) Savings for dishwasher and clothes washer are for mechanical energy only; hot water savings are reported in DHW. All savings at customer's point-of-use. 2) Any differences in totals are due to rounding.*

### 5.5.1 Interpretation of Results

Highlights of the results presented in the preceding exhibits are summarized below.

❑ **Electricity Savings by Service Region**

The Island and Isolated service region accounts for 92% of the potential savings.

❑ **Electricity Savings by Milestone Year**

Approximately 48% of the savings are available by the first milestone year because some of the efficiency upgrades are economically attractive at full replacement cost. Under the economic scenario, therefore, they are implemented immediately.

❑ **Electricity Savings by Segment**

Single-family detached dwellings account for more than 80% of the potential savings, which reflects their dominant market share within the overall Residential sector and their generally higher electrical intensity per dwelling.

❑ **Electricity Savings by End Use – Island and Isolated Service Region**

- Space heating accounts for 30% of the total electricity savings in the Economic Potential Forecast. Of this, approximately 53% come from foundation insulation, 13% come from more efficient windows, 9% come from programmable thermostats and 8% come from improved new building design. It should be noted that space heating savings are substantially reduced by decreases in internal loads associated with savings to electronics, lighting and appliances within the home.

- The new buildings account for a larger fraction of space heating savings than of other end use savings. Savings in new buildings are 37% of space heating savings, whereas savings in new buildings are 21% of overall savings. This is because the new building design measures save a disproportionate amount of space heating energy.

- Four electronic end uses (computers, televisions, television peripherals and other electronics) account for 30% of the total electricity savings in the Economic Potential Forecast. Of this, reducing standby losses accounts for 58% of the savings and ENERGY STAR computers account for 34%.

- Savings from lighting account for 22% of the total electricity savings in the Economic Potential Forecast. Of this, compact fluorescent lamps (both standard and specialized) account for over 90% of the savings.

- DHW accounts for 10% of the total electricity savings in the Economic Potential Forecast. Of this, nearly 83% are from DHW savings associated with ENERGY STAR clothes washers.

- **Electricity Savings by End Use – Labrador Interconnected Service Region**

- Space heating accounts for 81% of the total electricity savings in the Economic Potential Forecast. Approximately 67% of space heating savings are from foundation insulation and approximately 23% are from air leakage sealing.

- Lighting and the four electronic end uses referred to above each account for approximately 9% of the savings in the Economic Potential Forecast.

- Appliance measures are not included in the economic potential results for the Labrador Interconnected Service Region. The lower electricity rates in that region caused those measures to fail the CCE test.

### 5.5.2 Caveats

A systems approach was used to model the energy impacts of the CDM measures presented in the preceding section. In the absence of a systems approach, there would be double counting of savings and an accurate assessment of the total contribution of the energy-efficient upgrades would not be possible. More specifically, there are two particularly important considerations:

- **More than one upgrade may affect a given end use**. For example, improved insulation reduces space heating electricity use, as does the installation of new energy-efficient windows. On its own, each measure will reduce overall space heating electricity use. However, the two savings are not additive. The order in which some upgrades are introduced is also important. In this study, the approach has been to select and model the impact of "bundles of measures" that reduce the load for a given end use (e.g., wall insulation and window upgrades that reduce the space heating load) and then to introduce measures that meet the remaining load more efficiently (e.g., a high-efficiency space heating system).

- **There are interactive effects among end uses**. For example, the electricity savings from more efficient appliances and lighting result in reduced waste heat. During the space heating season, this appliance and lighting waste heat contributes to the building's internal heat gains, which lower the amount of heat that must be provided by the space heating system.

- The magnitude of the interactive effects can be significant. Based on selected building energy use simulations, a 100 kWh savings in appliance or lighting electricity use could result in an increased space heating load of 50 to 70 kWh, depending on housing dwelling type and geographical location. This is higher than the ratio of approximately 0.5 more typical of other jurisdictions. It is credible that the fraction would be higher in Newfoundland and Labrador because it is dependent more on the length of the heating season than on its severity. Newfoundland and Labrador experience more months in which heating is required than most other jurisdictions in Canada. Nonetheless, given that some fraction of the heat energy from lighting and other end uses escapes to the outside, the simulation may somewhat overstate the interaction. A ratio of 0.6 has been incorporated into the model to account for this uncertainty.

### 5.5.3 Sensitivity Analysis – Alternative Avoided Costs

A sensitivity analysis was conducted using preliminary avoided cost values that assume development of the Lower Churchill/DC link. The sensitivity analysis reviewed the scope of measures that would pass or fail the economic screen under the changed avoided costs. Based on the preliminary avoided cost values assessed, the analysis concluded that any impacts would be modest.

## 5.6 CDM MEASURE SUPPLY CURVES

A supply curve was constructed for each of the two service regions based on the economic potential savings associated with the above measures. The following approach was followed:

- Measures are introduced in sequence to see incremental impact and cost
- Sequence is determined by principle of 1) reduce load 2) meeting residual load with most efficient technology
- Is organized by CCE levels.

Exhibits 5.5 and 5.6 show the supply curves for, respectively, the Island and Isolated and the Labrador Interconnected service regions. Exhibits 5.7 and 5.8 show the measures included in each of the supply curves.

Exhibits 5.5 and 5.6 both show measures with CCEs above the thresholds for the two regions. This is because the economic screening process did not consider either interaction between measures or interaction between end uses. All measures were included in the analysis if their CCE values were below the threshold, excluding interactive effects. In the economic potential analysis itself, however, these interactive effects are included in full. Measures that apply to the same end use are applied in sequence, as described above, substantially reducing the savings available to those applied later. Furthermore, measures that reduce the internal heat loads produced by lighting, electronics and appliances tend to increase the need for space heating. This space heating penalty is applied against the savings from those measures. For consistency with previous exhibits, the supply curve shows all the measures that were included in the economic potential analysis, including those that now exceed the economic threshold.

**Exhibit 5.5: Supply Curve for Residential Sector, Island and Isolated Service Region, 2026**

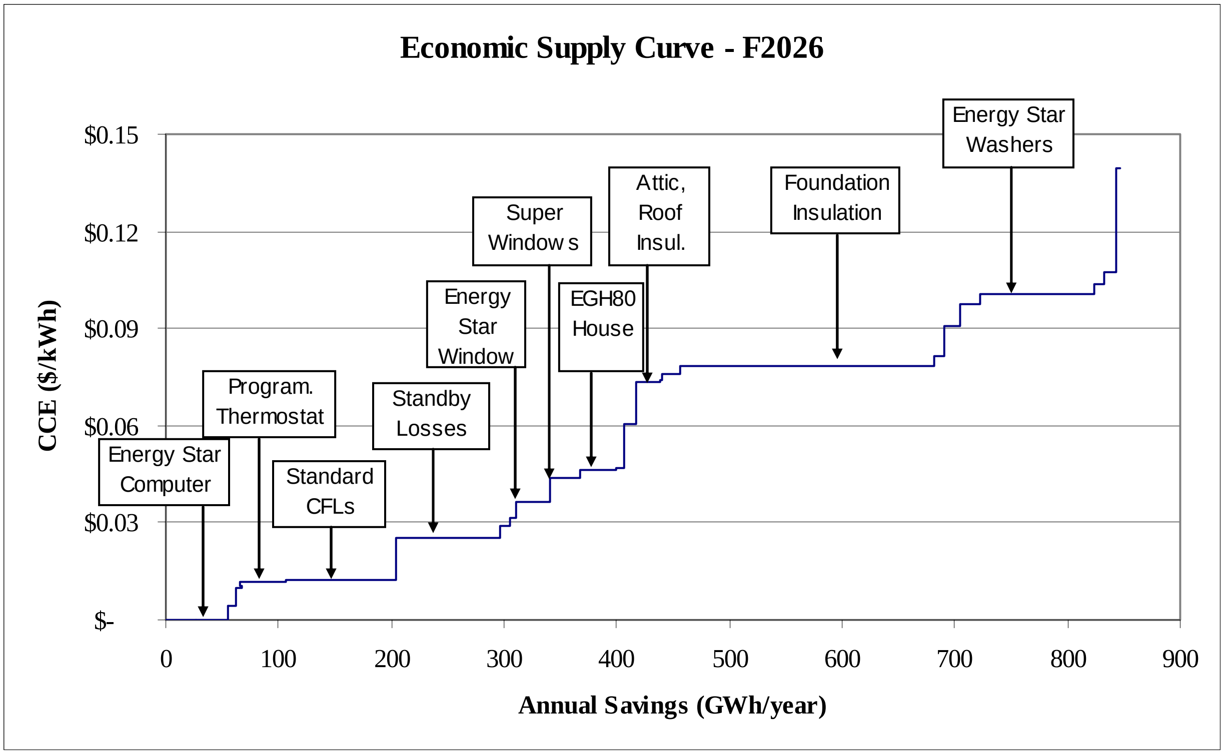



**Exhibit 5.6: Supply Curve for Residential Sector, Labrador Interconnected Service Region, 2026**

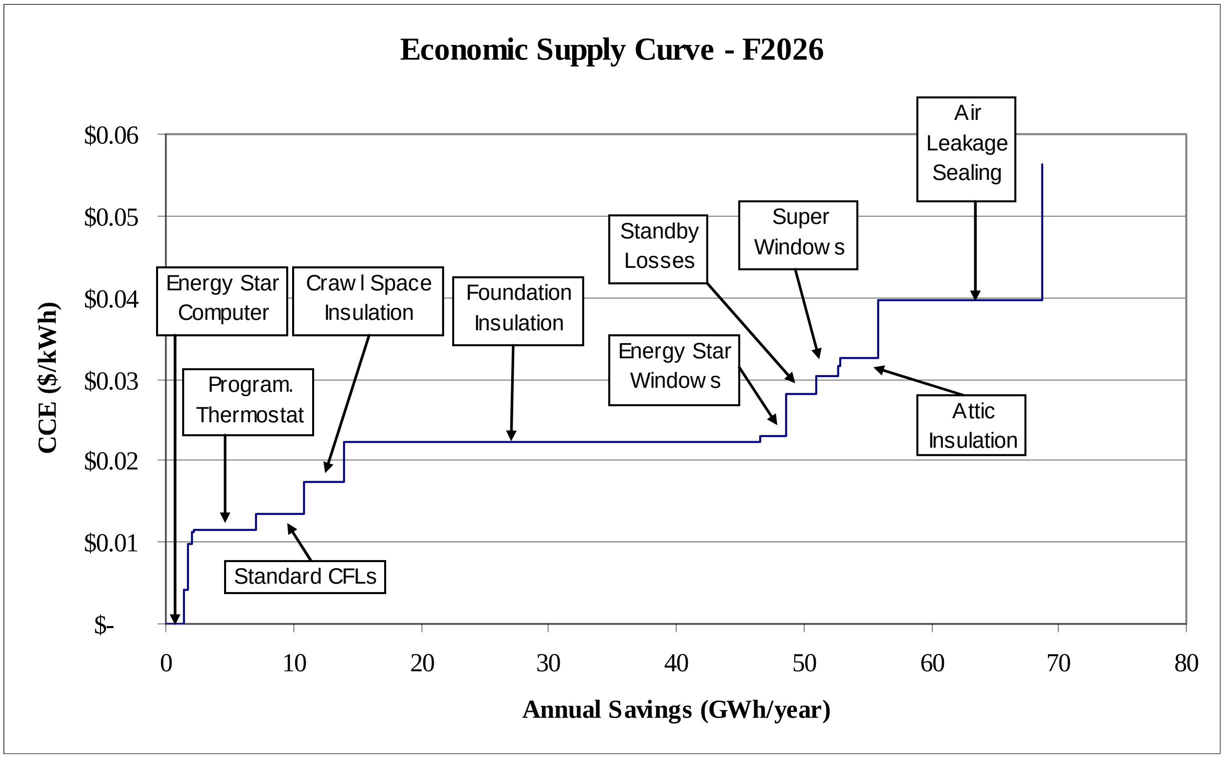


**Exhibit 5.7: Summary of Residential Sector Energy-efficiency Measures, Island and Isolated Service Region 2026**[117]

| Measure | Average CCE ($/kWh) | Annual Savings (GWh/year) |
|---|---|---|
| Energy Star Computer | $0.00 | 55 |
| DHW Pipe Wrap | $0.00 | 7 |
| Low-Flow Showerheads and Faucets | $0.01 | 6 |
| Standard T8 Lighting - Common Areas | $0.01 | 0.1 |
| 25% Lower Energy Apartment Building | $0.01 | -1 |
| Programmable Thermostats | $0.01 | 40 |
| CFLs - Standard | $0.01 | 97 |
| Standby Losses | $0.03 | 92 |
| Crawl-space Insulation | $0.03 | 10 |
| 40% Lower Energy Apartment Building | $0.03 | 4 |
| Timer | $0.03 | 1 |
| Energy Star Windows , Advanced Glazing | $0.04 | 29 |
| Super High Performance Windows | $0.04 | 28 |
| New House Designed to an EGNH 80 Rating | $0.05 | 32 |
| Building recommissioning | $0.05 | 6 |
| Motion Sensor | $0.05 | 1 |
| Air Source Heat Pump | $0.06 | 11 |
| Ground Source Heat Pump | $0.07 | 0.4 |
| Attic Insulation, Roof Insulation | $0.07 | 21 |
| Wall Insulation | $0.07 | 1 |
| High Efficiency HRV | $0.08 | 16 |
| Foundation Insulation | $0.08 | 225 |
| Energy Star Fridge | $0.08 | 8 |
| Redesign with high performance T8s | $0.09 | 1 |
| Energy Star TV | $0.09 | 13 |
| Air Leakage Sealing | $0.10 | 19 |
| Energy Star Top Loading Clothes Washer | $0.10 | 102 |
| LED Holiday Lights | $0.10 | 9 |
| CFLs Specialised | $0.11 | 10 |
| Energy Efficient Freezer | $0.14 | 4 |

[117] The above exhibit includes measures with a CCE that exceeds the study's avoided cost threshold. The increased CCE is due to the impact of interactive effects. The measures are shown to maintain consistency with previous exhibits. The inclusion of interaction between measures has a particularly large effect on space heating savings. More efficient lighting and appliances contribute less waste heat to the home and therefore the space heating requirement is greater. In the 25% Lower Energy Apartment Building, for example, the savings in space heating energy are actually overwhelmed by the increased load because the lights and appliances are more efficient. This is less of an issue in Labrador, where fewer appliance measures pass the economic screen.

**Exhibit 5.8: Summary of Residential Sector Energy-efficiency Measures, Labrador Interconnected Service Region 2026**[118]

| Measure | Average CCE ($/kWh) | Annual Savings (GWh/year) |
|---|---|---|
| Redesign with high performance T8s | -$0.03 | 0.004 |
| Energy Star Computer | $0.00 | 1 |
| DHW Pipe Wrap | $0.00 | 0.4 |
| Low-Flow Showerheads and Faucets | $0.01 | 0.3 |
| 25% Lower Energy Apartment Building | $0.01 | 0.1 |
| Standard T8 Lighting - Common Areas | $0.01 | 0.002 |
| Programmable Thermostats | $0.01 | 5 |
| CFLs - Standard | $0.01 | 4 |
| Crawl-space Insulation | $0.02 | 3 |
| Foundation Insulation | $0.02 | 33 |
| Energy Star Windows , Advanced Glazing | $0.02 | 2 |
| Standby Losses | $0.03 | 2 |
| Super High Performance Windows | $0.03 | 2 |
| 40% Lower Energy Apartment Building | $0.03 | 0.1 |
| Attic Insulation, Roof Insulation | $0.03 | 3 |
| Timer | $0.04 | 0.02 |
| Air Leakage Sealing | $0.04 | 13 |
| Building recommissioning | $0.04 | 0.1 |
| Motion Sensor | $0.06 | 0.03 |

[118] The above exhibit includes measures with a CCE that exceeds the study's avoided cost threshold. The increased CCE is due to the impact of interactive effects. The measures are shown to maintain consistency with previous exhibits. The measure for redesign with high-performance T8s has a negative CCE for the Labrador Interconnected service region because the only circumstance under which it passes for Labrador is when a renovation is planned that already involves lighting replacement. The advanced T8s with redesign would incorporate fewer fixtures than a standard lighting replacement and therefore capital cost would actually be lower. In the Island and Isolated service region, there would certainly be cases where the measure would be installed as part of an already planned renovation (and hence would have a negative incremental cost), but the measure passes at full cost as well, so the average CCE is $0.09/kWh.

# 6. ACHIEVABLE POTENTIAL

## 6.1 INTRODUCTION

This section presents the Residential sector Achievable Potential electricity savings for the study period (2006 to 2026). The Achievable Potential is defined as the proportion of the savings identified in the Economic Potential Forecast that could realistically be achieved within the study period.

The remainder of this discussion is organized into the following subsections:

- Description of Achievable Potential
- Approach to the Estimation of Achievable Potential
- Workshop Results
- Summary of Achievable Electricity Savings
- Peak Load Impacts.

## 6.2 DESCRIPTION OF ACHIEVABLE POTENTIAL

Achievable Potential recognizes that it is difficult to induce all customers to purchase and install all the electrical efficiency technologies that meet the criteria defined by the Economic Potential Forecast. For example, customer decisions to implement energy-efficient measures can be constrained by important factors such as:

- Higher first cost of efficient product(s)
- Need to recover investment costs in a short period (payback)
- Lack of product performance information
- Lack of product availability
- Consumer awareness.

The rate at which customers accept and purchase energy-efficient products can be influenced by a variety of factors including the level of financial incentives, information and other measures put in place by the Utilities, governments and the private sector to remove barriers such as those noted above.

Exhibit 6.1 presents the level of electricity consumption that is estimated in the Achievable Potential scenarios. As illustrated, the Achievable Potential scenarios are “banded” by the two forecasts presented in previous sections, namely, the Economic Potential Forecast and the Reference Case.

Electricity savings under Achievable Potential are typically less than in the Economic Potential Forecast. In the Economic Potential Forecast, efficient new technologies are assumed to fully penetrate the market as soon as it is financially attractive to do so. However, the Achievable Potential recognizes that under “real world” conditions, the rate at which customers are likely to implement new technologies will be influenced by additional practical considerations and will, therefore, occur more slowly than under the assumptions employed in the Economic Potential Forecast. Exhibit 6.1 also shows that future electricity consumption under the Reference Case is greater than in either of the two Achievable Potential forecasts. This is because the Reference Case represents a "worst case" situation in which there are no additional utility market interventions and hence no additional electricity savings beyond those that occur "naturally."

Exhibit 6.1 presents the achievable results as a band of possibilities, rather than a single line. This recognizes that any estimate of Achievable Potential over a 20-year period is necessarily subject to uncertainty and that there are different levels of potential CDM program intervention.

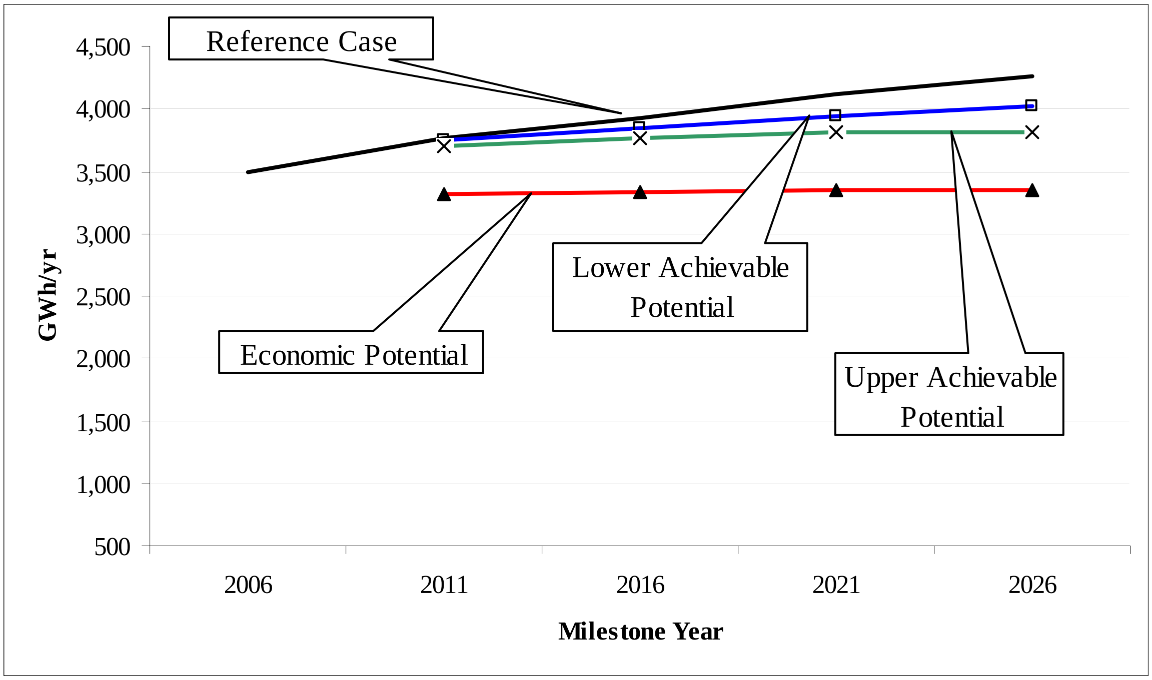
- **The Upper Achievable Potential** assumes both an aggressive program approach and a very supportive context, e.g., healthy economy, very strong public commitment to climate change mitigation, etc.

  However, the Upper Achievable Potential scenario also recognizes that there are limits to the scope of influence of any electric utility. It recognizes that some markets or submarkets may be so price sensitive or constrained by market barriers beyond the influence of CDM programs that they will only fully act if forced to by legal or other legislative means. It also recognizes that there are practical constraints related to the pace that existing inefficient equipment can be replaced by new, more efficient models or that existing building stock can be retrofitted to new energy performance levels

  For the purposes of this study, the Upper Achievable Potential can, informally, be described as: "*Economic Potential less those customers that "can't" or "won't" participate."*

- **The Lower Achievable Potential** assumes that existing CDM programs and the scope of technologies addressed are expanded, but at a more modest level than in the Upper Achievable Potential. Market interest and customer commitment to energy efficiency and sustainable environmental practices remain approximately as current. Similarly, federal, provincial and municipal government energy-efficiency and GHG mitigation efforts remain similar to the present.

**Exhibit 6.1: Annual Electricity Consumption – Illustration of Achievable Potential Relative to Reference Case and Economic Potential Forecast for the Residential Sector (GWh/yr.)**



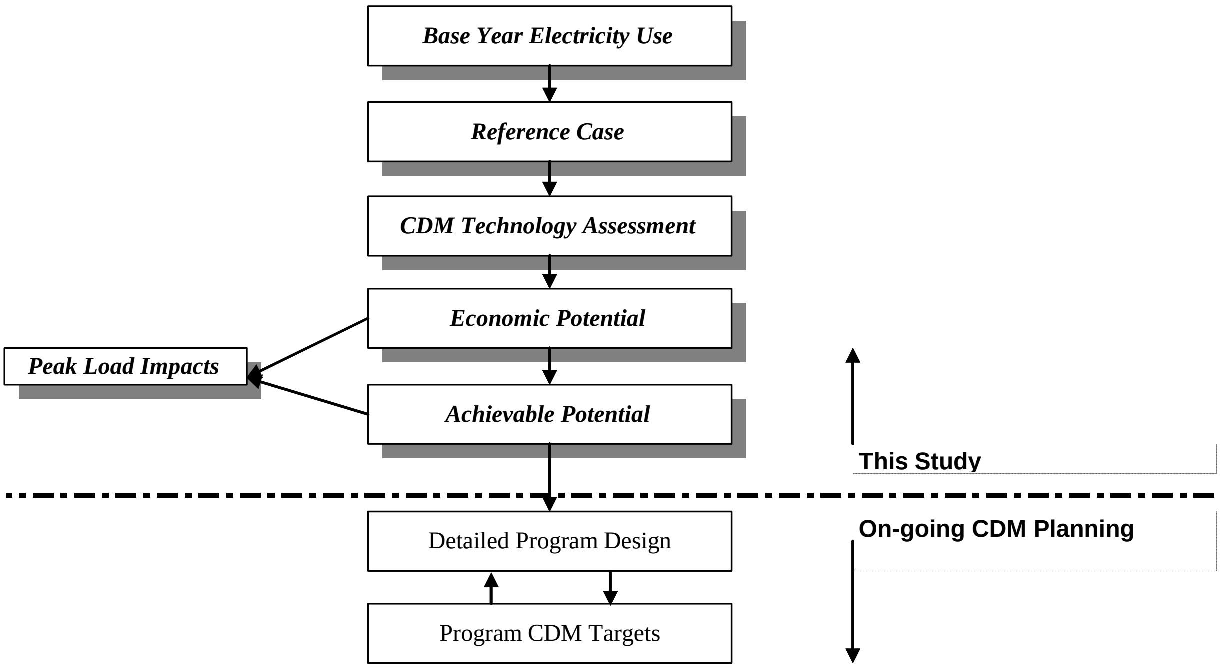

## ❑ Achievable Potential versus Detailed Program Design

It should also be emphasized that the estimation of Achievable Potential is not synonymous with either the setting of specific program targets or with program design. While both are closely linked to the discussion of Achievable Potential, they involve more detailed analysis that is beyond the scope of this study.[119]

Exhibit 6.2 illustrates the relationship between Achievable Potential and the more detailed program design.

[119] The Achievable Potential savings assume program start-up in 2007. Consequently, electricity savings in the first milestone year of 2011 will need to be adjusted to reflect actual program initiation dates. This step will occur during the detailed program design phase, which will follow this study.

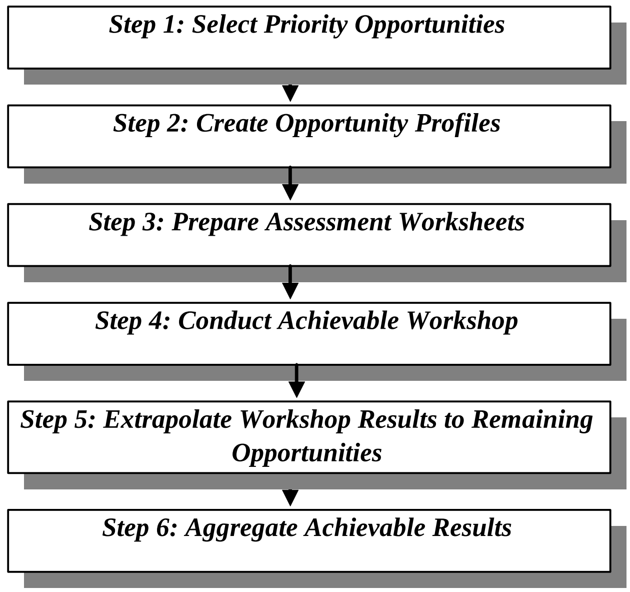
**Exhibit 6.2: Achievable Potential versus Detailed Program Design**




## 6.3 APPROACH TO THE ESTIMATION OF ACHIEVABLE POTENTIAL

Achievable Potential was estimated in a six-step approach. A schematic showing the major steps is shown in Exhibit 6.3 and each step is discussed below.

**Exhibit 6.3: Approach to Estimating Achievable Potential**



## ❑ Step 1: Select Priority Opportunities

The first step in developing the Achievable Potential estimates required that the energy saving opportunities identified in the Economic Potential Forecasts be "bundled" into a set of opportunity areas that would facilitate the subsequent assessment of their potential market penetration.

The amount of time available in the Achievable Potential workshop for the discussion of energy-efficiency opportunities was limited. Consequently, the energy-efficiency opportunity areas shown in Exhibit 6.4 were selected based primarily on the basis that they represent a significant portion of the energy savings potential identified in the Economic Potential Forecast. Where two or more opportunities offered similar levels of potential energy savings, consideration was also given to whether discussion of the selected opportunity area in the workshop would provide insights into the participation rates to be used for related opportunities that could not be covered during the workshop.

Nine energy-efficiency opportunity areas were selected for discussion in the Residential sector workshop that was held on October 30, 2007. Exhibit 6.4 identifies the opportunity areas and shows the approximate percentage that each represents of the total Residential sector potential contained in the Economic Potential Forecast.

**Exhibit 6.4: Residential Sector Opportunity Areas**

| Opportunity Area | Title | Approximate % of Economic Savings Potential |
|---|---|---|
| R1 | Programmable thermostats | 5% |
| R2 | Convert incandescent lighting to CFL | 11% |
| R3 | Foundation insulation | 28% |
| R4 | Air leakage sealing | 3% |
| R5 | Efficient windows | 6% |
| R6 | EnerGuide 80 (EG80) for new housing | 3% |
| R7 | Power bar with integrated timer | 10% |
| R8 | ENERGY STAR computer | 6% |
| R9 | ENERGY STAR clothes washer | 11% |
| | **Total** | 83% |

## ❑ Step 2: Create Opportunity Profiles

The next step involved the development of brief profiles for the priority opportunity areas noted above in Exhibit 6.4. A sample profile for Opportunity R1 (programmable thermostats) is presented in Exhibit 6.5; the remaining Opportunity Profiles are provided in Appendix B.

The purpose of the Opportunity Profiles was to provide a "high-level" logic framework that would serve as a guide for participant discussions in the achievable workshop. These Profiles state technical and program assumptions upon which to base an estimate of potential market penetration. The intent was to define a broad rationale and direction without getting into the much greater detail required of program design, which, as noted previously, is beyond the scope of this project.

## Exhibit 6.5: Sample Opportunity Profile

**R1: Programmable Thermostat**

***Overview:***

Digital programmable thermostats provide improved temperature setting accuracy and are capable of multiple time settings. When combined with an assumed 4ºC temperature setback during night and unoccupied periods, typical space heat savings are in the range of 10% to 15% relative to the baseline, depending on the type of dwelling and its vintage.

Other utility studies have indicated that a lower savings percentage should be used to reflect the fact that the thermostat's setback capabilities do not completely reflect how they are used, e.g., some home occupants reliably set back manual thermostats, and some home occupants do not use the setback features on their electronic thermostats. Accordingly a value of 6% savings has been used in this study.

***Target Technologies and Dwelling Types:***

- The programmable setback thermostat is a mature technology
- This technology is applicable to all dwelling types but is most easily applied where a limited number of thermostats can be used to control all the heating devices in the dwelling.

***Opportunity Costs and Savings Profile***:

- This technology is assumed to cost an average of $70 per dwelling.
- In single-family dwellings with baseboard electric heating, it is possible, in most cases, to combine more than one baseboard per thermostat so that three to four thermostats can be used.[120] In dwellings with forced air systems, one thermostat will usually control the whole dwelling.
- Customer payback is approximately one year, somewhat longer in Labrador.
- The CCE for this measure in detached dwellings ranges from 0.6 in Labrador to 1.2 on the Island, or somewhat higher for attached dwellings and apartments.
- Potential energy performance or technology price trends affecting this opportunity include:
- Pricing and performance are relatively stable for this technology.
- For homes with a need for more thermostats because of multiple baseboards, another option is the high-efficiency (more accurate) thermostat, which is lower cost but is still expected to save approximately 3%.
- There is added uncertainty in the savings estimates for this technology because of the behavioural aspect.

***Target Audience(s)& Potential Delivery Allies:***

- Homeowners and renters
- HVAC contractors and retailers

***Constraints & Challenges:***

- Some consumers still think a thermostat behaves like a gas pedal (the higher you set it, the faster the house warms up!)
- Tendency for some users to override the setback
- Installation is simple for central thermostats on 24-V loops, but not for in-line thermostats controlling a powerful baseboard.

***Opportunities & Synergies:***

- Could build on/expand previous thermostat rebate programs
- Could be offered in conjunction with other programs, through trade allies or even used as a premium to entice consumers to participate in other programs
- Amenable to use of point-of-sale rebates or other in-store promotions.

***Experience Related to Possible Participation Rates:***

[120] Workshop discussion found that the use of one thermostat to control multiple baseboard heaters was rarely practical.

As illustrated in Exhibit 6.5, each Opportunity Profile addresses the following areas:

- ***Overview*** **–** provides a summary statement of the broad goal and rationale for the opportunity.

- ***Target Technologies and Dwelling Types*** **–** highlights the major technologies and the dwelling types where the most significant opportunities have been identified in the Economic Potential Forecast.

- ***Opportunity Costs and Savings Profile*** **–** provides information on the financial attractiveness of the opportunity from the perspective of both the customer and NLH or NP.

- ***Target Audiences and Potential Delivery Allies*** **–** identifies key market players that would be expected to be involved in the actual delivery of services. The list of stakeholders shown is intended to be "indicative" and is by no means comprehensive.

- ***Constraints and Challenges*** **–** identifies key market barriers that are currently constraining the increased penetration of energy-efficient technologies or measures. Interventions for addressing the identified barriers are noted. Again, it is recognized that the interventions are not necessarily comprehensive; rather, their primary purpose was to help guide the workshop discussions.

- ***Opportunities and Synergies*** **–** identifies information or possible synergies with other opportunities that may affect workshop participant views on possible customer participation rates.

- ***Experience Related to Possible Participation Rates*** **–** provides benchmark data on the past performance of the Utilities' programs, where available.

**❑ Step 3: Prepare Draft Opportunity Assessment Worksheets**

A draft Assessment Worksheet was prepared for each Opportunity Profile in advance of the workshop. The Assessment Worksheets complemented the information contained in the Opportunity Profiles by providing quantitative data on the potential energy savings for each opportunity as well as providing information on the size and composition of the eligible population of potential participants. Energy impacts and population data were taken from the detailed modelling results contained in the Economic Potential Forecast.

A sample Assessment Worksheet for Opportunity R1 – Programmable Thermostats is presented in Exhibit 6.6 (worksheets for the remaining opportunity areas are provided in Appendix B). As illustrated in Exhibit 6.6, each Assessment Worksheet addresses the following areas:

- ***Economic Potential Annual Savings*** **–** shows the total economically attractive potential for electricity savings, by milestone period, for the measures included in the opportunity area.

- ***Cumulative Thousands of Dwellings Affected*** **–** shows the total population of potential participants that could theoretically take part in the opportunity area. Numbers shown are from the eligible populations used in the Economic Potential Forecasts. The definition of "participant" varies by opportunity area. In the example shown, a participant is defined as a "dwelling."

- ***Achievable Participation*** **–** show the percentage of economic savings that workshop participants concluded could be achieved in each milestone period. As noted in the introduction to this section, two achievable scenarios are shown: Lower and Upper. For example, Exhibit 6.6 shows a participation rate of 20% (Lower) and 90% (Upper) in existing single-family dwellings by the year 2026. This means that by 2026, between 20% and 90% of the potential savings contained in the Economic Potential Forecast could be achieved.

- ***Achievable Potential Annual Savings*** **–** shows the calculated electricity savings in each milestone period based on the savings and participation rates presented in the preceding columns of the Worksheet.

- ***Achievable Thousands of Dwellings Affected*** **–** shows the number of participants that would be affected in order to achieve the electricity savings shown.

## Exhibit 6.6: Sample Residential Sector Opportunity Assessment Worksheet[121]

### *R1: Space heating, Programmable Thermostats: Economic Scenario, Residential Sector, Island and Isolated Region **

***Existing/Renovated***

| Building Type | Economic Potential Annual Savings (GWh) | | Cumulative Thousands of Dwellings Affected | | Lower Achievable Scenario: Achievable Participation | | Lower Achievable Scenario: Achievable Potential Annual Savings (GWh) | | Lower Achievable Scenario: Achievable Thous. Dwellings Affected | | Upper Achievable Scenario: Achievable Participation | | Upper Achievable Scenario: Achievable Potential Annual Savings (GWh) | | Upper Achievable Scenario: Achievable Thous. Dwellings Affected | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2011 | 2026 | 2011 | 2026 | 2011 | 2026 | 2011 | 2026 | 2011 | 2026 | 2011 | 2026 | 2011 | 2026 | 2011 | 2026 |
| Detached | 31 | 27 | 79 | 79 | | 20% | | 5 | | 16 | | 90% | | 24 | | 71 |
| Attached | 5 | 5 | 10 | 10 | | | | | | | | | | | | |
| Apartment | 3 | 2 | 10 | 10 | | | | | | | | | | | | |
| Other | 1 | 1 | 11 | 11 | | 20% | | 0 | | 2 | | | | | | |
| Total | 40 | 35 | 110 | 109 | | | | 6 | | 18 | | | | 24 | | 71 |

Curve B Curve C

***New***

| Building Type | Economic Potential Annual Savings (GWh) | | Cumulative Thousands of Dwellings Affected | | Lower Achievable Scenario: Achievable Participation | | Lower Achievable Scenario: Achievable Potential Annual Savings (GWh) | | Lower Achievable Scenario: Achievable Thous. Dwellings Affected | | Upper Achievable Scenario: Achievable Participation | | Upper Achievable Scenario: Achievable Potential Annual Savings (GWh) | | Upper Achievable Scenario: Achievable Thous. Dwellings Affected | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2011 | 2026 | 2011 | 2026 | 2011 | 2026 | 2011 | 2026 | 2011 | 2026 | 2011 | 2026 | 2011 | 2026 | 2011 | 2026 |
| Detached | 2 | 5 | 3 | 12 | 20% | 20% | 0 | 1 | 1 | 2 | 20% | 20% | 0 | 1 | 1 | 2 |
| Attached | 0 | 1 | 1 | 2 | 20% | 20% | 0 | 0 | 0 | 0 | 20% | 20% | 0 | 0 | 0 | 0 |
| Apartment | 0 | 1 | 1 | 2 | 20% | 20% | 0 | 0 | 0 | 0 | 20% | 20% | 0 | 0 | 0 | 0 |
| Other | 0 | 0 | 0 | 0 | 20% | 20% | 0 | 0 | 0 | 0 | 20% | 20% | 0 | 0 | 0 | 0 |
| Total | 3 | 7 | 5 | 16 | | | 1 | 1 | 1 | 3 | | | 1 | 1 | 1 | 3 |
| Grand Total | 42 | 41 | 114 | 125 | | | 1 | 7 | 1 | 21 | | | 1 | 25 | 1 | 74 |

**NOTES:**
* Includes savings of heating and ventilation.

[121] This exhibit shows the worksheet as it was after the workshop. Discussion focused on the existing detached dwellings for the Island and Isolated service region, developing Upper and Lower participation estimates for the milestone year 2026, and a curve shape between 2006 and 2026. All other percentage values shown are either left blank or are placeholders that were in the worksheet before the workshop. Only the values for existing detached Island and Isolated dwellings were transferred to the RSEEM model. Values for other types of dwellings were based on those and on the discussions with workshop participants about how participation might vary between regions, housing types, and vintages. Any differences in totals are due to rounding.

### ❑ Step 4: Achievable Potential Workshop

The most critical step in developing the estimates of Achievable Potential was the one-day workshop held October 30, 2007. Workshop participants consisted of core members of the consultant team, program personnel from the Utilities and local trade allies.

The purpose of this workshop was twofold:

- Promote discussion regarding the technical and market conditions confronting the identified energy-efficiency opportunities

- Compile participant views related to how much of the identified economic savings could realistically be achieved over the study period.

The discussion of each opportunity area began with a brief consultant presentation. The floor was then opened to participant discussion. Key areas that were explored for each opportunity area included:

- Target audiences and potential delivery allies
- Constraints, barriers and challenges
- Potential opportunities and synergies
- Estimates of Lower Achievable and Upper Achievable for milestone years
- Guidelines for consultants for extrapolating to related sub sectors.

Following discussion of the broad market and intervention conditions affecting each opportunity area, workshop participant views were recorded on Lower and Upper customer participation rates. To facilitate this portion of the workshop, the discussion of the Residential sector opportunity areas focused initially on single-family detached dwellings in the Island and Isolated service region. The following process was employed:

- The participation rate for the Upper Potential in 2026 was estimated. As noted previously, this participation rate was "roughly" defined as 100% of the Economic Potential minus the market share represented by the "can't" or 'won't" population.

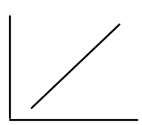
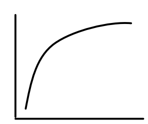
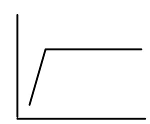
- The shape of the adoption curve was selected for the Upper scenario. Rather than seek consensus on the specific values to be employed in each of the intervening milestone years, workshop participants selected one of four curve shapes that best matched their view of the appropriate "ramp-up" rate for each opportunity.

- The preceding process was repeated for the Lower scenario.

Exhibit 6.7 shows the four curves that were used in the workshop discussions.

- **Curve A** represents a steady increase in the expected participation rate over the 20-year study period
- **Curve B** represents a relatively slow participation rate during the first half of the 20-year study period followed by a rapid growth in participation during the second half of the 20-year study period
- **Curve C** represents a rapid initial participation rate followed by a relatively slow growth in participation during the remainder of the 20-year study period
- **Curve D** represents a very rapid initial participation rate that results in virtual full saturation of the applicable market during the first milestone period of the 20-year study period.

**Exhibit 6.7: Adoption Curve Shapes (2006 to 2026)**

| Curve A | Curve B | Curve C | Curve D |
|---|---|---|---|
|  |  |  |  |

Finally, as applicable, workshop participants provided guidelines to the consultants for extrapolating the results of the workshop discussion to the remaining sub sectors and service regions.

### ❑ Step 5: Extrapolate Workshop Results to Remaining Opportunities

As noted earlier, it was not possible to fully address all opportunities in the one-day workshop. Consequently, the workshop focused on the “big ticket” opportunities. Participation rates for the remaining opportunities were completed by the consultants, guided by the workshop results and discussions. The values shown in the summary tables incorporate the results of the two sets of inputs.

### ❑ Step 6: Aggregate Achievable Potential Results

The final step involved aggregating the results of the individual opportunity areas to provide a view of the potential Achievable savings for the total Residential sector.

## 6.4 WORKSHOP RESULTS

The following subsection provides a summary of the participation rates established by the workshop participants for each of the opportunity areas discussed during the workshop.[122] As noted previously, the Residential sector opportunity areas were:

- R1 - Programmable thermostats
- R2 - Convert incandescent lighting to CFL
- R3 - Foundation insulation
- R4 - Air leakage sealing
- R5 - Efficient windows
- R6 - EnerGuide 80 (EG80) for new housing
- R7 - Power bar with integrated timer
- R8 - ENERGY STAR computer
- R9 - ENERGY STAR clothes washer.

Further detail on each of the above opportunity areas is provided below; as applicable, the following information is provided for each:

- Summary of Upper and Lower Achievable participation rates
- Shape of Adoption Curve selected by the workshop participants
- Highlights of key issues arising during the workshop discussions
- Summary of major assumptions employed by the consultants for extrapolating the workshop results to other sub sectors.

### 6.4.1 R1 – Programmable Thermostats

Workshop participants concluded that, under the conditions represented by the Upper Achievable scenario, participation rates up to 90% could be achieved in single-family detached homes in the Island and Isolated service region by 2026. Workshop participants agreed that Adoption Curve C represented the best fit with the pace of participation in the intervening years from 2007 to 2026 under this Upper Achievable scenario.

Under the more modest market conditions represented by the Lower Achievable scenario, participation rates up to 20% could be achieved in single-family detached homes in the Island and Isolated service region by 2026. Workshop participants agreed that Adoption Curve B represented the best fit with the pace of participation in the intervening years from 2007 to 2026 under this Lower Achievable scenario.

Based on the workshop discussions, it was assumed that participation rates in the remaining dwelling types would be similar to the above values. Participation rates in the

[122] Measures from the Commercial sector that were applicable to apartment buildings were discussed in the commercial Achievable workshop. Refer to the companion report on the Commercial sector for details on the workshop discussions. Apartment measures discussed in the commercial Achievable workshop included: C1, Standard T8 Lighting and Redesign with High-performance T8s - Common Areas, Existing Buildings; C2, Redesign with high-performance T8s, New Buildings; C4, High-performance glazings; C5, Building recommissioning; C6, Ground source heat pumps; and C7, 40% Lower Energy Apartment Building.

Labrador Interconnected service region were assumed to be similar to those for the Island and Isolated service region.

Selected highlights:

- Discussion focused on the high-efficiency thermostats with accuracy within 0.5ºC. Programmable thermostats were regarded as having much lower potential because of the low incidence of electrically heated houses that can be controlled with a small number of thermostats (such as one thermostat controlling a forced air system). The cost of a large number of programmable thermostats to control individual baseboards would generally not be justified.
- Behaviour is a major factor in savings from programmable thermostats (e.g., some people with manual thermostats diligently set them back, and some people with programmable thermostats do not).
- Humidity control is a concern with set-back strategies in some houses, where condensation on windows can cause damage and mould. Ability to adopt temperature setback could be a selling point for efficient windows.
- The presence of thermostats accurate to within 1ºC was estimated to be approximately 65% of existing stock, with lower penetration in rural areas. Many rural houses have baseboards installed with only the built-in thermostatic control on the baseboard itself.
- There is potential for using the high-efficiency thermostats through most of the house and installing programmable thermostats in main living areas (such as the living room or the most-used bedroom).

### 6.4.2 R2 – Convert Incandescent Lighting to CFLs

Workshop participants concluded that, under the conditions represented by the Upper Achievable scenario, participation rates up to 98% could be achieved in single-family detached homes in the Island and Isolated service region by 2026. Workshop participants agreed that Adoption Curve B represented the best fit with the pace of participation in the intervening years from 2007 to 2026 under this Upper Achievable scenario.

Under the more modest market conditions represented by the Lower Achievable scenario, participation rates up to 90% could be achieved in single-family detached homes in the Island and Isolated service region by 2026. Workshop participants agreed that Adoption Curve A represented the best fit with the pace of participation in the intervening years from 2007 to 2026 under this Lower Achievable scenario.

Based on the workshop discussions, it was assumed that participation rates in the remaining dwelling types would be similar to the above values. Participation rates in the Labrador Interconnected service region were assumed to be similar to those for the Island and Isolated service region.

Selected highlights:

- 
- There are fewer barriers to uptake of CFLs than for other measures. There is continuing improvement in quality and the suitability of lamps to more applications continues to broaden.
- There are still issues around disposal, light quality, product quality and lighting levels, some of them real and some of them perceptions based on earlier products. Workshop participants expected these issues to be addressed during the timeframe of the study.
- Uptake of CFLs has been high in Labrador. It tends to be lower in rural areas.

The preceding results were used as a reference point for estimating participation rates related to other opportunities in the Residential sector.

Highlights:

- Participation rates for standard CFLs were also applied to LED holiday lighting, motion sensors and timers.
- Participation rates for specialized CFLs were also informed by the discussion on standard CFLs.
- Other technologies that are well established in the marketplace were estimated to have similar uptake if supported by the Utilities' program activity. These included ECPM furnace fan motors, low-flow showerheads and faucets, DHW tank insulating blankets and DHW piping insulation.
- T8 lighting in apartment buildings drew on the participation rates identified during the Commercial sector workshop (see Section 6.4.1 in the companion Commercial report.

### 6.4.3 R3 – Insulate Foundations

Workshop participants concluded that, under the conditions represented by the Upper Achievable scenario, participation rates up to 75% in existing single-family detached homes and up to 98% in new single-family detached homes could be achieved in the Island and Isolated service region by 2026. Workshop participants agreed that Adoption Curve B for existing homes and Curve C for new homes represented the best fits with the pace of participation in the intervening years from 2007 to 2026 under this Upper Achievable scenario.

Under the more modest market conditions represented by the Lower Achievable scenario, participation rates up to 25% in existing single-family detached homes and up to 55% in new single-family detached homes could be achieved in the Island and Isolated service region by 2026. Workshop participants agreed that Adoption Curve B for existing homes and Curve A for new homes represented the best fits with the pace of participation in the intervening years from 2007 to 2026 under this Lower Achievable scenario.

Based on the workshop discussions, it was assumed that participation rates in the remaining dwelling types would be similar to the above values. The measure is not applicable to apartment buildings. Participation rates in the Labrador Interconnected service region were assumed to be somewhat lower than those for the Island and Isolated service region because there are fewer basements and more crawl spaces. If the program could be broadened to include crawl space insulation, overall savings potential in the Labrador Interconnected service region would be increased.

Selected highlights:

- Code for basement insulation is often ignored (up to 90%) because of lack of enforcement. Insulation is often installed within a few years as part of basement refinishing
- NP has had surprisingly good uptake for a program on foundation insulation, without a great deal of marketing. NLH has had smaller uptake in Labrador Interconnected due to the lack of financial drivers
- There were concerns about encouraging consumers to install insulation as a do-it-yourself project (e.g., consumers may not be familiar with code)
- Technical innovation is a possibility in future, lowering the installation cost and the payback.

The preceding results were used as a reference point for estimating participation rates related to other insulation opportunities in the Residential sector.

Highlights:

- Participation rates for foundation insulation were also applied to crawl space insulation
- The estimate of participation for attic insulation was also informed by the discussion of foundation insulation.

### 6.4.4 R4 – Seal Air Leaks

Workshop participants concluded that, under the conditions represented by the Upper Achievable scenario, participation rates up to 90% could be achieved in new single-family detached homes in the Island and Isolated service region by 2026. Workshop participants agreed that Adoption Curve B represented the best fit with the pace of participation in the intervening years from 2007 to 2026 under this Upper Achievable scenario.

Under the more modest market conditions represented by the Lower Achievable scenario, participation rates up to 55% could be achieved in single-family detached homes in the Island and Isolated service region by 2026. Workshop participants agreed that Adoption Curve B represented the best fit with the pace of participation in the intervening years from 2007 to 2026 under this Lower Achievable scenario.

The workshop discussions focused on single-family detached homes and did not include consideration of other dwelling types. Participation rates in the Labrador Interconnected service region were assumed to be somewhat lower than those for the Island and Isolated service region, because of lower electricity prices.

Selected highlights:

- Opinions ranged widely on the capital cost of undertaking this upgrade, from as little as $400 to over $1,000 per house. Opinions on savings ranged from 10% of heating energy to as much as 15%
- For the purposes of discussion, reduction of leakage to 1.75 air changes per hour was considered a target
- Improved comfort in the home is likely to be an attractive selling feature.

#### 6.4.5 R5 – Upgrade to ENERGY STAR Windows at Time of Window Replacement or New Installation

Workshop participants concluded that, under the conditions represented by the Upper Achievable scenario, participation rates up to 100% could be achieved in both existing and new single-family detached homes in the Island and Isolated service region by 2026. Workshop participants agreed that Adoption Curve B in existing homes and Curve C in new homes represented the best fits with the pace of participation in the intervening years from 2007 to 2026 under this Upper Achievable scenario.

Under the more modest market conditions represented by the Lower Achievable scenario, participation rates up to 80% in existing single-family detached homes and up to 85% in new single-family detached homes could be achieved in the Island and Isolated service region by 2026. Workshop participants agreed that Adoption Curve B for existing homes and Curve C for new homes represented the best fits with the pace of participation in the intervening years from 2007 to 2026 under this Lower Achievable scenario.

Based on the workshop discussions, it was assumed that participation rates in the remaining dwelling types would be similar to the above values. The measure is replaced by the high-performance glazing commercial measure in apartment buildings. Participation rates in the Labrador Interconnected service region were assumed to be similar to those for the Island and Isolated service region.

Selected highlights:

- Workshop participants questioned the assumption that incremental cost of high-efficiency windows in the replacement (retail) market is higher than it is in the new construction (wholesale) market. Although high mark ups on the increment are the pattern in other jurisdictions, workshop participants said that retailers in Newfoundland and Labrador are not following that pattern. The measure already passes the economic screens with the current assumptions so this change would not increase the potential.

The preceding results were used as a reference point for estimating participation rates related to other window opportunities in the Residential sector.

Highlights:

- Participation rates for the super high-performance windows were assumed to trail participation rates for ENERGY STAR windows by approximately 10 years.

### 6.4.6 R6 – Construct New Houses to Achieve EG80 Rating

Workshop participants concluded that, under the conditions represented by the Upper Achievable scenario, participation rates up to 98% could be achieved in new single-family detached homes in the Island and Isolated service region by 2026. Workshop participants agreed that Adoption Curve D represented the best fit with the pace of participation in the intervening years from 2007 to 2026 under this Upper Achievable scenario. Curve D rises linearly and reaches a plateau; for this technology and scenario, that is assumed to occur in 2015.

Under the more modest market conditions represented by the Lower Achievable scenario, participation rates up to 10% could be achieved in single-family detached homes in the Island and Isolated service region by 2026. Workshop participants agreed that Adoption Curve A represented the best fit with the pace of participation in the intervening years from 2007 to 2026 under this Lower Achievable scenario.

Based on the workshop discussions, it was assumed that participation rates in the remaining dwelling types would be similar to the above values. Participation rates in the Labrador Interconnected service region were assumed to be similar to those for the Island and Isolated service region.

Selected highlights:

- A relatively small number of builders can be targeted for program activity (approximately 15-20 builders construct 50% of the homes each year)
- Provincial legislation may change the building code to require this level of energy performance at some point in the study period. That change is occurring in Nova Scotia as of 2011
- In the absence of legislation, education will be a critical program component. It is particularly important to involve the real estate community.

### 6.4.7 R7 – Reduce Standby Losses for Household Electronics using Power Bar Timers

Workshop participants concluded that, under the conditions represented by the Upper Achievable scenario, participation rates up to 25% could be achieved in single-family detached homes in the Island and Isolated service region by 2021; these rates would then descend to 0% as the technology is superseded by features built into the electronic devices. Workshop participants created Adoption Curve E to represent this bell curve shape.

The Lower Achievable scenario was assumed to be similar to the Upper Achievable scenario for this technology.

Based on the workshop discussions, it was assumed that participation rates in the remaining dwelling types would be similar to the above values. Participation rates in the Labrador Interconnected service region were assumed to be similar to those for the Island and Isolated service region.
Selected highlights:

- Discussions focused on a specific technology solution to standby losses, namely a power bar with a built-in timer that controls several of the outlets. These power bars are available in the marketplace. Discussion also focused on the television and its peripherals (especially set-top boxes), although the approach is applicable to other household electronics
- There were concerns that this device may not be suitable for some television peripherals, because power loss will erase their programming
- Workshop participants believed that a combination of technology improvements and energy standards would result in manufacturers incorporating power management features into the electronic devices themselves, eventually rendering this technology obsolete.

### 6.4.8 R8 – Upgrade to New ENERGY STAR Computer at Time of Replacement or New Purchase

Workshop participants concluded that, under the conditions represented by the Upper Achievable scenario, participation rates up to 80% could be achieved in single-family detached homes in the Island and Isolated service region by 2026. Workshop participants agreed that Adoption Curve B represented the best fit with the pace of participation in the intervening years from 2007 to 2026 under this Upper Achievable scenario.

Under the more modest market conditions represented by the Lower Achievable scenario, participation rates up to 15% could be achieved in single-family detached homes in the Island and Isolated service region by 2026. Workshop participants agreed that Adoption Curve B represented the best fit with the pace of participation in the intervening years from 2007 to 2026 under this Lower Achievable scenario.

Based on the workshop discussions, it was assumed that participation rates in the remaining dwelling types would be similar to the above values. Participation rates in the Labrador Interconnected service region were assumed to be similar to those for the Island and Isolated service region.

Selected highlights:

- ENERGY STAR for most appliances has generally been lower in Newfoundland and Labrador than in other jurisdictions, partly because of poor product availability. ENERGY STAR computers may fare somewhat better because there is no incremental cost.

The preceding results were used as a reference point for estimating participation rates related to other opportunities in the Residential sector.

Highlights:

- The discussion of ENERGY STAR computers informed the participation rates used for ENERGY STAR appliances, such as fridges, freezers, clothes washers and televisions.

### 6.4.9 R9 – Upgrade to New ENERGY STAR Clothes Washer at Time of Replacement or New Purchase

Workshop participants did not discuss this measure separately, but did discuss ENERGY STAR appliances in general during the discussion of computers. The clothes washer measure, although it has a large potential, has a CCE very close to the threshold. This leaves very little room for program activity or incentives. It would therefore be difficult to achieve significant penetration. Further, the efficient top loading clothes washer is the one that passes the CCE test. It is very rare in the marketplace, with only one or two models available in Canada. The front loading washer is more available and is even more efficient, but is also more expensive and does not pass the CCE test. For these reasons this measure was seen as a lower priority for workshop discussion.

### 6.4.10 Extrapolated Participation Rates – Remaining Energy-efficiency Opportunities

As noted previously, the workshop results and follow up email responses were used as a reference point, combined with consultant experience, to estimate participation rates for the remaining energy-efficiency opportunities that are contained in the Economic Potential Forecast.

Exhibits 6.8 and 6.9 provide, respectively, a summary of the estimated Upper and Lower participation rates for the remaining energy-efficiency opportunities. As illustrated, each exhibit shows:

- Workshop reference number, which refers to the package of Opportunity Profiles that were provided to workshop participants
- The affected technology
- The participation rates for each of the milestone years
- Notes that illustrate sources used by the consultants when estimating the participation rates shown.

## Exhibit 6.8: Participation Rates – Upper Achievable Potential[123]

| Measure Information | | Participation Rates | | Notes |
|---|---|---|---|---|
| **Workshop Reference #** | **Technology** | **F2026** | **Curve** | |
| R1 | Efficient (More Accurate) Thermostat | 90% | B | R1: Workshop input. |
| R2 | CFLs - Standard | 98% | B | R2: Workshop input. |
| R3 | Foundation Insulation, Existing | 75% | B | R3: Workshop input. |
| R3 | Foundation Insulation, New | 98% | A | R3: Workshop input. |
| R4 | Air Leakage Sealing | 90% | B | R4: Workshop input. |
| R5 | Energy Star Windows , Existing | 100% | B | R5: Workshop input. |
| R5 | Energy Star Windows , New | 100% | C | R5: Workshop input. |
| R6 | New House Designed to an EGNH 80 Rating | 98% | A | R6: Workshop input. |
| R7 | Standby Losses | 0% | E* | R7: Workshop input. |
| R8 | Energy Star Computer | 80% | B | R8: Workshop input. |
| C1 | Standard T8 Lighting - Common Areas, Existing Bldgs | 97% | A | C1: Workshop input. |
| C1 | Redesign with high performance T8s, Existing Bldgs | 40% | A | C1: Workshop input. |
| C2 | Redesign with high performance T8s, New Bldgs | 100% | C | C2: Workshop input. |
| C4 | High performance glazings | 20% | A | C4: Workshop input. |
| C5 | Building recommissioning | 85% | B | C5: Workshop input. |
| C6 | Ground source heat pumps | 20% | A | C6: Workshop input. |
| C7 | 40% Lower Energy Apartment Building | 56% | A/B** | C7: Workshop input. |
| | Super High Performance Windows | 25% | | Trail the participation rates for R5 by 10 years. |
| | Attic Insulation | 56% | | Similar participation to R3. |
| | Crawl-space Insulation | 75% | | Similar participation to R3, but much smaller incidence of crawlspaces. |
| | Programmable Thermostats | 5% | | Not much forced air electric heating (cf R1), but install on grouped baseboards in main areas. |
| | High Efficiency HRV | 25% | | Advanced version of accepted technology: use rates for Super windows. |
| | High Efficiency HRV | 75% | | Advanced version of accepted technology: use rates for Super windows. |
| | Furnace Fan Motor (ECPMM) | 98% | | Based on CFLs - standard, where it passes, because it can have high adoption if pushed |
| | Low-Flow Showerheads and Faucets | 98% | | Based on CFLs - standard, where it passes, because it can have high adoption if pushed |
| | DHW Tank Insulating Blanket | 98% | | Based on CFLs - standard, where it passes, because it can have high adoption if pushed |
| | DHW Pipe Wrap | 98% | | Based on CFLs - standard, where it passes, because it can have high adoption if pushed |
| | Energy Star Fridge | 80% | | R8 input probably reasonable for participation above E* reference penetration. |
| | Energy Star Fridge | 80% | | R8 input probably reasonable for participation above E* reference penetration. |
| | Energy Efficient Freezer | 80% | | R8 input probably reasonable for participation above E* reference penetration. |
| | Energy Star Top Loading Clothes Washer | 80% | | R8 input probably reasonable for participation above E* reference penetration. |
| | Energy Star TV | 80% | | Based on Energy Star Computer (R8) |
| | LED Holiday Lights | 98% | | Based on CFLs (R2). |
| | Timer | 98% | | Based on CFLs (R2). |
| | Motion Sensor | 98% | | Based on CFLs (R2). |
| | CFLs Specialised | 98% | | Based on CFL standard (R2). |
| | Replace air-source heat pump with a low temperature heat pump | 10% | | Not available yet. Use 0% until 2011, climb to 10% by 2026. |

* E - this curve, created by the workshop participants, is a bell-shaped curve that peaks in 2021 and descends back to zero after the technology is superseded by other advances
** A/B - this curve is a hybrid between curves A and B

[123] The low-temperature heat pump measure in this exhibit is for apartment buildings only. Units designed for apartments are under development. The low-temperature heat pumps for single detached homes, which are available, did not pass the economic screen and are not included in this exhibit.

## Exhibit 6.9: Participation Rates – Lower Achievable Potential [124]

| Measure Information | | Participation Rates | | Notes |
|---|---|---|---|---|
| Workshop Reference # | Technology | F2026 | Curve | |
| R1 | Efficient (More Accurate) Thermostat | 20% | C | R1: Workshop input. |
| R2 | CFLs - Standard | 90% | A | R2: Workshop input. |
| R3 | Foundation Insulation, Existing | 25% | B | R3: Workshop input. |
| R3 | Foundation Insulation, New | 55% | C | R3: Workshop input. |
| R4 | Air Leakage Sealing | 55% | B | W4: Workshop input. |
| R5 | Energy Star Windows , Existing | 80% | B | R5: Workshop input. |
| R5 | Energy Star Windows , New | 100% | C | R5: Workshop input. |
| R6 | New House Designed to an EGNH 80 Rating | 10% | D | R6: Workshop input. |
| R7 | Standby Losses | 0% | E* | R7: Workshop input. |
| R8 | Energy Star Computer | 15% | B | R8: Workshop input. |
| C1 | Standard T8 Lighting - Common Areas, Existing Bldgs | 80% | A | C1: Workshop input. |
| C1 | Redesign with high performance T8s, Existing Bldgs | 15% | A | C1: Workshop input. |
| C2 | Redesign with high performance T8s, New Bldgs | 80% | C | C2: Workshop input. |
| C4 | High performance glazings | 7% | A | C4: Workshop input. |
| C5 | Building recommissioning | 40% | A/B** | C5: Workshop input. |
| C6 | Ground source heat pumps | 2% | B | C6: Workshop input. |
| C7 | 40% Lower Energy Apartment Building | 38% | A/B** | C7: Workshop input. |
| | Super High Performance Windows | 20% | | Trail the rates for R5 by 10 years. |
| | Attic Insulation | 19% | | Similar participation to R3. |
| | Crawl-space Insulation | 25% | | Similar participation to R3, but much smaller incidence of crawlspaces. |
| | Programmable Thermostats | 2% | | Not much forced air electric heating (informed by R1 discussion). |
| | High Efficiency HRV | 20% | | Advanced version of accepted technology: use rates for Super windows. |
| | High Efficiency HRV | 25% | | Advanced version of accepted technology: use rates for Super windows. |
| | Furnace Fan Motor (ECPMM) | 90% | | Based on CFLs - standard, where it passes, because it can have high adoption if pushed |
| | Low-Flow Showerheads and Faucets | 90% | | Based on CFLs - standard, where it passes, because it can have high adoption if pushed |
| | DHW Tank Insulating Blanket | 90% | | Based on CFLs - standard, where it passes, because it can have high adoption if pushed |
| | DHW Pipe Wrap | 90% | | Based on CFLs - standard, where it passes, because it can have high adoption if pushed |
| | Energy Star Fridge | 15% | | R8 input probably reasonable for participation above E* reference penetration. |
| | Energy Star Fridge | 15% | | R8 input probably reasonable for participation above E* reference penetration. |
| | Energy Efficient Freezer | 15% | | R8 input probably reasonable for participation above E* reference penetration. |
| | Energy Star Top Loading Clothes Washer | 15% | | R8 input probably reasonable for participation above E* reference penetration. |
| | Energy Star TV | 15% | | Based on Energy Star Computer (R8) |
| | LED Holiday Lights | 90% | | Based on CFLs (R2). |
| | Timer | 90% | | Based on CFLs (R2). |
| | Motion Sensor | 90% | | Based on CFLs (R2). |
| | CFLs Specialised | 90% | | Based on CFL standard (R2). |
| | Replace air-source heat pump with a low temperature heat pump | 5% | | Not available yet. Use 0% until 2011, climb to 5% by 2026. |

* E - this curve, created by the workshop participants, is a bell-shaped curve that peaks in 2021 and descends back to zero after the technology is superseded by other advances
** A/B - this curve is a hybrid between curves A and B

[124] The low-temperature heat pump measure in this exhibit is for apartment buildings only. Units designed for apartments are under development. The low-temperature heat pumps for single detached homes, which are available, did not pass the economic screen and are not included in this exhibit.

## 6.5 SUMMARY OF ACHIEVABLE ELECTRICITY SAVINGS

Exhibit 6.10 provides a summary of the Achievable electricity savings under both the Lower and Upper scenarios for the Island and Isolated service region.

As illustrated, under the Reference Case residential electricity use would grow from the Base Year level of 3,228 GWh/yr. to approximately 3,968 GWh/yr. by 2026. This contrasts with the Upper Achievable scenario in which electricity use would increase to approximately 3,529 GWh/yr. for the same period, a difference of approximately 439 GWh/yr., or about 11% reduction. Under the Lower Achievable scenario, electricity use would increase to approximately 3,732 GWh/yr. for the same period, a difference of approximately 236 GWh/yr., or about 6% reduction.

**Exhibit 6.10: Reference Case versus Upper and Lower Achievable Potential Electricity Consumption in Residential Sector for the Island and Isolated Service Region (GWh/yr.)**

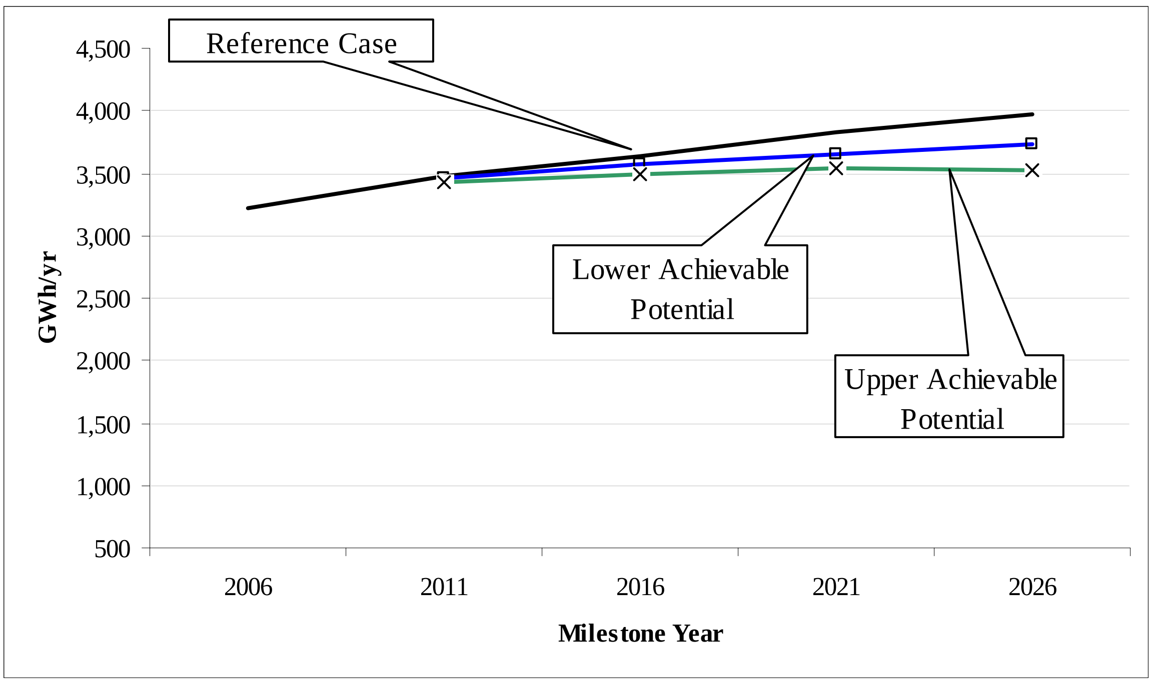
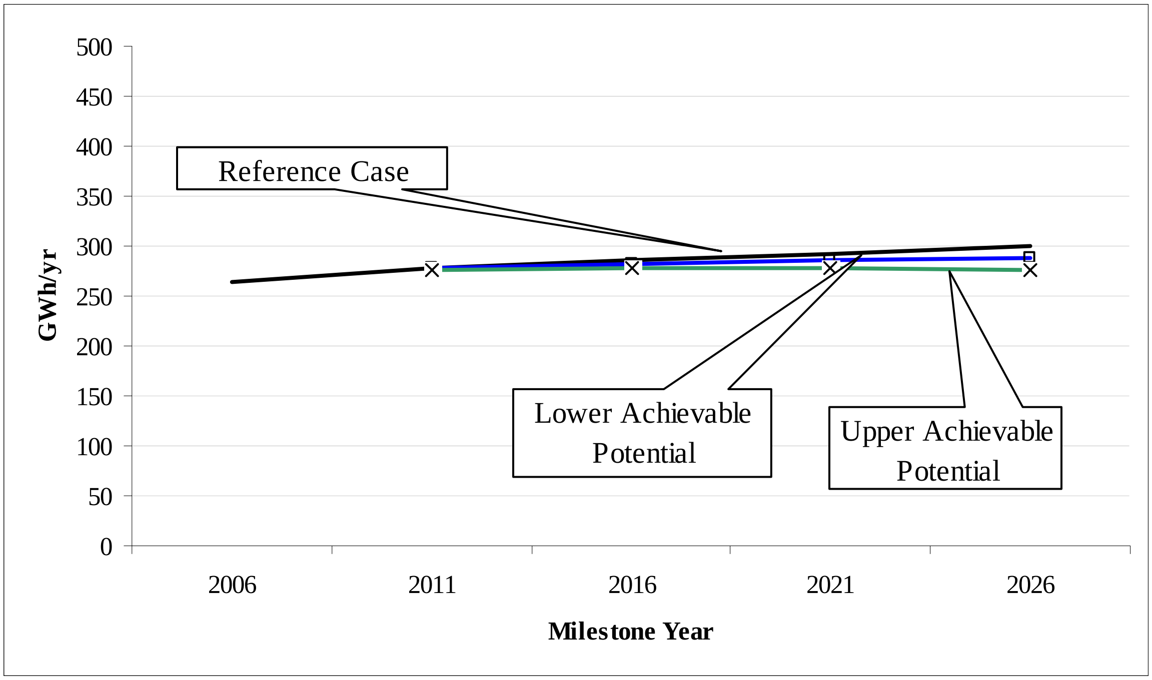



Exhibit 6.11 provides a summary of the achievable electricity savings under both the Lower and Upper scenarios for the Labrador Interconnected service region.

As illustrated, under the Reference Case residential electricity use would grow from the Base Year level of 264 GWh/yr. to approximately 300 GWh/yr. by 2026. This contrasts with the Upper Achievable scenario in which electricity use would increase to approximately 275 GWh/yr. for the same period, a difference of approximately 25 GWh/yr., or about 8% reduction. Under the Lower Achievable scenario, electricity use would increase to approximately 287 GWh/yr. for the same period, a difference of approximately 13 GWh/yr., or about 4% reduction.

**Exhibit 6.11: Reference Case versus Upper and Lower Achievable Potential Electricity Consumption in Residential Sector for the Labrador Interconnected Service Region (GWh/yr.)**




Further detail on the total potential electricity savings provided by the Achievable Potential forecasts is provided in the following exhibits:

- Exhibits 6.12 and 6.13 present, respectively, the Upper and Lower Achievable results by end use, dwelling type and milestone year for the Island and Isolated service region
- Exhibits 6.14 and 6.15 present, respectively, the Upper and Lower Achievable results by end use, dwelling type and milestone year for the Labrador Interconnected service region
- Exhibits 6.16 and 6.17 present, respectively, the Upper and Lower Achievable savings in 2026 by major end use and dwelling type for the Island and Isolated service region
- Exhibits 6.18 and 6.19 present, respectively, the Upper and Lower Achievable savings in 2026 by major end use and service region for the Labrador Interconnected service region
- Exhibit 6.20 presents the Upper and Lower Achievable savings by milestone year and service region.

## Exhibit 6.12: Summary of Annual Electricity Savings for the Island and Isolated Service Region by End Use and Dwelling Type, Upper Achievable Potential (GWh/yr.)

| Dwelling Type | Milestone Year | Residential | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Total | Space Heating | Ventilation | DHW | Cooking | Refrigerator | Freezer | Dishwasher | Clothes Washer | Clothes Dryer | Lighting | Computer and peripherals | Television | Television Peripherals | Other Electronics | Small Appliances & Other |
| Detached | 2011 | 47.1 | 1.9 | 0.0 | 9.0 | | 0.0 | 0.0 | | 0.0 | 0.0 | 34.4 | 1.0 | 0.0 | 0.7 | 0.0 | |
| | 2016 | 121.6 | 15.0 | 0.1 | 14.9 | | 0.6 | 0.3 | | 0.3 | 2.4 | 70.2 | 8.0 | 1.3 | 8.2 | 0.2 | |
| | 2021 | 233.0 | 45.9 | 0.1 | 24.7 | | 2.2 | 1.2 | | 0.9 | 7.8 | 107.0 | 16.0 | 4.8 | 21.8 | 0.5 | |
| | 2026 | 362.0 | 116.0 | 0.2 | 38.6 | | 4.4 | 2.6 | | 2.1 | 17.5 | 144.6 | 26.3 | 9.7 | 0.0 | 0.0 | |
| Attached | 2011 | 5.6 | 0.0 | 0.0 | 1.1 | | 0.0 | 0.0 | | 0.0 | 0.0 | 4.2 | 0.1 | 0.0 | 0.1 | 0.0 | |
| | 2016 | 15.5 | 1.6 | 0.0 | 1.8 | | 0.1 | 0.0 | | 0.0 | 0.2 | 8.6 | 1.2 | 0.2 | 1.7 | 0.0 | |
| | 2021 | 29.6 | 4.6 | 0.0 | 3.0 | | 0.4 | 0.0 | | 0.1 | 0.8 | 13.3 | 2.4 | 0.6 | 4.3 | 0.1 | |
| | 2026 | 41.6 | 10.4 | 0.0 | 4.8 | | 0.8 | 0.0 | | 0.2 | 1.8 | 18.2 | 4.0 | 1.3 | 0.0 | 0.0 | |
| Apartment | 2011 | 3.5 | 0.3 | 0.1 | 0.7 | | 0.0 | 0.0 | | 0.0 | 0.0 | 2.2 | 0.1 | 0.0 | 0.1 | 0.0 | |
| | 2016 | 9.5 | 0.6 | 0.2 | 1.6 | | 0.1 | 0.0 | | 0.0 | 0.1 | 4.6 | 0.8 | 0.1 | 1.3 | 0.0 | |
| | 2021 | 18.0 | 1.2 | 0.4 | 3.2 | | 0.3 | 0.0 | | 0.0 | 0.3 | 7.1 | 1.6 | 0.4 | 3.4 | 0.0 | |
| | 2026 | 25.1 | 4.5 | 0.7 | 5.2 | | 0.7 | 0.0 | | 0.1 | 0.8 | 9.6 | 2.7 | 0.9 | 0.0 | 0.0 | |
| Isolated | 2011 | 1.0 | 0.0 | 0.0 | 0.2 | | 0.0 | 0.0 | | 0.0 | 0.0 | 0.8 | 0.0 | 0.0 | 0.0 | 0.0 | |
| | 2016 | 2.2 | 0.0 | 0.0 | 0.3 | | 0.0 | 0.0 | | 0.0 | 0.0 | 1.5 | 0.1 | 0.0 | 0.1 | 0.0 | |
| | 2021 | 3.7 | 0.1 | 0.0 | 0.5 | | 0.0 | 0.0 | | 0.0 | 0.2 | 2.3 | 0.2 | 0.1 | 0.3 | 0.0 | |
| | 2026 | 5.0 | 0.2 | 0.0 | 0.8 | | 0.1 | 0.1 | | 0.0 | 0.3 | 3.1 | 0.3 | 0.1 | 0.0 | 0.0 | |
| Other | 2011 | 0.4 | -0.1 | 0.0 | 0.0 | | 0.0 | 0.0 | | 0.0 | 0.0 | 0.6 | 0.0 | 0.0 | 0.0 | 0.0 | |
| | 2016 | 1.0 | -0.1 | 0.0 | 0.0 | | 0.0 | 0.0 | | 0.0 | 0.0 | 1.1 | 0.0 | 0.0 | 0.0 | 0.0 | |
| | 2021 | 1.6 | -0.1 | 0.0 | 0.0 | | 0.0 | 0.0 | | 0.0 | 0.0 | 1.7 | 0.0 | 0.0 | 0.0 | 0.0 | |
| | 2026 | 2.1 | -0.1 | 0.0 | 0.0 | | 0.0 | 0.0 | | 0.0 | 0.0 | 2.2 | 0.0 | 0.0 | 0.0 | 0.0 | |
| Vacant and Partial | 2011 | 0.6 | -0.1 | 0.0 | 0.0 | | 0.0 | 0.0 | | 0.0 | 0.0 | 0.8 | 0.0 | 0.0 | 0.0 | 0.0 | |
| | 2016 | 1.4 | -0.1 | 0.0 | 0.0 | | 0.0 | 0.0 | | 0.0 | 0.0 | 1.5 | 0.0 | 0.0 | 0.0 | 0.0 | |
| | 2021 | 2.1 | -0.1 | 0.0 | 0.0 | | 0.0 | 0.0 | | 0.0 | 0.0 | 2.2 | 0.0 | 0.0 | 0.0 | 0.0 | |
| | 2026 | 2.8 | -0.1 | 0.0 | 0.0 | | 0.0 | 0.0 | | 0.0 | 0.0 | 2.9 | 0.0 | 0.0 | 0.0 | 0.0 | |
| TOTAL | 2011 | 58.2 | 2.0 | 0.1 | 10.9 | | 0.0 | 0.0 | | 0.0 | 0.0 | 42.8 | 1.2 | 0.1 | 1.0 | 0.0 | |
| | 2016 | 151.1 | 17.0 | 0.3 | 18.6 | | 0.8 | 0.4 | | 0.3 | 2.8 | 87.6 | 10.0 | 1.6 | 11.3 | 0.3 | |
| | 2021 | 287.9 | 51.6 | 0.6 | 31.4 | | 2.9 | 1.3 | | 1.1 | 9.1 | 133.5 | 20.1 | 5.9 | 29.7 | 0.7 | |
| | 2026 | 438.7 | 130.9 | 0.9 | 49.5 | | 5.9 | 2.7 | | 2.5 | 20.5 | 180.7 | 33.2 | 12.1 | 0.0 | 0.0 | |

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*Notes: 1) Results are measured at the customer's point-of-use and do not include line losses. 2) Any differences in totals are due to rounding. 3) A value displays as 0 if it is between 0 and 0.5. Totals are calculated using the actual numerical value. 4) Negative values in the space heating end use are a result of the reduction in internal heat gains due to lighting and appliance measures being greater than any savings from space heating measures. 5) Savings for television peripherals and other electronics are from standby loss reduction measures. Workshop participants believed that by 2026 advances in the appliances themselves would eliminate the savings available from add-on devices such as timed power bars. Savings in the last milestone period therefore drop to zero.*

## Exhibit 6.13: Summary of Annual Electricity Savings for the Island and Isolated Service Region by End Use and Dwelling Type, Lower Achievable Potential (GWh/yr.)

| Dwelling Type | Milestone Year | Residential | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Total | Space Heating | Ventilation | DHW | Cooking | Refrigerator | Freezer | Dishwasher | Clothes Washer | Clothes Dryer | Lighting | Computer and peripherals | Television | Television Peripherals | Other Electronics | Small Appliances & Other |
| Detached | 2011 | 12.2 | 0.5 | 0.0 | 2.2 | | 0.0 | 0.0 | | 0.0 | 0.0 | 8.4 | 0.3 | 0.0 | 0.7 | 0.0 | |
| | 2016 | 54.8 | 3.3 | 0.0 | 6.0 | | 0.1 | 0.1 | | 0.1 | 0.5 | 33.1 | 2.5 | 0.7 | 8.2 | 0.2 | |
| | 2021 | 128.2 | 11.1 | 0.1 | 11.0 | | 0.4 | 0.2 | | 0.2 | 1.4 | 74.5 | 5.3 | 1.8 | 21.8 | 0.5 | |
| | 2026 | 190.8 | 30.8 | 0.1 | 15.3 | | 0.8 | 0.5 | | 0.4 | 3.3 | 132.9 | 5.0 | 1.8 | 0.0 | 0.0 | |
| Attached | 2011 | 1.5 | 0.0 | 0.0 | 0.3 | | 0.0 | 0.0 | | 0.0 | 0.0 | 1.0 | 0.0 | 0.0 | 0.1 | 0.0 | |
| | 2016 | 7.2 | 0.1 | 0.0 | 0.7 | | 0.0 | 0.0 | | 0.0 | 0.0 | 4.0 | 0.4 | 0.1 | 1.7 | 0.0 | |
| | 2021 | 16.6 | 0.4 | 0.0 | 1.3 | | 0.1 | 0.0 | | 0.0 | 0.1 | 9.2 | 0.8 | 0.2 | 4.3 | 0.1 | |
| | 2026 | 22.3 | 2.1 | 0.0 | 1.9 | | 0.2 | 0.0 | | 0.0 | 0.3 | 16.7 | 0.8 | 0.2 | 0.0 | 0.0 | |
| Apartment | 2011 | 1.3 | 0.2 | 0.0 | 0.3 | | 0.0 | 0.0 | | 0.0 | 0.0 | 0.6 | 0.0 | 0.0 | 0.1 | 0.0 | |
| | 2016 | 5.2 | 0.4 | 0.1 | 0.8 | | 0.0 | 0.0 | | 0.0 | 0.0 | 2.3 | 0.2 | 0.1 | 1.3 | 0.0 | |
| | 2021 | 11.6 | 0.7 | 0.2 | 1.5 | | 0.1 | 0.0 | | 0.0 | 0.1 | 5.0 | 0.5 | 0.2 | 3.4 | 0.0 | |
| | 2026 | 14.6 | 2.1 | 0.3 | 2.6 | | 0.1 | 0.0 | | 0.0 | 0.1 | 8.7 | 0.5 | 0.2 | 0.0 | 0.0 | |
| Isolated | 2011 | 0.2 | 0.0 | 0.0 | 0.0 | | 0.0 | 0.0 | | 0.0 | 0.0 | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 | |
| | 2016 | 1.0 | 0.0 | 0.0 | 0.1 | | 0.0 | 0.0 | | 0.0 | 0.0 | 0.7 | 0.0 | 0.0 | 0.1 | 0.0 | |
| | 2021 | 2.3 | 0.0 | 0.0 | 0.2 | | 0.0 | 0.0 | | 0.0 | 0.0 | 1.6 | 0.1 | 0.0 | 0.3 | 0.0 | |
| | 2026 | 3.4 | 0.0 | 0.0 | 0.3 | | 0.0 | 0.0 | | 0.0 | 0.1 | 2.9 | 0.0 | 0.0 | 0.0 | 0.0 | |
| Other | 2011 | 0.1 | 0.0 | 0.0 | 0.0 | | 0.0 | 0.0 | | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | |
| | 2016 | 0.4 | -0.1 | 0.0 | 0.0 | | 0.0 | 0.0 | | 0.0 | 0.0 | 0.5 | 0.0 | 0.0 | 0.0 | 0.0 | |
| | 2021 | 1.1 | -0.1 | 0.0 | 0.0 | | 0.0 | 0.0 | | 0.0 | 0.0 | 1.2 | 0.0 | 0.0 | 0.0 | 0.0 | |
| | 2026 | 1.9 | -0.1 | 0.0 | 0.0 | | 0.0 | 0.0 | | 0.0 | 0.0 | 2.0 | 0.0 | 0.0 | 0.0 | 0.0 | |
| Vacant and Partial | 2011 | 0.1 | 0.0 | 0.0 | 0.0 | | 0.0 | 0.0 | | 0.0 | 0.0 | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 | |
| | 2016 | 0.6 | -0.1 | 0.0 | 0.0 | | 0.0 | 0.0 | | 0.0 | 0.0 | 0.7 | 0.0 | 0.0 | 0.0 | 0.0 | |
| | 2021 | 1.4 | -0.1 | 0.0 | 0.0 | | 0.0 | 0.0 | | 0.0 | 0.0 | 1.5 | 0.0 | 0.0 | 0.0 | 0.0 | |
| | 2026 | 2.6 | -0.1 | 0.0 | 0.0 | | 0.0 | 0.0 | | 0.0 | 0.0 | 2.7 | 0.0 | 0.0 | 0.0 | 0.0 | |
| TOTAL | 2011 | 15.5 | 0.7 | 0.0 | 2.8 | | 0.0 | 0.0 | | 0.0 | 0.0 | 10.6 | 0.3 | 0.1 | 1.0 | 0.0 | |
| | 2016 | 69.2 | 3.7 | 0.1 | 7.6 | | 0.2 | 0.1 | | 0.1 | 0.6 | 41.4 | 3.1 | 0.8 | 11.3 | 0.3 | |
| | 2021 | 161.3 | 12.0 | 0.3 | 14.1 | | 0.5 | 0.2 | | 0.2 | 1.7 | 93.0 | 6.6 | 2.3 | 29.7 | 0.7 | |
| | 2026 | 235.7 | 34.8 | 0.4 | 20.1 | | 1.1 | 0.5 | | 0.5 | 3.8 | 166.0 | 6.3 | 2.2 | 0.0 | 0.0 | |

*Notes: 1) Results are measured at the customer's point-of-use and do not include line losses. 2) Any differences in totals are due to rounding. 3) A value displays as 0 if it is between 0 and 0.5. Totals are calculated using the actual numerical value. 4) Negative values in the space heating end use are a result of the reduction in internal heat gains due to lighting and appliance measures being greater than any savings from space heating measures. 5) Savings for television peripherals and other electronics are from standby loss reduction measures. Workshop participants believed that by 2026 advances in the appliances themselves would eliminate the savings available from add-on devices such as timed power bars. Savings in the last milestone period therefore drop to zero.*

## Exhibit 6.14: Summary of Annual Electricity Savings for the Labrador Interconnected Service Region by End Use and Dwelling Type, Upper Achievable Potential (GWh/yr.)

| Dwelling Type | Milestone Year | Residential | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Total | Space Heating | Ventilation | DHW | Cooking | Refrigerator | Freezer | Dishwasher | Clothes Washer | Clothes Dryer | Lighting | Computer and peripherals | Television | Television Peripherals | Other Electronics | Small Appliances & Other |
| Detached | 2011 | 1.8 | 0.2 | 0.0 | 0.4 | | | | | | | 1.1 | 0.0 | | 0.0 | 0.0 | |
| | 2016 | 5.3 | 2.0 | 0.0 | 0.5 | | | | | | | 2.3 | 0.2 | | 0.2 | 0.0 | |
| | 2021 | 11.1 | 6.1 | 0.0 | 0.6 | | | | | | | 3.5 | 0.4 | | 0.5 | 0.0 | |
| | 2026 | 19.2 | 13.3 | 0.0 | 0.5 | | | | | | | 4.7 | 0.7 | | 0.0 | 0.0 | |
| | | | | | | | | | | | | | | | | | |
| Attached | 2011 | 0.5 | 0.0 | 0.0 | 0.1 | | | | | | | 0.4 | 0.0 | | 0.0 | 0.0 | |
| | 2016 | 1.4 | 0.3 | 0.0 | 0.2 | | | | | | | 0.7 | 0.1 | | 0.1 | 0.0 | |
| | 2021 | 2.8 | 1.1 | 0.0 | 0.2 | | | | | | | 1.1 | 0.1 | | 0.2 | 0.0 | |
| | 2026 | 4.5 | 2.7 | 0.0 | 0.2 | | | | | | | 1.5 | 0.2 | | 0.0 | 0.0 | |
| | | | | | | | | | | | | | | | | | |
| Apartment | 2011 | 0.1 | 0.0 | 0.0 | 0.0 | | | | | | | 0.0 | 0.0 | | 0.0 | 0.0 | |
| | 2016 | 0.2 | 0.0 | 0.0 | 0.0 | | | | | | | 0.1 | 0.0 | | 0.0 | 0.0 | |
| | 2021 | 0.3 | 0.0 | 0.0 | 0.0 | | | | | | | 0.2 | 0.0 | | 0.1 | 0.0 | |
| | 2026 | 0.4 | 0.1 | 0.0 | 0.0 | | | | | | | 0.2 | 0.0 | | 0.0 | 0.0 | |
| | | | | | | | | | | | | | | | | | |
| Isolated | 2011 | 0.0 | 0.0 | 0.0 | 0.0 | | | | | | | 0.0 | 0.0 | | 0.0 | 0.0 | |
| | 2016 | 0.0 | 0.0 | 0.0 | 0.0 | | | | | | | 0.0 | 0.0 | | 0.0 | 0.0 | |
| | 2021 | 0.0 | 0.0 | 0.0 | 0.0 | | | | | | | 0.0 | 0.0 | | 0.0 | 0.0 | |
| | 2026 | 0.0 | 0.0 | 0.0 | 0.0 | | | | | | | 0.0 | 0.0 | | 0.0 | 0.0 | |
| | | | | | | | | | | | | | | | | | |
| Other | 2011 | 0.0 | 0.0 | 0.0 | 0.0 | | | | | | | 0.0 | 0.0 | | 0.0 | 0.0 | |
| | 2016 | 0.0 | 0.0 | 0.0 | 0.0 | | | | | | | 0.0 | 0.0 | | 0.0 | 0.0 | |
| | 2021 | 0.1 | 0.0 | 0.0 | 0.0 | | | | | | | 0.1 | 0.0 | | 0.0 | 0.0 | |
| | 2026 | 0.1 | 0.0 | 0.0 | 0.0 | | | | | | | 0.1 | 0.0 | | 0.0 | 0.0 | |
| | | | | | | | | | | | | | | | | | |
| TOTAL | 2011 | 2.5 | 0.2 | 0.0 | 0.6 | | | | | | | 1.6 | 0.0 | | 0.0 | 0.0 | |
| | 2016 | 6.9 | 2.4 | 0.0 | 0.7 | | | | | | | 3.2 | 0.3 | | 0.3 | 0.0 | |
| | 2021 | 14.3 | 7.2 | 0.0 | 0.8 | | | | | | | 4.8 | 0.5 | | 0.8 | 0.0 | |
| | 2026 | 24.2 | 16.1 | 0.0 | 0.7 | | | | | | | 6.5 | 0.9 | | 0.0 | 0.0 | |

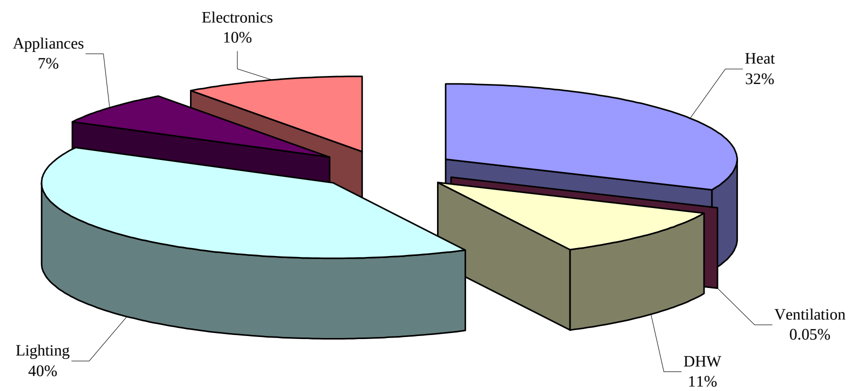
*Notes: 1) Results are measured at the customer's point-of-use and do not include line losses. 2) Any differences in totals are due to rounding. 3) A value displays as 0 if it is between 0 and 0.5. Totals are calculated using the actual numerical value. 4) Negative values in the space heating end use are a result of the reduction in internal heat gains due to lighting and appliance measures being greater than any savings from space heating measures. 5) Savings for television peripherals and other electronics are from standby loss reduction measures. Workshop participants believed that by 2026 advances in the appliances themselves would eliminate the savings available from add-on devices such as timed power bars. Savings in the last milestone period therefore drop to zero.*

## Exhibit 6.15: Summary of Annual Electricity Savings for the Labrador Interconnected Service Region by End Use and Dwelling Type, Lower Achievable Potential (GWh/yr.)

| Dwelling Type | Milestone Year | Residential | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Total | Space Heating | Ventilation | DHW | Cooking | Refrigerator | Freezer | Dishwasher | Clothes Washer | Clothes Dryer | Lighting | Computer and peripherals | Television | Television Peripherals | Other Electronics | Small Appliances & Other |
| Detached | 2011 | 0.6 | 0.1 | 0.0 | 0.1 | | | | | | | 0.3 | 0.0 | | 0.0 | 0.0 | |
| | 2016 | 2.2 | 0.6 | 0.0 | 0.3 | | | | | | | 1.1 | 0.1 | | 0.2 | 0.0 | |
| | 2021 | 5.3 | 1.7 | 0.0 | 0.4 | | | | | | | 2.4 | 0.1 | | 0.5 | 0.0 | |
| | 2026 | 9.5 | 4.5 | 0.0 | 0.5 | | | | | | | 4.3 | 0.1 | | 0.0 | 0.0 | |
| | | | | | | | | | | | | | | | | | |
| Attached | 2011 | 0.2 | 0.0 | 0.0 | 0.0 | | | | | | | 0.1 | 0.0 | | 0.0 | 0.0 | |
| | 2016 | 0.6 | 0.1 | 0.0 | 0.1 | | | | | | | 0.3 | 0.0 | | 0.1 | 0.0 | |
| | 2021 | 1.4 | 0.3 | 0.0 | 0.1 | | | | | | | 0.8 | 0.0 | | 0.2 | 0.0 | |
| | 2026 | 2.4 | 0.9 | 0.0 | 0.1 | | | | | | | 1.3 | 0.0 | | 0.0 | 0.0 | |
| | | | | | | | | | | | | | | | | | |
| Apartment | 2011 | 0.0 | 0.0 | 0.0 | 0.0 | | | | | | | 0.0 | 0.0 | | 0.0 | 0.0 | |
| | 2016 | 0.1 | 0.0 | 0.0 | 0.0 | | | | | | | 0.0 | 0.0 | | 0.0 | 0.0 | |
| | 2021 | 0.2 | 0.0 | 0.0 | 0.0 | | | | | | | 0.1 | 0.0 | | 0.1 | 0.0 | |
| | 2026 | 0.3 | 0.1 | 0.0 | 0.0 | | | | | | | 0.2 | 0.0 | | 0.0 | 0.0 | |
| | | | | | | | | | | | | | | | | | |
| Isolated | 2011 | 0.0 | 0.0 | 0.0 | 0.0 | | | | | | | 0.0 | 0.0 | | 0.0 | 0.0 | |
| | 2016 | 0.0 | 0.0 | 0.0 | 0.0 | | | | | | | 0.0 | 0.0 | | 0.0 | 0.0 | |
| | 2021 | 0.0 | 0.0 | 0.0 | 0.0 | | | | | | | 0.0 | 0.0 | | 0.0 | 0.0 | |
| | 2026 | 0.0 | 0.0 | 0.0 | 0.0 | | | | | | | 0.0 | 0.0 | | 0.0 | 0.0 | |
| | | | | | | | | | | | | | | | | | |
| Other | 2011 | 0.0 | 0.0 | 0.0 | 0.0 | | | | | | | 0.0 | 0.0 | | 0.0 | 0.0 | |
| | 2016 | 0.0 | 0.0 | 0.0 | 0.0 | | | | | | | 0.0 | 0.0 | | 0.0 | 0.0 | |
| | 2021 | 0.1 | 0.0 | 0.0 | 0.0 | | | | | | | 0.1 | 0.0 | | 0.0 | 0.0 | |
| | 2026 | 0.1 | 0.0 | 0.0 | 0.0 | | | | | | | 0.1 | 0.0 | | 0.0 | 0.0 | |
| | | | | | | | | | | | | | | | | | |
| TOTAL | 2011 | 0.7 | 0.2 | 0.0 | 0.1 | | | | | | | 0.4 | 0.0 | | 0.0 | 0.0 | |
| | 2016 | 2.9 | 0.7 | 0.0 | 0.3 | | | | | | | 1.5 | 0.1 | | 0.3 | 0.0 | |
| | 2021 | 7.0 | 2.0 | 0.0 | 0.6 | | | | | | | 3.3 | 0.2 | | 0.8 | 0.0 | |
| | 2026 | 12.3 | 5.5 | 0.0 | 0.7 | | | | | | | 6.0 | 0.2 | | 0.0 | 0.0 | |

*Notes: 1) Results are measured at the customer's point-of-use and do not include line losses. 2) Any differences in totals are due to rounding. 3) A value displays as 0 if it is between 0 and 0.5. Totals are calculated using the actual numerical value. 4) Negative values in the space heating end use are a result of the reduction in internal heat gains due to lighting and appliance measures being greater than any savings from space heating measures. 5) Savings for television peripherals and other electronics are from standby loss reduction measures. Workshop participants believed that by 2026 advances in the appliances themselves would eliminate the savings available from add-on devices such as timed power bars. Savings in the last milestone period therefore drop to zero.*

**Exhibit 6.16: Savings by Major End Use,
Upper Achievable – Island and Isolated Service Region 2026 (%)**




*Totals for Exhibits 6.16 and 6.17 may not add to 100% due to rounding.*

**Exhibit 6.17: Savings by Major End Use,
Lower Achievable – Island and Isolated Service Region 2026 (%)**

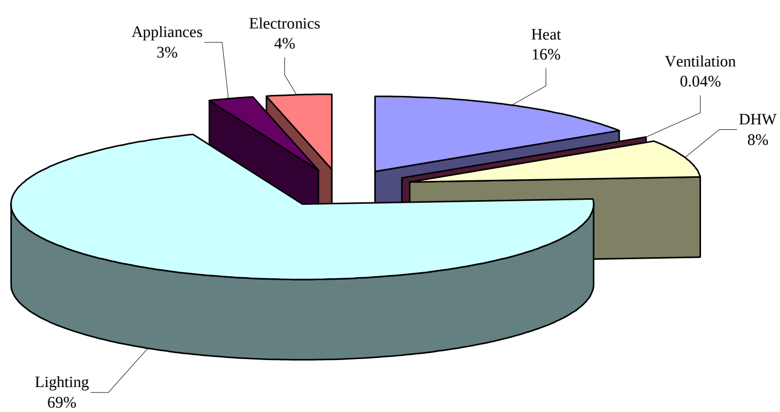
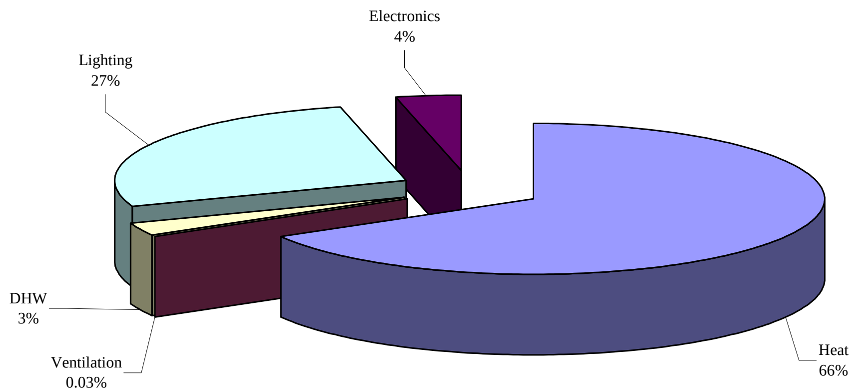


**Exhibit 6.18: Savings by Major End Use, Upper Achievable – Labrador Interconnected Service Region 2026 (%)**




*Totals for Exhibits 6.18 and 6.19 may not add to 100% due to rounding.*

**Exhibit 6.19: Savings by Major End Use and Dwelling Type, Lower Achievable – Labrador Interconnected Service Region 2026 (GWh/yr.)**

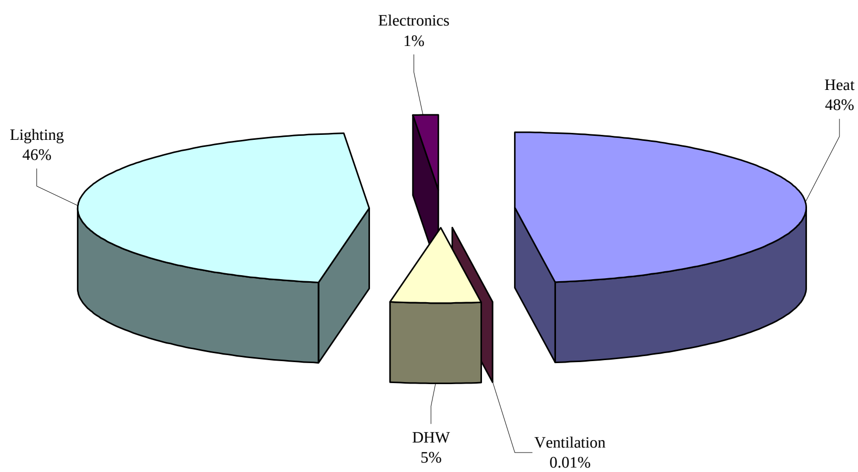
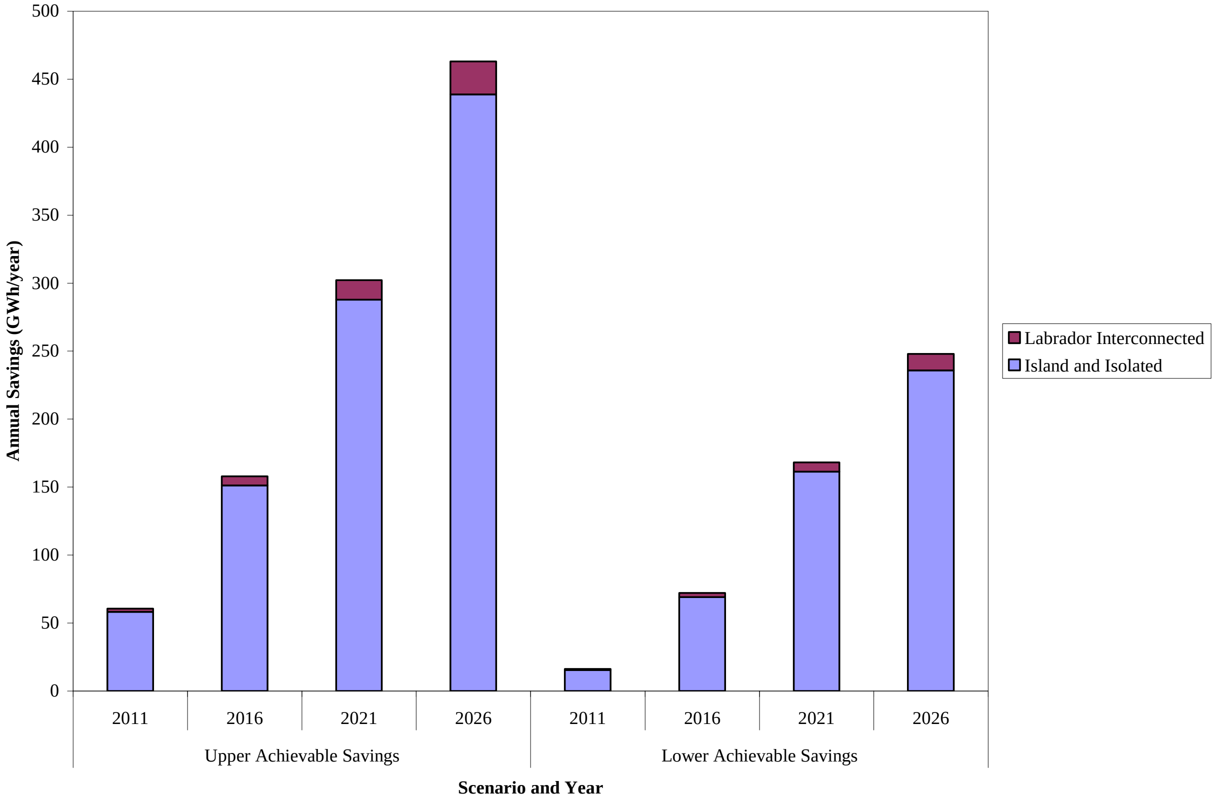


**Exhibit 6.20: Savings by Scenario, Milestone Year and Service Region (GWh/yr.)**




## 6.6 PEAK LOAD IMPACTS

The electricity (electric energy) savings (GWh) contained in the preceding scenarios also result in a reduction in electric demand (MW).[125]

The conversion of electricity savings to hourly demand requires the following steps:

- Annual electricity savings for each combination of sub sector and end use are disaggregated *by month*
- Monthly electricity savings are then further disaggregated *by day type* (weekday, weekend day and peak day)
- Finally, each day type is disaggregated *by hour*.

The above steps that convert electricity to electric demand require the development and application of the following four factors (sets of ratios).

[125] Peak load savings were modelled using Applied Energy Group's Cross-Sector Load Shape Library Model (LOADLIB).

- **Monthly Usage Factor**

This factor represents the percentage of annual electricity use that occurs in each month of the year. This set of monthly fractions (percentages) reflects the seasonality of the load shape, whether a facility, process or end use, and is dictated by weather or other seasonal factors. This allocation factor can be obtained from either (in decreasing order of priority): (a) monthly consumption statistics from end-use load studies; (b) monthly seasonal sales (preferably weather normalized) obtained by subtracting a "base" month from winter and summer heating and cooling months; or (c) heating or cooling degree days on an appropriate base.

- **Weekend to Weekday Factor**

This factor is a ratio that describes the distribution of electricity use between weekends and weekdays

- **Peak Day Factor**

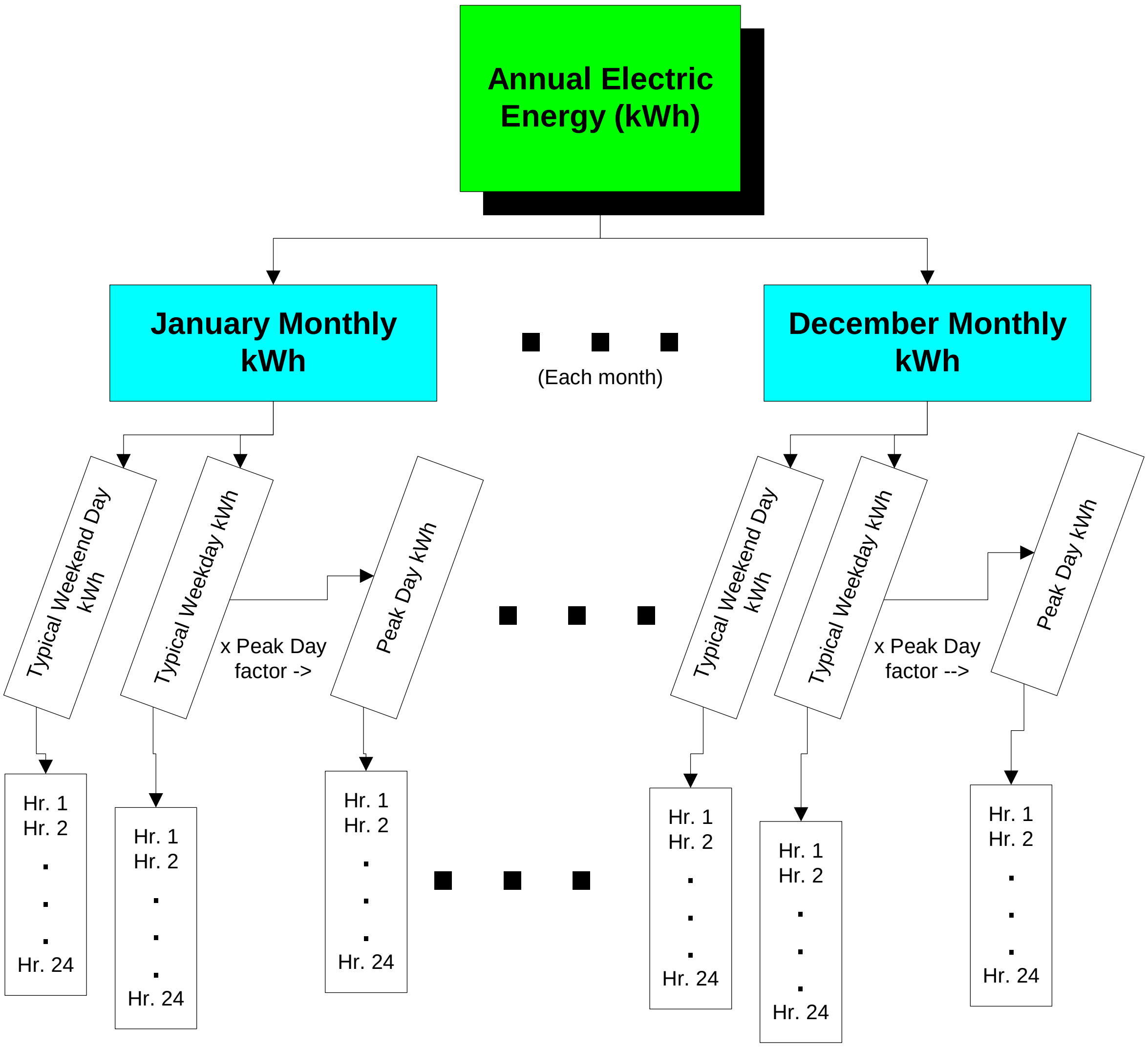
This factor defines the degree of daily weather sensitivity associated with the load shape, particularly heating or cooling; it compares a peak (e.g., hottest or coldest) day to a typical weekday in that month.

- **Hourly Factor**

This factor describes the typical distribution of daily electricity use for each day type (weekday, weekend day, peak day) and for each month. It reflects the operating hours of the electric equipment or end use by sub sector. For example, for lighting, this would be affected by time of day and season (affected by daylight).

Exhibit 6.21 provides an illustration of the sequential application of the above factors to convert annual electricity to hourly demand. Further description is provided in Appendix C.

**Exhibit 6.21: Illustration of Electricity to Peak load Calculation**




The study defined the Newfoundland Labrador system peak as:

> *The morning period from 7 am to noon and the evening period from 4 pm to 8 pm on the four coldest days in the December to March period; this is a total of 36 hours per year.*

Exhibit 6.22 presents a summary of the peak load reductions that would occur during the peak period noted above as a result of the electricity savings contained in Upper and Lower Achievable scenarios. In each case, the reductions are an average value over the peak period and are defined relative to the Reference Case.

**Exhibit 6.22: Peak load Reductions (MW) Relative to Reference Case by Milestone Year, Service Region and Achievable Scenario**

| Service Region | Milestone Year | Peak Demand Reduction MW | |
|---|---|---|---|
| | | Upper Achievable | Lower Achievable |
| Island and Isolated | 2011 | 10.8 | 2.9 |
| | 2016 | 29.1 | 13.3 |
| | 2021 | 57.8 | 32.4 |
| | 2026 | 91.1 | 48.9 |
| | | | |
| Labrador Interconnected | 2011 | 0.6 | 0.2 |
| | 2016 | 1.8 | 0.8 |
| | 2021 | 3.8 | 1.9 |
| | 2026 | 6.5 | 3.3 |
| | | | |
| TOTAL | 2011 | 11.4 | 3.1 |
| | 2016 | 30.9 | 14.1 |
| | 2021 | 61.6 | 34.3 |
| | 2026 | 97.6 | 52.2 |

# 7. CONCLUSIONS AND NEXT STEPS

This study has confirmed the existence of significant cost-effective CDM potential within Newfoundland and Labrador's Residential sector. The study results provide:

- Specific estimates of the potential CDM savings opportunities, defined by sector, sub sector, end use and, in several cases, specific technology(s)
- A baseline set of energy technology penetrations and energy use practices that can assist in the design of specific programs.

The next step[126] in this process involves the selection of a cost-effective portfolio of CDM programs and the setting of specific CDM targets and spending levels. To provide a preliminary reference point for this next step in the program development process, the study team conducted a brief literature search in an attempt to identify typical CDM spending levels in other jurisdictions. The literature search identified two (relatively) recent studies that had addressed similar issues on behalf of other Canadian utilities. The two studies are:

- *Demand-Side Management: Determining Appropriate Spending Levels and Cost-Effectiveness Testing,* which was prepared by Summit Blue Consulting and the Regulatory Assistance Project for the Canadian Association of Members of Public Utility Tribunals (CAMPUT). The study was completed in January 2006.
- *Planning and Budgeting for Energy Efficiency/Demand-Side Management Programs,* which was prepared by Navigant Consulting for Union Gas (Ontario) Limited. The study was completed in July 2005.

The CAMPUT study, which included a review of U.S. and Canadian jurisdictions, concluded that an annual CDM expenditure equal to about 1.5% of annual electricity revenues might be appropriate for a utility (or jurisdiction) that is in the early stages of CDM[127] programming. This level of funding recognizes that it takes time to properly introduce programs into the market place.

The same study found that once program delivery experience is gained, a ramping up to a level of about 3% of annual electricity revenues is appropriate. The study also notes that higher percentages may be warranted if rapid growth in electricity demand is expected, or if there is an increasing gap between demand and supply due to such things as plant retirements or siting limitations. The current emphasis on climate change mitigation measures would presumably also fall into a similar category of potential CDM drivers.

The CAMPUT study also notes that even those states with 3% of annual revenues as their CDM target have found that there are more cost-effective CDM opportunities than could be met by the 3% funding. The finding is consistent with the situation in British Columbia. In the case of BC Hydro, CDM expenditures over the past few years have been about 3.3% of electricity

[126] Full treatment of these next steps is beyond the scope of the current project.
[127] The term DSM (demand-side management) and CDM are used interchangeably in this section.

revenues.[128] However, the results of BC Hydro's recently completed study (Conservation Potential Review (CPR) 2007) identified over 20,000 GWh of remaining cost-effective CDM opportunities by 2026. The magnitude of remaining cost-effective CDM opportunities combined with the aggressive targets set out in British Columbia's provincial Energy Plan suggest that BC Hydro's future CDM expenditures are likely to increase significantly if the new targets are to be met.

**Additional notes:**

- Neither of the studies noted above found any one single, simple model for setting CDM spending levels and targets. Rather, the more general conclusion is that utilities use a number of different approaches that are reasonable for their context. In fact, the CAMPUT report identified seven approaches to setting CDM spending levels:

    - Based on cost-effective CDM potential estimates
    - Based on percentages of utility revenues
    - Based on Mills/kWh of utility electric sales
    - Levels set through resource planning process
    - Levels set through the restructuring process
    - Tied to projected load growth
    - Case-by-case approach.

- The CAMPUT study also notes that, although not always explicit, a key issue in most jurisdictions is resolving the trade off between wanting to procure all cost-effective energy-efficiency measures and concerns about the resulting short-term effect on rates. The study concluded that CDM budgets based on findings from an Integrated Resource Plan or a benefit-cost assessment tend to accept whatever rate effects are necessary to secure the overall resource plan, inclusive of the cost-effective energy-efficiency measures.

[128] CAMPUT, 2006. p. 14.

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# CONSERVATION AND DEMAND MANAGEMENT (CDM) POTENTIAL

# NEWFOUNDLAND and LABRADOR

## Commercial Sector

***–Final Report–***

*Prepared for:*

**Newfoundland & Labrador Hydro and Newfoundland Power**

*Prepared by:*

**Marbek Resource Consultants Ltd.**

*In association with:*

**CBCL Ltd.
and
Applied Energy Group**

*January 18, 2008*

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# EXECUTIVE SUMMARY

## Background and Objectives

Newfoundland and Labrador Hydro and Newfoundland Power (collectively the Utilities) have partnered to produce this study, recognizing the role that each has in energy conservation and least cost electric utility planning within the province. Increasing electricity costs and the expectations of a growing number of their customers and stakeholders have contributed to the increased focus on conservation and demand management (CDM) and resulted in a number of recent initiatives and projects targeting energy savings in the province. This study is the next step in the Utilities efforts to develop a comprehensive plan for CDM in Newfoundland and Labrador. The Utilities envision electricity conservation and demand management (CDM) to be a valuable component in meeting the province’s future electricity requirements.

This study will also be a significant component in the further implementation of the Province's recently released Energy Plan. The Energy Plan establishes a long-term vision for how the province's energy resources will be developed and utilized to benefit the people of the province today as well as for future generations. Electricity conservation and demand management (CDM) are an important component of the provincial Energy Plan as are the conservation and demand management components for the other energy resources of the province.

This report meets, in part, the requirements of the Public Utilities Board Order PU 8 2007 requiring NLH to file this study and a five-year plan for implementation of CDM programs in 2008.

The objective of this study is to identify the potential contribution of specific CDM technologies and measures in the Residential, Commercial and Industrial sectors and to assess their economic costs and benefits. The Newfoundland and Labrador economy is expected to grow over the next 20 years, with an associated increase in energy consumption. The benefits of increased penetration of energy efficiency technologies include reduced energy costs for individuals and businesses, as well as environmental benefits through reduced pollution and greenhouse gas emissions.

The outputs from this study will assist the Utilities CDM planners and others to develop specific CDM programs for implementation and to optimize the contribution of CDM technologies and measures to the province's overall energy future.

## Scope and Organization

This study covers a 20-year study period from 2006 to 2026 and addresses the Residential, Commercial and Industrial sectors as well as street lighting. The study results combine customers from both NLH and NP and are presented for two service regions: Island and Isolated and the Labrador Interconnected. For the purposes of this study, the isolated diesel system customers have been combined with those in the Island and Isolated service region due to their relatively small size and electricity usage. Given pending load constraints, the study emphasizes the Island and Isolated service region.

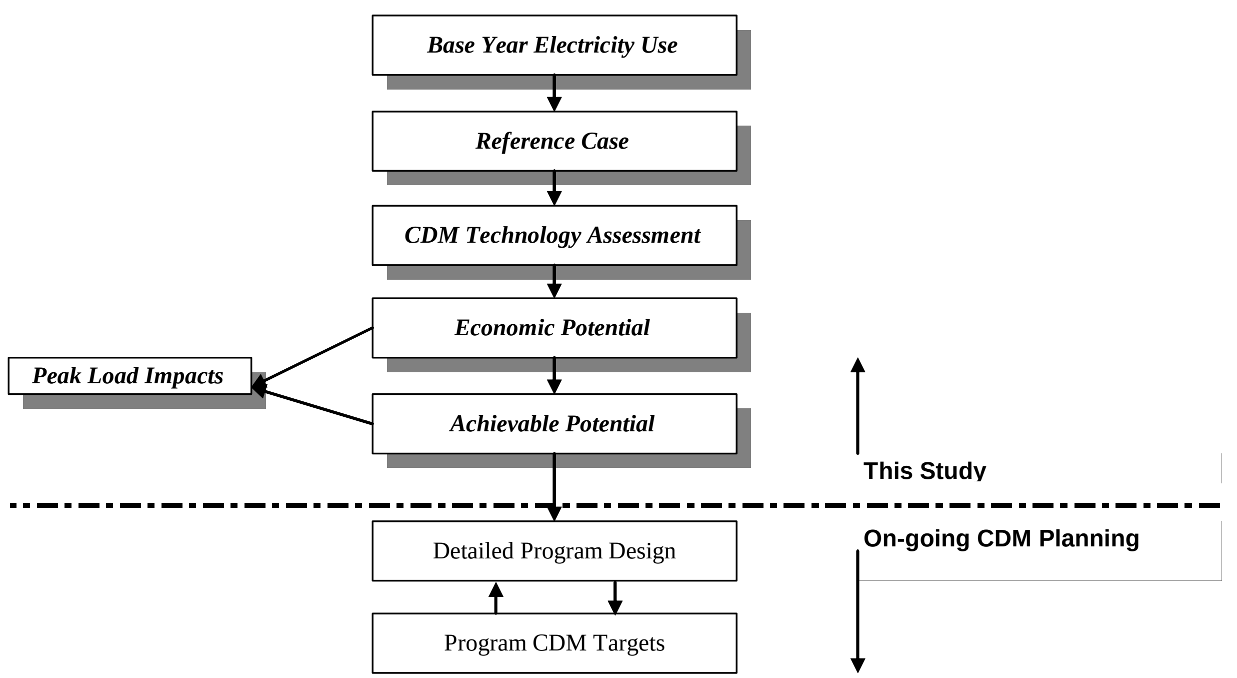
The study reviews all commercially viable electrical efficiency technologies or measures. In addition, the study also reviews selected peak load reduction and fuel switching measures.

- **Approach**

The detailed end-use analysis of electrical efficiency opportunities in the Commercial sector employed two linked modelling platforms: **CEEAM** (Commercial Electricity and Emissions Analysis Model), a Marbek in-house simulation model developed in conjunction with Natural Resources Canada (NRCan) for modelling electricity use in commercial/institutional building stock, and **CSEEM** (Commercial Sector Energy End-use Model), an in-house spreadsheet-based macro model. Peak load savings were modelled using Applied Energy Group's Cross-Sector Load Shape Library Model (LOADLIB).

The major steps involved in the analysis are shown in Exhibit ES1 and are discussed in greater detail in Chapter 1. As illustrated in Exhibit ES1, the results of this study, and in particular the estimation of Achievable Potential,[1] support the on-going work of the Utilities; however, it should be emphasized that the estimation of Achievable Potential is not synonymous with either the setting of specific targets or with program design.

**Exhibit ES1: Study Approach - Major Analytical Steps**




[1] The proportion of savings identified that could realistically be achieved within the study period without consideration for budgetary constraints.

## ❑ Overall Study Findings[2]

As in any study of this type, the results presented in this report are based on a large number of important assumptions. Assumptions such as those related to the current penetration of energy-efficient technologies, the rate of future growth in the stock of commercial buildings and customer willingness to implement new CDM measures are particularly influential. Wherever possible, the assumptions used in this study are consistent with those used by the Utilities and are based on best available information, which in many cases includes the professional judgement of the consultant team, Utilities' personnel and local experts. The reader should, therefore, use the results presented in this report as best available estimates; major assumptions, information sources and caveats are noted throughout the report.

The study findings confirm the existence of significant potential cost-effective opportunities for CDM in Newfoundland and Labrador's Commercial sector. Electricity savings from efficiency improvements within the Island and Isolated service region would provide between 387 and 261 GWh/yr. of electricity savings by 2026 in, respectively, the Upper and Lower Achievable scenarios. The most significant Achievable Savings opportunities were in the actions that addressed lighting, HVAC fans and pumps and space heating.

The study also assessed the peak load reductions that would result from the electricity savings (noted above). Electricity savings would provide peak load reductions of approximately 54 to 35 MW during the Utilities' typical Winter Peak Day[3] by 2026 in, respectively, the Upper and Lower Achievable scenarios.

## ❑ Summary of Electricity Savings

A summary of the levels of annual electricity consumption contained in each of the forecasts addressed by the study is presented in Exhibits ES2 and ES3, by milestone year, and discussed briefly in the paragraphs below.

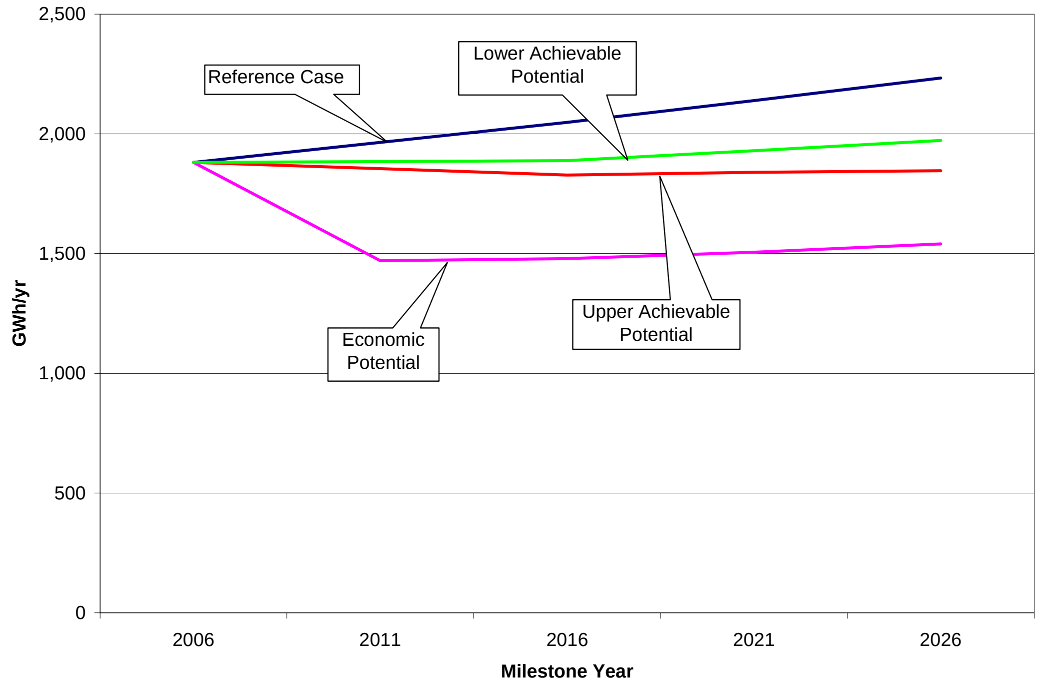
**Exhibit ES2: Summary of Forecast Results for the Island and Isolated Service Region – Annual Electricity Consumption, Commercial Sector (GWh/yr.)**

| *Annual Consumption (GWh/yr.) Commercial Sector* | | | | | | *Potential Annual Savings (GWh/yr.)* | | |
|---|---|---|---|---|---|---|---|---|
| *Milestone Year* | *Base Year* | *Reference Case* | *Economic* | *Achievable* | | *Economic* | *Achievable* | |
| | | | | *Upper* | *Lower* | | *Upper* | *Lower* |
| ***2006*** | 1,881 | 1,881 | 1,881 | 1,881 | 1,881 | | | |
| ***2011*** | | 1,965 | 1,471 | 1,855 | 1,884 | 494 | 110 | 80 |
| ***2016*** | | 2,048 | 1,479 | 1,828 | 1,888 | 569 | 220 | 160 |
| ***2021*** | | 2,138 | 1,506 | 1,840 | 1,930 | 632 | 298 | 209 |
| ***2026*** | | 2,233 | 1,541 | 1,846 | 1,972 | 693 | 387 | 261 |

*Results are measured at the customer's point-of-use and do not include line losses.

[2] Consistent with the study scope, the results presented in this Executive Summary address the Island and Isolated service region. The main report provides a similar breakdown for the Labrador Interconnected service region.
[3] Winter Peak Day is defined as the week day hours from 7 am to 12 pm and 4 pm to 8 pm on the four coldest days in the December to March period; totals 36 hours.

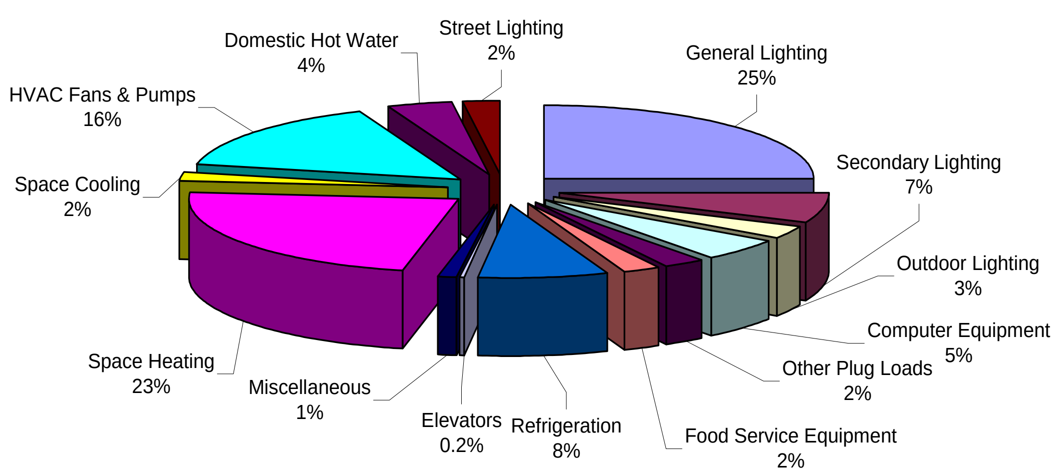
**Exhibit ES3: Graphic of Forecast Results for the Island and Isolated Service Region – Annual Electricity Consumption, Commercial Sector (GWh/yr.)**




### *Base Year Electricity Use*

In the Base Year of 2006, the Commercial sector in the Island and Isolated service region consumed about 1,881 GWh. Exhibit ES4 shows that space lighting (general and secondary lighting) accounts for about 32% of total commercial electricity use, space heating accounts for about 23%, followed by HVAC fans and pumps (16%) and refrigeration (8%).

**Exhibit ES4: Base Year Electricity Use by End Use in the Island and Isolated Service Region, Commercial Sector**




*Totals may not add to 100% due to rounding.*

In the Island and Isolated Service Region, the Small Commercial sub sector accounts for the largest share of the total electricity consumption at 28%, followed by Office at 17%, Other Buildings at 8% and Food Retail at 7%.

### *Reference Case*

In the absence of new Utility initiatives, the study estimates that electricity consumption in the Commercial sector will grow from 1,881 GWh/yr. in 2006 to about 2,233 GWh/yr. by 2026 in the Island and Isolated service region. This represents an overall growth of about 19% in the period and compares very closely with NLH's load forecast, which also included consideration of the impacts of "natural conservation."

### *Economic Potential Forecast*

Under the conditions of the Economic Potential Forecast,[4] the study estimated that electricity consumption in the Commercial sector would fall to about 1,541 GWh/yr. by 2026 in the Island and Isolated service region. Annual savings relative to the Reference Case are 693 GWh/yr., or about 31%.

### *Achievable Potential*

The Achievable Potential is the proportion of the economic electricity savings (as noted above) that could realistically be achieved within the study period. In the Commercial sector within the Island and Isolated service region, the Achievable Potential for electricity savings was estimated to be 387 GWh/yr. and 261 GWh/yr. by 2026 in, respectively, the Upper and Lower scenarios.

Consistent with the results in the Economic Potential Forecast, the most significant achievable savings opportunities were in the actions that addressed lighting, HVAC fans and pumps and space heating.

## ❑ Peak Load Savings

The electricity savings noted above also result in a reduction in capacity requirements (MW), which can be of particular value to the Utilities during periods of high electricity demand. The study defined the Newfoundland and Labrador system peak period as:

> *The morning period from 7 am to noon and the evening period from 4 pm to 8 pm on the four coldest days in the December to March period; this is a total of 36 hours per year.*

The resulting peak load reductions are presented in Exhibit ES5. The Commercial sector peak load savings was estimated to be 54 MW and 35 MW by 2026 in, respectively, the Upper and Lower scenarios. In each case, the reductions are an average value over the peak period and are defined relative to the Reference Case.

[4] The level of electricity consumption that would occur if all equipment and building envelopes were upgraded to the level that is cost effective against future avoided electricity costs.

**Exhibit ES5: Peak Load Savings from Electricity Savings in the Island and Isolated Service Region, Commercial Sector**

| Milestone Year | Energy Savings (GWh/yr.) | | Peak Load Reduction (MW) | |
|---|---|---|---|---|
| | Upper Achievable | Lower Achievable | Upper Achievable | Lower Achievable |
| 2011 | 110 | 80 | 16 | 11 |
| 2016 | 220 | 160 | 31 | 23 |
| 2021 | 298 | 209 | 41 | 29 |
| 2026 | 387 | 261 | 53 | 34 |

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**APPENDICES**

## List of Exhibits

# 1. INTRODUCTION

## 1.1 BACKGROUND AND OBJECTIVES

Newfoundland and Labrador Hydro and Newfoundland Power (collectively the Utilities) have partnered to produce this study, recognizing the role that each has in energy conservation and least cost electric utility planning within the province. Increasing electricity costs and the expectations of a growing number of their customers and stakeholders have contributed to the increased focus on conservation and demand management (CDM) and resulted in a number of recent initiatives and projects targeting energy savings in the province. This study is the next step in the Utilities efforts to develop a comprehensive plan for CDM in Newfoundland and Labrador. The Utilities envision electricity conservation and demand management (CDM) to be a valuable component in meeting the province's future electricity requirements.

This study will also be a significant component in the further implementation of the Province's recently released Energy Plan. The Energy Plan establishes a long-term vision for how the province's energy resources will be developed and utilized to benefit the people of the province today as well as for future generations. Electricity conservation and demand management (CDM) are an important component of the provincial Energy Plan as are the conservation and demand management components for the other energy resources of the province.

This report is prepared to meet, in part, the requirements of the Public Utilities Board Order PU 8 2007 requiring NLH to file this study and a five year plan for implementation of CDM programs in 2008.

The objective of this study is to identify the potential contribution of specific CDM technologies and measures in the Residential, Commercial and Industrial sectors and to assess their economic costs and benefits. The Newfoundland and Labrador economy is expected to grow over the next 20 years, with an associated increase in energy consumption. The benefits of increased penetration of energy efficiency technologies include reduced energy costs for individuals and businesses, as well as environmental benefits through reduced pollution and greenhouse gas emissions.

The outputs from this study will assist the Utilities CDM planners and others to develop specific CDM programs for implementation and to optimize the contribution of CDM technologies and measures to the province's overall energy future.

## 1.2 STUDY SCOPE

The scope of this study is summarized below:

- **Sector Coverage:** This study addresses three sectors: Residential, Commercial and Industrial as well as street lighting. It was agreed that the primary focus is on the Residential and Commercial sectors; the Industrial sector will be treated at a "high level."

- **Geographical Coverage**: The study addresses the customers of both utilities. Due to differences in cost and rate structures, the Utilities' customers are organized into two service regions, which in this report are referred to as the Island and Isolated and Labrador Interconnected. For the purposes of this study, the isolated diesel system customers have been combined with those in the Island and Isolated service region due to their relatively small size and electricity usage.

- **Study Period**: This study covers a 20-year period. The Base Year is the calendar year 2006, with milestone periods at five-year increments: 2011, 2016, 2021 and 2026. The Base Year of 2006 was selected as this was the most recent calendar year for which complete customer data were available.

- **Technologies:** The study addresses conservation and demand management (CDM) measures. Although CDM refers to a broad range of potential measures (see Section 1.3, Definitions), for the purposes of this study, it was agreed that the primary focus is on energy-efficiency measures. This includes measures that reduce electricity use as well as the associated capacity impact on a winter peak period. The study also provides a high-level treatment of selected demand management measures, such as direct control of space heating loads, etc.[5]

### 1.2.1 Data Caveat

As in any study of this type, the results presented in this report are based on a large number of important assumptions. Assumptions such as those related to the current penetration of energy-efficient technologies, the rate of future growth in the stock of commercial buildings and customer willingness to implement new CDM measures are particularly influential. Wherever possible, the assumptions used in this study are consistent with those used by the Utilities and are based on best available information, which in many cases includes the professional judgement of the consultant team, Utilities' personnel and local experts. The reader should, therefore, use the results presented in this report as best available estimates; major assumptions, information sources and caveats are noted throughout the report.

## 1.3 DEFINITIONS

This study uses numerous terms that are unique to analyses such as this one and consequently it is important to ensure that readers have a clear understanding of what each term means when applied to this study.

A brief description of some of the most important terms and their application within this study is included below. The reader is also referred to the Terms Used in Building Profiles, found in Section 8 of this report.

[5] The information provided is based on the detailed analysis that Marbek is currently undertaking in other jurisdictions.

| | |
|---|---|
| ***Base Year Electricity Use*** | The Base Year is the starting point for the analysis. It provides a detailed description of "where" and "how" electrical energy is currently used in the existing Commercial sector building stock. Building electricity use simulations were undertaken for the major sub sector types and calibrated to actual utility customer billing data for the Base Year. As noted previously, the Base Year for this study is the calendar year 2006. |
| ***Reference Case Electricity Use (includes Natural Conservation)*** | The Reference Case Electricity Use estimates the expected level of electrical energy consumption that would occur over the study period in the absence of new (post-2006) utility-based CDM initiatives. It provides the point of comparison for the subsequent calculation of "economic" and "achievable" electricity savings potentials. Creation of the Reference Case required the development of profiles for new buildings in each of the sub sectors, estimation of the expected growth in building stock and finally an estimation of "natural" changes affecting electricity consumption over the study period. The Reference Case is calibrated to the NLH Long Term Planning (PLF) Review Forecast, Summer/Fall 2006. |
| ***Conservation and Demand Management (CDM) Measures*** | CDM refers to a broad range of potential measures that can include energy efficiency (use more efficiently), energy conservation (use less), demand management (use less during peak periods), fuel switching (use a different fuel to provide the energy service) and self-generation/co-generation (displace load off of grid).<br><br>As noted in Section 1.2, it was agreed that the primary focus is on energy-efficiency measures. This includes measures that reduce electricity use as well as the associated capacity impact on a winter peak period. |
| ***The Cost of Conserved Energy (CCE)*** | The CCE is calculated for each energy-efficiency measure. The CCE is the annualized incremental capital and operating and maintenance (O&M) cost of the upgrade measure divided by the annual energy savings achieved, excluding any administrative or program costs. The CCE represents the cost of conserving one kWh of electricity; it can be compared directly to the cost of supplying one new kWh of electricity. |
| ***Economic Potential Electricity Forecast*** | The Economic Potential Electricity Forecast is the level of electricity consumption that would occur if all equipment and building envelopes were upgraded to the level that is cost effective against the future avoided cost of electricity in the Newfoundland and Labrador Hydro service area (for this study, the value was set at $0.0980/kWh for the Island and Isolated service region and $0.0432/kWh for the |

Labrador Interconnected service region).[6] All the energy-efficiency upgrades included in the technology assessment that had a CCE equal to, or less than, the preceding avoided costs of new electricity supply were incorporated into the Economic Potential Forecast.

***Achievable Potential*** The Achievable Potential is the proportion of the savings identified in the Economic Potential Forecast that could realistically be achieved within the study period. Achievable Potential recognizes that it is difficult to induce customers to purchase and install all the electrical efficiency technologies that meet the criteria defined by the Economic Potential Forecast. The results are presented as a range, defined as “Lower” and “Upper.”

## 1.4 APPROACH

To meet the objectives outlined above, the study was conducted within an iterative process that involved a number of well-defined steps. At the completion of each step, the client reviewed the results and, as applicable, revisions were identified and incorporated into the interim results. The study then progressed to the next step. A summary of the steps is presented below.

***Step 1:*** **Develop Base Year Electricity Calibration Using Actual Utility Billing Data**

- Compile and analyze available data on Newfoundland and Labrador’s existing building stock.
- Develop detailed technical descriptions of the existing building stock.
- Undertake computer simulations of electricity use in each building type and compare these with actual building billing and audit data.
- Compile actual utility billing data.
- Create sector model inputs and generate results.
- Calibrate sector model results using actual utility billing data.

***Step 2:*** **Develop Reference Case Electricity Use**

- Compile and analyze building design, equipment and operations data and develop detailed technical descriptions of the new building stock.
- Develop computer simulations of electricity use in each new building type.
- Compile data on forecast levels of building stock growth and “natural” changes in equipment efficiency levels and/or practices.
- Define sector model inputs and create forecasts of electricity use for each of the milestone years.
- Compare sector model results with NLH load forecast for the study period.

***Step 3:*** **Identify and Assess Energy-efficiency Measures**

- Develop list of energy-efficiency upgrade measures.
- Compile detailed cost and performance data for each measure.

[6] Sensitivity analysis was also conducted using avoided cost values expected to prevail if the Lower Churchill/DC Link project is completed.

- Identify the baseline technologies employed in the Reference Case, develop energy-efficiency upgrade options and associated electricity savings for each option, and determine the CCE for each upgrade option.

***Step 4:*** **Estimate Economic Electricity Savings Potential**

- Compile utility economic data on the forecast cost of new electricity generation; costs of $0.0980kWh and $0.0432/kWh were selected as the economic screens for, respectively, the Island and Isolated and Labrador Interconnected service regions.
- Identify the combinations of energy-efficiency upgrade options and building types where the cost of saving one kilowatt of electricity is equal to, or less than, the cost of new electricity generation.
- Apply the economically attractive electrical efficiency measures from Step 3 within the energy use simulation model developed previously for the Reference Case.
- Determine annual electricity consumption in each building type and end use when the economic efficiency measures are employed.
- Compare the electricity consumption levels when all economic efficiency measures are used with the Reference Case consumption levels and calculate the electricity savings.

***Step 5:*** **Estimate Achievable Potential Electricity Savings**

- "Bundle" the electricity and peak load reduction opportunities identified in the Economic Potential Forecasts into a set of opportunities.
- For each of the identified opportunities, create an Opportunity Profile that provides a "high-level" implementation framework, including measure description, cost and savings profile, target sub sectors, potential delivery allies, barriers and possible synergies.
- Review historical achievable program results and prepare preliminary Assessment Worksheets.
- Conduct a full day workshop involving the client, the consultant team and technical experts to reach general agreement on "upper" and "lower" range of Achievable Potential.

***Step 6:*** **Estimate Peak Load Impacts of Electricity Savings**

- The electricity (electric energy) savings (GWh) calculated in the preceding steps were converted to peak load (electric demand) savings (MW).[7]
- The study defined the Newfoundland and Labrador system peak period as the morning period from 7 am to noon and the evening period from 4 to 8 pm on the four coldest days of the year during the December to March period; this is a total of 36 hours per year.
- The conversion of electricity savings to hourly demand drew on a library of specific sub sector and end use electricity load shapes. Using the load shape data, the following steps were applied:

[7] Peak load savings were modeled using Applied Energy Group's Cross-Sector Load Shape Library Model (LOADLIB).

- Annual electricity savings for each combination of sub sector and end use were disaggregated *by month*
- Monthly electricity savings were then further disaggregated *by day type* (weekday, weekend day and peak day)
- Finally, each day type was disaggregated *by hour*.

## 1.5 ANALYTICAL MODELS

The analysis of the Commercial sector employed two linked modelling platforms:

- CEEAM (*C*ommercial *E*lectricity and *E*missions *A*nalysis *M*odel), an in-house, simulation model developed in conjunction with Natural Resources Canada (NRCan) for modelling electricity use in commercial/institutional building stock.

- CSEEM (*C*ommercial *S*ector *E*lectricity *E*nd-use *M*odel), an in-house spreadsheet-based macro model.

CEEAM was used to develop commercial electricity end-use intensities (EUIs) for each of the commercial and institutional building archetypes. CEEAM has been successfully employed in numerous domestic and international CDM work. Domestically, this includes assignments for BC Hydro, Terasen Gas, Manitoba Hydro, the Ontario Power Authority (OPA), Consumers Gas and NRCan, including the extensive national climate change analysis conducted for the Federal Buildings Table. CEEAM is a robust modelling platform and its results have been verified against actual end-use metered data for commercial buildings in the cities of Ottawa and Toronto and against DOE-2.1E.

CEEAM was developed specifically for applications such as this study. One of its particular strengths is the capability to simulate electricity performance not only in a given building but also in an entire stock of similar buildings (e.g., all Large Offices). In particular, it is capable of tracking the penetration of multiple technologies and combinations that are not possible in other simulation software, such as DOE-2.

CEEAM simulates the electricity consumption and peak load for all electricity end uses present in a given commercial building segment. CEEAM calculates energy use and emissions by end use and reports them in $kWh/m^2/yr.$ and kg $eCO_2/m^2$. Because CEEAM is a full modelling program, it calculates both building heating and cooling loads (internal and transmission). It therefore accounts for interactive effects such as the increase in heating electricity use and decrease in cooling electricity use from lighting retrofits. CEEAM also uses equipment part load performance curves to accurately model the seasonal efficiency of heating and cooling plants.

The commercial EUIs derived by CEEAM provide inputs into Marbek's in-house CSEEM. CSEEM consists of two modules:

- A General Parameters module that contains general sector data (e.g., floor space, growth rates, etc.)

- A Building Profile module that contains the EUI data for each of the selected building sub sectors.

CSEEM combines the data from each of the modules and provides total electricity use by service region, building sub sector and end use. CSEEM also enables the analyst to estimate the demand impacts of the electrical efficiency measures introduced in the Economic Potential Forecast.

## 1.6 STUDY ORGANIZATION AND REPORTS

The study was organized and conducted by sector using a common methodology, as outlined above. The results for each sector are presented in individual reports as well as in a summary report. They are entitled:

- *Conservation and Demand Management Potential (2006 to 2026), Newfoundland and Labrador, Residential Sector*

- *Conservation and Demand Management Potential (2006 to 2026), Newfoundland and Labrador, Commercial Sector*

- *Conservation and Demand Management Potential (2006 to 2026), Newfoundland and Labrador, Industrial Sector*

- *Conservation and Demand Management Potential (2006 to 2026), Newfoundland and Labrador, Residential, Commercial and Industrial Sectors, Summary Report*

The study also prepared a brief CDM program evaluation report, which is entitled:

- *Conservation and Demand Management Potential (2006 to 2026), Newfoundland and Labrador, Program Evaluation Guidelines*.

This report presents the Commercial sector results; it is organized as follows:

- Section 2 presents a profile of Commercial sector Base Year Electricity Use in Newfoundland and Labrador, including a discussion of the major steps involved and the data sources employed.

- Section 3 presents a profile of Commercial sector Reference Case Electricity Use in Newfoundland and Labrador for the study period 2006 to 2026, including a discussion of the major steps involved.

- Section 4 identifies and assesses the economic attractiveness of the selected energy-efficiency technology measures for the Commercial sector.

- Section 5 presents the Commercial sector Economic Potential Electricity Forecast for the study period 2006 to 2026.

- Section 6 presents the estimated Upper and Lower Achievable Potential for electricity savings for the study period 2006 to 2026.
- Section 7 presents conclusions and next steps.
- Section 8 presents a listing of major references.
- Section 9 provides an explanation of terms used in the building profiles.

# 2. BASE YEAR (2006) ELECTRICITY USE

## 2.1 INTRODUCTION

This section provides a profile of Base Year (2006) electricity use in Newfoundland and Labrador's Commercial[8] sector. The discussion is organized into the following subsections:

- Segmentation of Commercial Sector
- Definition of End Uses
- End-use Saturation and Fuel Share Data
- Detailed Building and Equipment Specifications
- Floor Area Calculations
- Summary of Model Results.

## 2.2 SEGMENTATION OF COMMERCIAL SECTOR

The first major task in developing the Base Year calibration involved the segmentation of the commercial building stock into specific sub sectors. The choice of specific building sub sectors is driven by both data availability and the need to facilitate the subsequent analysis and modelling of potential electrical efficiency improvements.

To facilitate the subsequent modelling and analysis of energy-efficiency opportunities, the selected building sub sectors need to be reasonably similar in terms of major design and operating considerations, such as building size, mechanical and electrical systems, annual operating hours, etc.

A summary of the Commercial sub sectors that are used in this study is provided in Exhibit 2.1.

**Exhibit 2.1: Commercial Sub Sectors**

- Office
- Non-food Retail
- Food Retail
- Accommodations (Hotels & Motels)
- Health Care (Hospitals & Nursing Homes)
- Schools (Elementary and Secondary)
- Universities and Colleges
- Warehouse/Wholesale
- Small Commercial (all customers in sector below approx. 50 kW)
- Isolated C/I Buildings
- Other Buildings
- Other Institutional
- Non-Buildings

[8] Throughout this report, use of the word "commercial" includes both commercial and institutional buildings unless otherwise noted.

The types of buildings included in most of the sub sectors shown in Exhibit 2.1 are self-explanatory. However, additional explanation is provided for four of the sub sectors:

- **Isolated C/I Buildings**. This sub sector includes buildings such as restaurants, schools, variety stores, medical clinics and multi-purpose garages and sheds that are located in isolated communities served by local diesel-powered systems.

- **Other Buildings**. This sub sector represents buildings that do not fit into the specific sub sectors shown in Exhibit 2.1 including churches, theatres, community centres, transportation buildings and recreation complexes.

- **Other Institutional**. This sub sector includes buildings such as barracks, mess halls, hangers and warehouses located at Canadian Forces Base Goose Bay.

- **Non-Buildings.** This sub sector includes facilities such as micro wave repeater stations and telephone exchanges. Although these facilities are housed within a "building," the majority of their electricity use is consumed by the unique equipment that it houses. This sub sector will be tracked throughout the study but will not be subjected to detailed analysis.

## 2.3 DEFINITION OF END USES

Electricity use within each of the sub sectors noted above is further defined on the basis of specific end uses. In this study, an end use is defined as, "the final application or final use to which energy is applied. End uses are the services of economic value to the users of energy." A summary of the major Commercial sector end uses used in this study is provided in Exhibit 2.2 together with a brief description of each.

**Exhibit 2.2: Commercial Sector End Uses**

| End-Use | Description/Comments |
|---|---|
| General Lighting | Lighting in main areas of a building, e.g., classrooms in a school |
| Secondary Lighting | Lighting in secondary areas of a building, e.g., corridors/lobbies in a school |
| Outdoor Lighting | Lighting used for parking lots and exterior building illumination |
| Computer Equipment | Computers, monitors, printers, fax machines, copiers and servers |
| Other Plug Loads | Other plug loads excluding computer equipment |
| Food Service Equipment | Food preparation equipment including ranges, broilers, ovens, etc. |
| Refrigeration | Fridges, freezers, coolers, and display cases |
| Elevator | Passenger and freight elevators |
| Miscellaneous Equipment | Air compressors, sump pumps, clothes washers, etc. |
| Space Heating | Electric boilers, unit heaters, baseboard heaters |
| Space Cooling | Air-conditioning compressors |
| HVAC Fans & Pumps | Fans, pumps, cooling tower fans, etc. |
| Domestic Hot Water | Electric water heaters |
| Street Lighting | Roadway lighting |

## 2.4 END-USE SATURATION AND FUEL SHARE DATA

The next step in the analysis involved an estimation of the electric fuel share for both space heating and domestic hot water,[9] and an estimation of saturation for space cooling.[10] Various information sources were used to derive these estimates, including analysis of utility sales data, and consultations with NLH/NP and local technical advisors.

Exhibits 2.3 and 2.4 present the estimated fuel shares and saturations for each sub sector and service region.

**Exhibit 2.3: Electric Fuel Share by Sub Sector and Service Region, (%)**

| Sub Sector | Island and Isolated | | Labrador Interconnected | |
|---|---|---|---|---|
| | Space Heating | Domestic Hot Water | Space Heating | Domestic Hot Water |
| Office | 79% | 90% | 100% | 100% |
| Non-food Retail | 62% | 90% | 100% | 100% |
| Food Retail | 67% | 70% | 100% | 100% |
| Health Care | 23% | 30% | 90% | 100% |
| Schools | 74% | 80% | 75% | 100% |
| Accommodations | 74% | 80% | 100% | 100% |
| University/College | 11% | 50% | 100% | 100% |
| Warehouse/Wholesale | 56% | 80% | 100% | 100% |
| Small Commercial | 63% | 83% | 98% | 100% |
| Other Buildings | 52% | 62% | 98% | 98% |
| Isolated Buildings | 15% | 10% | | |
| Other Institutional | | | 30% | 30% |

**Exhibit 2.4: Space Cooling Saturation by Sub Sector and Service Region, (%)**

| Sub Sector | Island and Isolated | Labrador Interconnected |
|---|---|---|
| Office | 80% | 50% |
| Non-food Retail | 70% | 25% |
| Food Retail | 60% | 15% |
| Health Care | 75% | 35% |
| Schools | 0% | 0% |
| Accommodations | 50% | 50% |
| University/College | 10% | 25% |
| Warehouse/Wholesale | 5% | 0% |
| Small Commercial | 31% | 26% |
| Other Buildings | 18% | 9% |
| Isolated Buildings | 0% | |
| Other Institutional | | 21% |

[9] Space heating fuel share refers to the percentage of the total floor space that is electrically heated; similarly, DHW fuel share refers to the percentage of the total floor space that is served by electric domestic hot water.
[10] Space cooling saturation refers to the percentage of the total floor space that is air conditioned.

## 2.5 DETAILED BUILDING AND EQUIPMENT SPECIFICATIONS

The next major task involved the development of detailed technical data on building specifications, mechanical and electrical equipment, operating practices and electricity use for each sub sector and end use identified above.

To facilitate the subsequent analysis of the potential impacts of energy-efficiency measures, the detailed data on building, equipment and operating practices were compiled using Marbek's commercial/institutional building energy use simulation model (CEEAM). Detailed building profiles were created for the stock of buildings within each sub sector, using weather data from Environment Canada.

Development of the detailed building profiles relied on an analysis of existing data sources. They included:

- Site visits
- Consultations with local technical advisors
- Building information and utility consumption provided by various organizations
- Professional experience of the study team personnel.

Exhibit 2.5 presents a sample summary building profile. Detailed profiles for each existing building sub sector are provided in Appendix A.

# Exhibit 2.5: Sample Summary Building Profile

| Building Type: | Office | Location: | Island and Isolated |
|---|---|---|---|

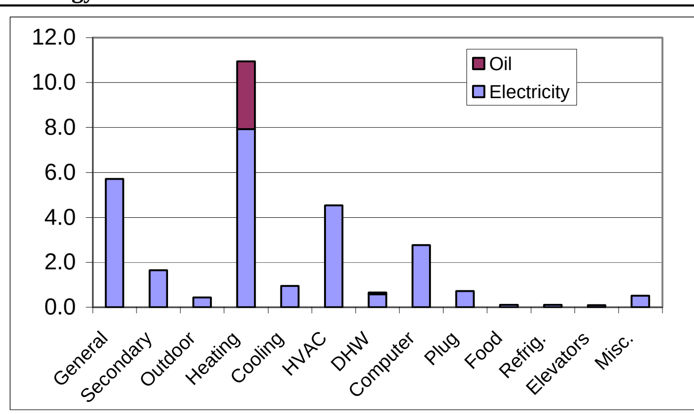
The building characteristics used to define the Office archetype are as follows:
- Average gross floor area of 40,000 ft²
- Average footprint of 13,333 ft² (approx. 115 ft x 115 ft)
- Average height of 3 storeys.

## Technical Profile of Major Building Systems

| | | | | | | |
|---|---|---|---|---|---|---|
| **Building Envelope:** | | | | | | |
| Roof U Value | 0.12 Btu/hr.ft² .°F | | | | | |
| Wall U Value | 0.09 Btu/hr.ft² .°F | | | | | |
| Window U Value | 0.70 Btu/hr.ft² .°F | | | | | |
| Shading Coefficient (SC) | 0.58 | | | | | |
| Window to Wall Ratio (WWR) | 0.36 | | | | | |
| **General Lighting:** | 550 Lux | | 1.5 W/ft² | | | |
| System Types | INC | CFL | T12 | T8 | MH | HPS |
| | 0% | 0% | 70% | 30% | 0% | 0% |
| **Secondary Lighting:** | 350 Lux | | 3.1 W/ft² | | | |
| System Types | INC | CFL | T12 | T8 | MH | HPS |
| | 50% | 45% | 0% | 0% | 5% | 0% |
| **Outdoor Lighting:** | | | 0.1 W/ft² | | | |
| System Types | FLUOR | INC | HID | Other | | |
| | 26% | 19% | 54% | 1% | | |
| Overall LPD | | | 1.8 W/ft² | | | |
| **Fans:** | | | | | | |
| System Types | CAV | VAV | | | | |
| | 75% | 25% | | | | |
| System Air Flow | 0.71 CFM/ft² | | | | | |
| Fan Power | 0.57 W/ft² | | | | | |
| **Space Heating:** | | | | | | |
| System Types | AS HP | WS HP | Resistance | Oil | | |
| | 0% | 0% | 79% | 21% | | |
| Peak Heating Load | 19 Btu/hr.ft² | | | | | |
| **Space Cooling** | | | | | | |
| System Types | Centrifugal | Centri HE | Recip Open | DX | | |
| | 20% | 0% | 0% | 80% | | |
| Peak Cooling Load | 27 Btu/hr.ft² | | 448 ft²/Ton | | | |
| **Pumps:** | | | | | | |
| Circulating Pumps | 0.1 W/ft² | | | | | |
| Condenser Pumps | 0.1 W/ft² | | | | | |

## Energy Profile

| End Use | Elec (kWh/ft².yr) | Oil (kWh/ft².yr) |
|---|---|---|
| GENERAL LIGHTING | 5.7 | |
| SECONDARY LIGHTING | 1.7 | |
| OUTDOOR LIGHTING | 0.4 | |
| SPACE HEATING | 7.9 | 3.0 |
| SPACE COOLING | 1.0 | |
| HVAC FANS & PUMPS | 4.5 | |
| DOMESTIC HOT WATER | 0.6 | 0.1 |
| COMPUTER EQUIPMENT | 2.8 | |
| OTHER PLUG LOADS | 0.7 | |
| FOOD SERVICE EQUIPMENT | 0.1 | |
| REFRIGERATION | 0.1 | |
| ELEVATORS | 0.1 | |
| MISCELLANEOUS | 0.5 | |
| | | |
| **Total** | **26.1** | **3.1** |



## 2.6 FLOOR AREA CALCULATIONS

Floor area is used to drive changes in Newfoundland and Labrador's commercial building stock over the study period, including changes to equipment and electricity use. For the purposes of this study, floor space was derived by dividing the actual sales data for each building sub sector by the applicable fuel share and saturation-weighted, whole-building electricity use intensity (EUI). Exhibit 2.6 shows the resulting estimates of floor area within each building sub sector in the Island and Isolated and Labrador Interconnected service regions.

**Exhibit 2.6: Floor Area by Sub Sector and Service Region, ($ft^2$)**

| Sub Sector | Island and Isolated | Labrador Interconnected | Total |
|---|---|---|---|
| Office | 12,178,467 | 316,584 | 12,495,051 |
| Non-food Retail | 4,326,634 | 911,653 | 5,238,286 |
| Food Retail | 2,356,898 | 173,358 | 2,530,256 |
| Health Care | 3,790,192 | 670,349 | 4,460,542 |
| Schools | 9,509,360 | 631,026 | 10,140,387 |
| Accommodations | 4,694,717 | 155,325 | 4,850,042 |
| University/College | 7,374,889 | 198,785 | 7,573,675 |
| Warehouse/Wholesale | 3,780,305 | 431,856 | 4,212,161 |
| Small Commercial | 23,464,658 | 1,368,078 | 24,832,736 |
| Other Buildings | 9,528,256 | 1,025,539 | 10,553,794 |
| Isolated Buildings | 1,919,228 | | 1,919,228 |
| Other Institutional | | 2,488,528 | 2,488,528 |
| **Total** | **82,923,605** | **8,371,081** | **91,294,686** |

*Note: Any differences in totals are due to rounding.*

For the Island and Isolated service region, the total floor area of the modelled sub sectors is approximately 83 million square feet. The largest sub sector is Small Commercial, which accounts for 28%[11] of the total floor area, followed by Office at 15%, Other Buildings at 11% and Schools at 11%.

For the Labrador Interconnected service region, the total floor area of the modelled sub sectors is approximately 8.4 million square feet. The largest sub sector is Other Institutional, which accounts for 30% of the total floor area, followed by Small Commercial at 16%, Other Buildings at 12% and Non-food Retail at 11%.

## 2.7 SUMMARY OF MODEL RESULTS

This section presents the results of the analysis of electricity consumption for the Base Year 2006. Electricity consumption is measured at the customer's point-of-use and does not include line losses.

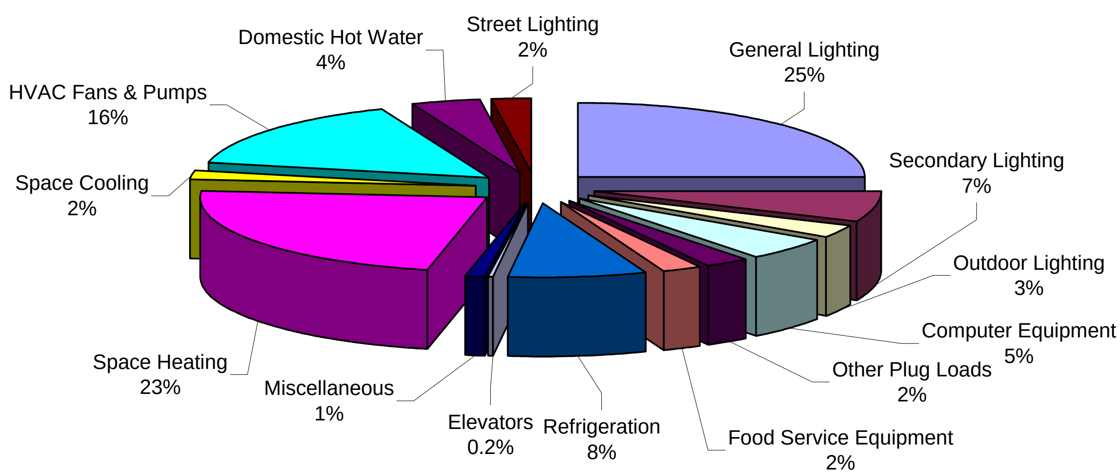
[11] Retail stores located in malls with individual metering that use less than 50 kW are included in the Small Commercial sub sector.

Exhibits 2.7 and 2.8 present the electricity consumption for, respectively, the Island and Isolated and Labrador Interconnected service regions by building sub sector and end use. Note: the Non-Buildings sub sector was not modelled and, therefore, the electricity consumption is carried as a total for the sub sector.

**Exhibit 2.7: Base Year Annual Electricity Consumption for the Island and Isolated Service Region by Sub Sector and End Use, (GWh/yr.)[12]**

| Sub Sector | Electricity Consumption by End Use (GWh/yr) | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | General Lighting | Secondary Lighting | Outdoor Lighting | Computer Equipment | Other Plug Loads | Food Service Equipment | Refrigeration | Elevators | Miscellaneous | Space Heating | Space Cooling | HVAC Fans & Pumps | Domestic Hot Water | Street Lighting | Total |
| Office | 69.5 | 20.1 | 5.3 | 33.8 | 8.7 | 1.3 | 1.3 | 1.2 | 6.3 | 96.6 | 11.6 | 55.2 | 7.1 | | 317.9 |
| Non-food Retail | 50.4 | 4.6 | 3.8 | 3.9 | 2.8 | 1.1 | 1.0 | 0.0 | 1.1 | 23.1 | 4.1 | 22.6 | 1.9 | | 120.3 |
| Food Retail | 21.2 | 3.1 | 3.1 | 2.1 | 2.0 | 3.7 | 73.0 | 0.0 | 0.6 | 8.0 | 1.2 | 10.6 | 2.1 | | 130.7 |
| Health | 4.3 | 21.2 | 3.3 | 4.2 | 6.6 | 7.8 | 1.5 | 0.8 | 1.0 | 17.6 | 2.8 | 26.0 | 3.8 | | 100.9 |
| Schools | 28.9 | 8.5 | 4.2 | 6.1 | 1.0 | 1.0 | 0.7 | 0.0 | 0.7 | 52.8 | 0.0 | 5.9 | 3.7 | | 113.6 |
| Accommodations | 13.1 | 14.9 | 2.1 | 2.6 | 2.3 | 6.1 | 3.6 | 0.5 | 1.2 | 27.8 | 1.5 | 10.8 | 25.2 | | 111.6 |
| University/College | 40.3 | 6.2 | 3.2 | 10.5 | 4.8 | 2.9 | 3.8 | 0.7 | 1.9 | 6.2 | 0.9 | 36.1 | 2.4 | | 119.9 |
| Warehouse/Wholesale | 18.8 | 2.8 | 1.7 | 1.7 | 3.1 | 0.4 | 5.9 | 0.0 | 1.0 | 12.9 | 0.1 | 3.6 | 1.5 | | 53.4 |
| Small Commercial | 150.0 | 28.5 | 13.2 | 25.4 | 11.5 | 9.8 | 43.2 | 0.5 | 5.2 | 134.3 | 8.4 | 84.2 | 20.0 | | 534.1 |
| Other Buildings | 49.3 | 8.6 | 5.1 | 2.7 | 1.0 | 3.4 | 3.0 | 0.0 | 2.0 | 38.2 | 1.4 | 25.4 | 2.8 | | 142.9 |
| Non-Buildings | | | | | | | | | | | | | | | 81.6 |
| Isolated Buildings | 6.1 | 1.4 | 0.7 | 0.9 | 0.6 | 0.4 | 3.0 | 0.0 | 0.0 | 0.5 | 0.0 | 1.0 | 0.1 | | 14.8 |
| Street Lighting | | | | | | | | | | | | | | 39.4 | 39.4 |
| **Total** | **452** | **120** | **46** | **94** | **45** | **38** | **140** | **4** | **21** | **418** | **32** | **282** | **71** | **39** | **1,881** |

*Note: Any differences in totals are due to rounding.*



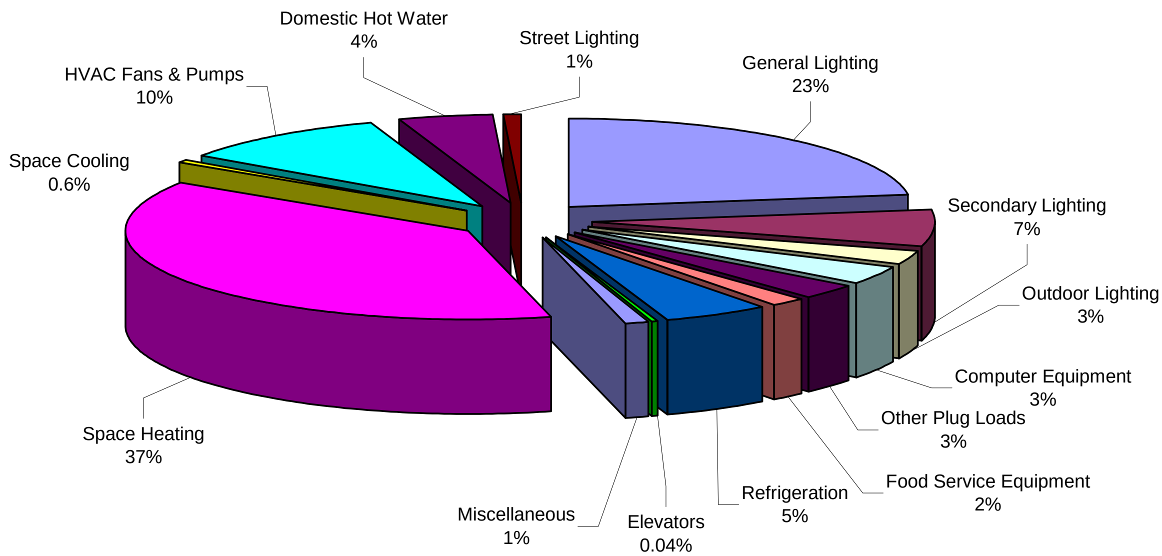

*Totals may not add to 100% due to rounding.*

[12] The pie chart presents percentage of electricity consumption by end use for buildings only; the sub sector Non-Buildings is included in the total load, but not included in the above pie chart.

## Exhibit 2.8: Base Year Annual Electricity Consumption for Labrador Interconnected Service Region by Sub Sector and End Use, (GWh/yr.)[13]

| Sub Sector | Electricity Consumption by End Use (GWh/yr) | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | General Lighting | Secondary Lighting | Outdoor Lighting | Computer Equipment | Other Plug Loads | Food Service Equipment | Refrigeration | Elevators | Miscellaneous | Space Heating | Space Cooling | HVAC Fans & Pumps | Domestic Hot Water | Street Lighting | Total |
| Office | 1.8 | 0.5 | 0.1 | 0.9 | 0.2 | 0.0 | 0.0 | 0.0 | 0.2 | 4.0 | 0.12 | 0.7 | 0.2 | | 8.9 |
| Non-food Retail | 9.8 | 0.9 | 0.8 | 0.8 | 0.6 | 0.2 | 0.2 | 0.0 | 0.2 | 10.7 | 0.24 | 2.3 | 0.4 | | 27.2 |
| Food Retail | 1.4 | 0.2 | 0.2 | 0.2 | 0.1 | 0.3 | 4.5 | 0.0 | 0.0 | 2.6 | 0.02 | 0.4 | 0.2 | | 10.1 |
| Health | 0.8 | 3.8 | 0.6 | 0.7 | 1.2 | 1.4 | 0.3 | 0.1 | 0.2 | 6.8 | 0.09 | 2.1 | 2.2 | | 20.2 |
| Schools | 2.2 | 0.6 | 0.3 | 0.4 | 0.1 | 0.1 | 0.0 | 0.0 | 0.0 | 5.1 | 0.00 | 0.8 | 0.3 | | 9.9 |
| Accommodations | 0.4 | 0.5 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.0 | 0.0 | 1.8 | 0.04 | 0.3 | 1.0 | | 4.6 |
| University/College | 1.1 | 0.2 | 0.1 | 0.3 | 0.1 | 0.1 | 0.1 | 0.0 | 0.2 | 2.4 | 0.04 | 0.6 | 0.1 | | 5.3 |
| Warehouse/Wholesale | 2.1 | 0.3 | 0.2 | 0.2 | 0.4 | 0.0 | 0.7 | 0.0 | 0.1 | 4.6 | 0.00 | 0.6 | 0.2 | | 9.4 |
| Small Commercial | 8.5 | 1.6 | 0.8 | 1.4 | 0.7 | 0.5 | 2.2 | 0.0 | 0.3 | 16.1 | 0.31 | 2.6 | 1.4 | | 36.3 |
| Other Buildings | 5.2 | 0.9 | 0.5 | 0.3 | 0.1 | 0.4 | 0.3 | 0.0 | 0.2 | 11.4 | 0.05 | 2.2 | 0.5 | | 22.1 |
| Non-Buildings | | | | | | | | | | | | | | | 7.2 |
| Other Institutional | 10.7 | 3.8 | 1.2 | 1.0 | 1.7 | 0.5 | 1.5 | 0.0 | 0.7 | 8.4 | 0.18 | 6.9 | 2.0 | | 38.7 |
| Street Lighting | | | | | | | | | | | | | | 1.6 | 1.6 |
| Total | 44.0 | 13.4 | 4.9 | 6.2 | 5.3 | 3.5 | 9.8 | 0.1 | 2.2 | 73.9 | 1.1 | 19.5 | 8.7 | 1.6 | 201.4 |

*Note: Any differences in totals are due to rounding.*




*Totals may not add to 100% due to rounding.*

[13] The pie chart presents percentage of electricity consumption by end use for buildings only; the sub sector Non-Buildings is included in the total load, but not included in the above pie chart.

Highlights of the results shown in Exhibits 2.7 and 2.8 are as follows:

**Base Year Electricity Use by Sub Sector**

- In the Island and Isolated Service Region, the Small Commercial sub sector accounts for the largest share of the total electricity consumption at 28%, followed by Office at 17%, Other Buildings at 8% and Food Retail at 7%.

- In the Labrador Interconnected service region, Other Institutional accounts for the largest share of total electricity consumption at 19%, followed by Small Commercial at 18%, Non-food Retail at 14% and Other Buildings at 11%.

**Base Year Electricity Use by End Use**

- In the Island and Isolated Service Region, general and secondary lighting combined account for the largest share of building electricity consumption at 32%, followed by space heating at 23%, HVAC fans and pumps at 16% and refrigeration at 8%.

- In the Labrador Interconnected service region, space heating accounts for the largest share of building electricity consumption at 37%, followed by general and secondary lighting combined at 30%, HVAC fans and pumps at 10% and refrigeration at 5%.

# 3. REFERENCE CASE ELECTRICITY USE

## INTRODUCTION

This section presents the Commercial sector Reference Case for the study period. The Reference Case estimates the expected level of electricity consumption that would occur over the study period in the absence of new utility-based initiatives or rate changes. The Reference Case, therefore, provides the point of comparison for the calculation of electricity savings opportunities associated with each of the subsequent scenarios that are assessed within this study.

The discussion is presented within the following subsections:

- Development of Detailed "New" Building and Equipment Specifications
- "Natural" Changes Affecting Electricity Consumption
- Expected Growth in Building Stock
- Summary of Model Results – Reference Case.

## 3.2 DEVELOPMENT OF DETAILED "NEW" BUILDING AND EQUIPMENT SPECIFICATIONS

The first task in building the Reference Case involved the development of detailed technical profiles that define building specifications, mechanical equipment, lighting equipment and electricity use for the "new" buildings in each of the commercial building sub sectors. In each case, the new building profiles were developed using Marbek's CSEEM and the same approach as described previously in Section 2.

Exhibit 3.1 presents a sample summary new building profile. It summarizes the major technical assumptions that have been used for new Offices in the development of the Reference Case. Detailed profiles for each new building sub sector are provided in Appendix A.

## Exhibit 3.1: Sample Summary New Building Profile - Office in Island and Isolated Service Region

| **Building Type:** | Office | **Location:** | Island and Isolated |
|---|---|---|---|

The building characteristics used to define the Office archetype are as follows:
- Average gross floor area of 40,000 ft²
- Average footprint of 13,333 ft² (approx. 115 ft x 115 ft)
- Average height of 3 storeys.

### Technical Profile of Major Building Systems

| | | | | | | |
|---|---|---|---|---|---|---|
| **Building Envelope:** | | | | | | |
| Roof U Value | 0.07 Btu/hr.ft² .°F | | | | | |
| Wall U Value | 0.03 Btu/hr.ft² .°F | | | | | |
| Window U Value | 0.49 Btu/hr.ft² .°F | | | | | |
| Shading Coefficient (SC) | 0.58 | | | | | |
| Window to Wall Ratio (WWR) | 0.35 | | | | | |
| **General Lighting:** | 500 Lux | | 1.2 W/ft² | | | |
| System Types | INC | CFL | T12 ES | T8 Mag | T8 Elec | MH |
| | 0% | 0% | 0% | 0% | 100% | 0% |
| **Secondary Lighting:** | 350 Lux | | 1.5 W/ft² | | | |
| System Types | INC | CFL | T12 ES | T8 Mag | T8 Elec | MH |
| | 10% | 30% | 0% | 0% | 40% | 20% |
| **Outdoor Lighting:** | | | 0.2 W/ft² | | | |
| System Types | FLUOR | INC | HID | Other | | |
| | 26% | 19% | 54% | 1% | | |
| Overall LPD | | | 1.4 W/ft² | | | |
| **Fans:** | | | | | | |
| System Types | CAV | VAV | | | | |
| | 50% | 50% | | | | |
| System Air Flow | 0.79 CFM/ft² | | | | | |
| Fan Power | 0.63 W/ft² | | | | | |
| **Space Heating:** | | | | | | |
| System Types | AS HP | WS HP | Resistance | Oil | | |
| | 0% | 0% | 100% | 0% | | |
| Peak Heating Load | 18 Btu/hr.ft² | | | | | |
| **Space Cooling** | | | | | | |
| System Types | Centrifugal | Centri HE | Recip Open | DX | | |
| | 0% | 20% | 0% | 80% | | |
| Peak Cooling Load | 26 Btu/hr.ft² | | 454 ft²/Ton | | | |
| **Pumps:** | | | | | | |
| Circulating Pumps | 0.1 W/ft² | | | | | |
| Condenser Pumps | 0.1 W/ft² | | | | | |

### Energy Profile

| | **Elec** | **Oil** |
|---|---|---|
| **End Use** | **kWh/ft².yr** | |
| GENERAL LIGHTING | 4.6 | |
| SECONDARY LIGHTING | 0.8 | |
| OUTDOOR LIGHTING | 0.8 | |
| SPACE HEATING | 8.3 | 0.0 |
| SPACE COOLING | 1.1 | |
| HVAC FANS & PUMPS | 4.2 | |
| DOMESTIC HOT WATER | 0.6 | 0.0 |
| COMPUTER EQUIPMENT | 2.8 | |
| OTHER PLUG LOADS | 0.7 | |
| FOOD SERVICE EQUIPMENT | 0.1 | |
| REFRIGERATION | 0.1 | |
| ELEVATORS | 0.0 | |
| MISCELLANEOUS | 0.5 | |
| | | |
| **Total** | **24.6** | **0.0** |

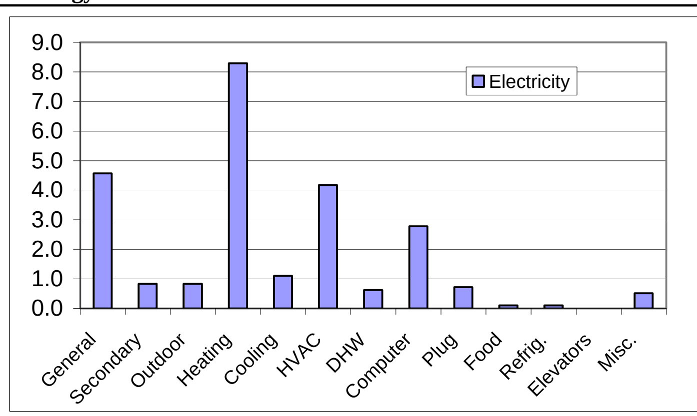


Exhibit 3.2 highlights the resulting whole building electric EUIs for each new commercial building sub sector. For the purposes of comparison, it also shows whole building electric EUIs for each of the existing building sub sectors. As shown, whole building electric EUIs decline for most sub sectors as a result of the following:

- Improved lighting system efficiency, including higher-efficacy lighting sources, more efficient lighting technologies and the use of automatic lighting controls
- Higher-efficiency building envelopes, including improved window U-values and higher levels of wall and roof insulation
- Higher-efficiency HVAC systems, including integrated designs, higher cooling equipment efficiencies and the use of building automation systems.

However, in some cases, gains made through energy efficiency are offset by the following factors that result in increased energy use in new buildings:

- Increased space heating and domestic hot water electric fuel shares, particularly in the Island and Isolated service region
- Increased saturation of space cooling in most sub sectors
- New design guidelines that require higher ventilation rates in selected sub sectors, such as in Schools, Food Retail and Health Care
- Increased use of outdoor lighting, particularly in the retail sub sectors.

## Exhibit 3.2: Comparison of Whole Building Electric EUIs by Sub Sector and Service Region, (kWh/ft$^2$/yr.)

| Sub Sector | Island and Isolated | | | Labrador Interconnected | | |
|---|---|---|---|---|---|---|
| | Existing Buildings | New Buildings | Comments | Existing Buildings | New Buildings | Comments |
| Office | 26.1 | 24.6 | New office buildings have higher efficiency lighting, HVAC and envelope systems, higher space cooling saturation, and higher space heating and hot water fuel shares resulting in a lower whole building EUI. | 28.0 | 27.3 | New office buildings have higher efficiency lighting, HVAC and envelope systems, and higher space cooling saturation resulting in a slightly lower whole building EUI. |
| Non-food Retail | 27.8 | 25.3 | New non-food retail buildings are typically "big box" stores with higher efficiency lighting, HVAC and envelope systems, higher space cooling saturation, and higher space heating and hot water fuel shares resulting in a lower whole building EUI. | 29.9 | 29.0 | New non-food retail buildings are typically "big box" stores with higher efficiency lighting, HVAC and envelope systems, and higher space cooling saturation resulting in a slightly lower whole building EUI. |
| Food Retail | 55.4 | 53.3 | New food retail buildings are typically "big box" stores with higher efficiency lighting, HVAC and envelope systems, higher space cooling saturation, higher space heating and hot water fuel shares, and higher penetration of refrigeration equipment resulting in a lower whole building EUI. | 58.3 | 54.8 | New food retail buildings are typically "big box" stores with higher efficiency lighting, HVAC and envelope systems, higher space cooling saturation, and higher penetration of refrigeration equipment resulting in a lower whole building EUI. |
| Health Care | 26.6 | 36.2 | New health care buildings have higher efficiency lighting, HVAC and envelope systems, higher space cooling saturation, higher ventilation rates, and higher space heating and hot water fuel shares resulting in a significantly higher whole building EUI. | 30.1 | 39.0 | New health care buildings have higher efficiency lighting, HVAC and envelope systems, higher space cooling saturation, higher ventilation rates, and higher space heating fuel shares resulting in a significantly higher whole building EUI. |
| Schools | 11.9 | 12.3 | New school buildings have higher efficiency lighting, HVAC and envelope systems, and higher space heating and hot water fuel shares resulting in a slightly higher whole building EUI. | 15.6 | 14.9 | New school buildings have higher efficiency lighting, HVAC and envelope systems, and higher space heating fuel shares resulting in a slightly lower whole building EUI. |
| Accomodations | 23.8 | 24.3 | New hotel/motel buildings have higher efficiency lighting, HVAC and envelope systems, and higher space heating and hot water fuel shares resulting in a slightly higher whole building EUI. | 29.5 | 28.5 | New hotel/motel buildings have higher efficiency lighting, HVAC and envelope systems, and higher space cooling saturation resulting in a slightly lower whole building EUI. |
| University/College | 16.3 | 19.4 | New university/college buildings have higher efficiency lighting, HVAC and envelope systems, higher space cooling saturation, and higher space heating and hot water fuel shares resulting in a higher whole building EUI. | 26.5 | 21.2 | New university/college buildings have higher efficiency lighting, HVAC and envelope systems, and higher space cooling saturation resulting in a lower whole building EUI. |
| Warehouse/Wholesale | 14.1 | 15.2 | New warehouse buildings have higher efficiency lighting, HVAC and envelope systems, and higher space heating and hot water fuel shares resulting in a slightly higher whole building EUI. | 21.9 | 18.3 | New warehouse buildings have higher efficiency lighting, HVAC and envelope systems resulting in a lower whole building EUI. |
| Small Commercial | 22.8 | 22.4 | New small commercial buildings have higher efficiency lighting, HVAC and envelope systems, higher space cooling saturation, and higher space heating and hot water fuel shares resulting in a slightly lower whole building EUI. | 26.6 | 25.7 | New small commercial buildings have higher efficiency lighting, HVAC and envelope systems, and higher space cooling saturation resulting in a lower whole building EUI. |
| Other Buildings | 15.0 | 15.9 | New other buildings have higher efficiency lighting, HVAC and envelope systems, and higher space heating and hot water fuel shares resulting in a slightly higher whole building EUI. | 21.6 | 19.2 | New other buildings have higher efficiency lighting, HVAC and envelope systems resulting in a lower whole building EUI. |
| Non-Buildings | | | | | | |
| Isolated Buildings | 7.7 | 7.4 | New isolated buildings have higher efficiency lighting and HVAC systems resulting in a slightly lower whole building EUI. | | | |
| Other Institutional | | | | 15.5 | 14.6 | New other institutional buildings have higher efficiency lighting, HVAC and envelope systems resulting in a lower whole building EUI. |

## 3.3 "NATURAL" CHANGES AFFECTING ELECTRICITY CONSUMPTION

The next task involved estimating the expected "natural" changes in electricity consumption patterns over the study period with consideration of three major factors:

- "Naturally occurring" improvements in equipment efficiency
- Expected stock penetration by more efficient equipment
- Changes in equipment density, e.g., computers and plug loads, etc.

These factors strongly influence future electricity use within the Commercial sector. While the first two factors will have the effect of reducing electricity consumption, the last factor will result in increased electricity demand.

Other considerations, such as operating hours, fuel share and end-use saturation changes may also affect future electricity demand. These values were assumed to remain constant for existing and new stock over the study period, with two exceptions. Electric fuel share for space heating and DHW in existing buildings was allowed to increase through time,[14] as was space cooling saturation for existing buildings.

Based on the assessment of current trends, the most significant "natural" changes are expected to involve the following end uses:

- Lighting
- Space cooling
- Computer equipment and other plug loads.

Further discussion of these changes follows and, in each case, the discussion identifies the technical change, the major driver(s) and the assumed electricity impact.

### 3.3.1 Lighting

As a result of natural conservation, it is assumed that the replacement of existing T12 fluorescent lighting and electromagnetic ballasts with new T8 fluorescent lamps and electronic ballasts will continue. Similarly, CFLs will continue to increase their market share over incandescent lamps, particularly in sectors such as Accommodations and Non-food Retail.

The continued growth of CFLs and T8 lighting/electronic ballasts is being driven by:

- Further price decreases and increased consumer recognition of the operating cost savings
- Energy regulations that are gradually removing electromagnetic fluorescent ballasts from the market place.

[14] Electric fuel share is expected to increase as a portion of older, oil-heated buildings are renovated and switched to electric heat and DHW.

Overall, the Reference Case assumes that by 2026 the energy intensity of lighting in the existing building stock will decrease by 10%.

### 3.3.2 Space Cooling

As a result of natural conservation and efficiency gains, it is assumed that new space cooling equipment will provide improved electricity performance compared to existing equipment. New centrifugal chillers achieve performance efficiencies in the range of 0.49-0.60 kW per ton. Similarly, packaged rooftop units are available on the market with energy-efficiency ratios (EER) of up to 12.[15] The combined effects of natural conservation and efficiency gains are estimated to result in a decrease of 6% in space cooling EUI over the length of the study.

As noted above, space cooling is expected to experience an increase in saturation levels, as shown in Exhibit 3.3. This increase will counter the effect of natural conservation and efficiency gains. Overall, total space cooling energy use is expected to increase by varying degrees depending on building sector.

**Exhibit 3.3: Changes to Space Cooling Saturation in Existing Buildings, by Sub Sector and Service Region (%)**

| Sub Sector | Island and Isolated | | Labrador Interconnected | |
|---|---|---|---|---|
| | A/C Saturation Existing Buildings 2006 | A/C Saturation Existing Buildings 2026 | A/C Saturation Existing Buildings 2006 | A/C Saturation Existing Buildings 2026 |
| Office | 80% | 90% | 50% | 60% |
| Non-food Retail | 70% | 80% | 25% | 40% |
| Food Retail | 60% | 80% | 15% | 30% |
| Health Care | 75% | 80% | 35% | 95% |
| Schools | 0% | 5% | 0% | 0% |
| Accommodations | 50% | 70% | 50% | 60% |
| University/College | 10% | 20% | 25% | 35% |
| Warehouse/Wholesale | 5% | 10% | 0% | 0% |
| Small Commercial | 31% | 50% | 26% | 40% |
| Other Buildings | 18% | 30% | 9% | 20% |
| Non-Buildings | | | | |
| Isolated Buildings | 0% | 0% | | |
| Other Institutional | | | 21% | 30% |

### 3.3.3 Computer Equipment and Other Plug Loads

Computer equipment and other plug loads will continue to grow as a result of increased density of computers per occupant, increased use of network computers and servers and growth in other peripherals, such as telephone network equipment. Increased penetration of laptops, more efficient server hardware and higher penetration of ENERGY STAR

[15] Current federal energy-efficiency regulations require a minimum EER of 10.3 for rooftop air conditioning units with a capacity of 5.5 - 11 tons.

rated computer equipment and other plug loads is expected to counterbalance the effect of increasing hardware density to some degree.

Overall, the Reference Case assumes that by 2026 the energy intensity of computer equipment and plug loads in the existing building stock will increase by 15%.[16]

### 3.3.4 Impact on Electricity Use

The net impact of the "natural" changes to the commercial building stock, independent of expected saturation or fuel switching changes, is equivalent to an overall reduction in energy intensity of approximately 1% by 2026 relative to the Base Year 2006. Most sub sectors will experience a reduction in energy use while others such as Health Care will experience a net increase of approximately 1% due to increases in computer equipment and plug loads. Total reductions are expected to be slightly lower in the Labrador Interconnected service region than in the Island and Isolated service region, as lighting and cooling represent a smaller portion of overall electricity use.

Exhibit 3.4 presents a comparison of electrical EUIs for an existing Office in the Island and Isolated service region for both the Base Year 2006 and 2026. As shown, lighting and space cooling experience a reduction due to the increased penetration of T8 lighting and more efficient cooling equipment, while computer equipment and plug loads increase by 15% due to increased equipment density.

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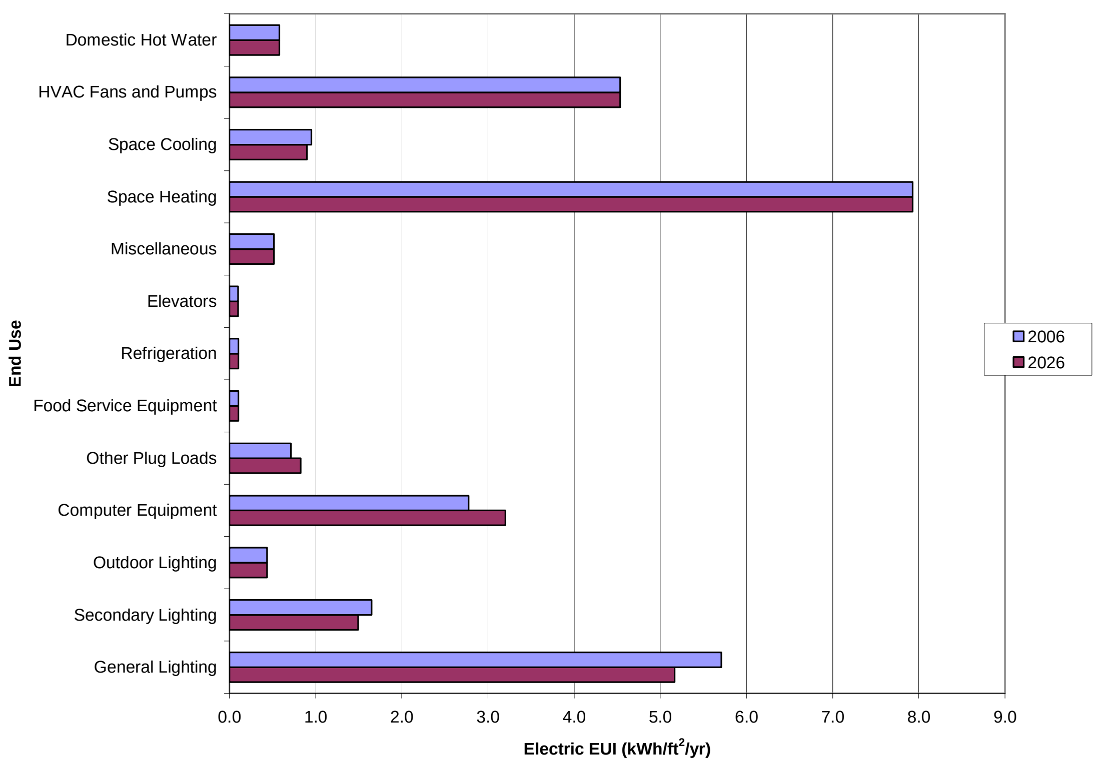
[16] Estimates based on scenarios presented in Arthur D. Little, *Electricity Consumption by Office and Telecommunication Equipment in Commercial Buildings*. U.S. Department of Energy, 2002.

## Exhibit 3.4: Comparison of Electrical EUI for Existing Office in Island and Isolated Service Region[17]

| End Use | 2006 (kWh/ft²/yr) | 2026 (kWh/ft²/yr) | % Reduction |
|---|---|---|---|
| General Lighting | 5.7 | 5.2 | 10% |
| Secondary Lighting | 1.7 | 1.5 | 10% |
| Outdoor Lighting | 0.4 | 0.4 | 0% |
| Computer Equipment | 2.8 | 3.2 | -15% |
| Other Plug Loads | 0.7 | 0.8 | -15% |
| Food Service Equipment | 0.1 | 0.1 | 0% |
| Refrigeration | 0.1 | 0.1 | 0% |
| Elevators | 0.1 | 0.1 | 0% |
| Miscellaneous | 0.5 | 0.5 | 0% |
| Space Heating | 7.9 | 7.9 | 0% |
| Space Cooling | 1.0 | 0.9 | 6% |
| HVAC Fans and Pumps | 4.5 | 4.5 | 0% |
| Domestic Hot Water | 0.6 | 0.6 | 0% |
| **Total** | 26.1 | 25.9 | 1% |

*Note: Any differences in totals are due to rounding.*




[17] Negative reduction shown above for computer equipment and plug loads represents an increased EUI.

## 3.4 EXPECTED GROWTH IN BUILDING STOCK

The next step in developing the Reference Case involved the development and application of estimated levels of floor space growth in each building sector and service region over the study period. The stock growth rates were derived from the sales forecast data provided by NLH from the NLH Long Term Planning (PLF) Review Forecast, Summer/Fall 2006. The derivation of floor space data in each of the milestone periods applied the following steps:

- Estimate and apply the expected impact of "natural conservation" (Section 3.3) for each sub sector (i.e., an updated EUI that includes the effects of natural conservation)

- Use the updated EUI to calculate the floor space required to match the NLH forecast electricity consumption in each combination of sub sector, milestone year and service region.

A summary is provided in Exhibits 3.5 and 3.6 for, respectively, the Island and Isolated and Labrador Interconnected service regions.

**Exhibit 3.5: Commercial Sector Floor Space - Island and Isolated Service Region**

| Subsector | Milestone Year | | | | |
|---|---|---|---|---|---|
| | 2006 | 2011 | 2016 | 2021 | 2026 |
| Office | 12,178,467 | 12,858,186 | 13,550,786 | 14,378,272 | 15,247,773 |
| Non-food Retail | 4,326,634 | 4,532,248 | 4,742,020 | 4,991,339 | 5,254,885 |
| Food Retail | 2,356,898 | 2,462,484 | 2,569,935 | 2,697,329 | 2,831,624 |
| Health Care | 3,790,192 | 3,853,257 | 3,917,019 | 3,986,628 | 4,063,562 |
| Schools | 9,509,360 | 10,018,076 | 10,534,471 | 11,142,498 | 11,783,405 |
| Accomodations | 4,694,717 | 4,917,421 | 5,143,450 | 5,410,901 | 5,691,876 |
| University/College | 7,374,889 | 7,428,897 | 7,483,589 | 7,542,692 | 7,608,872 |
| Warehouse/Wholesale | 3,780,305 | 3,911,537 | 4,044,507 | 4,202,884 | 4,367,996 |
| Small Commercial | 23,464,658 | 24,785,227 | 26,131,069 | 27,330,816 | 28,620,237 |
| Other Buildings | 9,528,256 | 9,854,396 | 10,185,108 | 10,578,414 | 10,989,451 |
| Non-Buildings | | | | | |
| Isolated Buildings | 1,919,228 | 2,159,540 | 2,312,767 | 2,467,213 | 2,621,676 |
| Other Institutional | | | | | |
| Total | 82,923,605 | 86,781,269 | 90,614,721 | 94,728,986 | 99,081,357 |

*Note: Any differences in totals are due to rounding.*

**Exhibit 3.6: Commercial Sector Floor Space - Labrador Interconnected Service Region**

| Subsector | Milestone Year | | | | |
|---|---|---|---|---|---|
| | 2006 | 2011 | 2016 | 2021 | 2026 |
| Office | 316,584 | 347,204 | 362,555 | 377,839 | 393,768 |
| Non-food Retail | 911,653 | 1,003,962 | 1,048,363 | 1,092,570 | 1,138,641 |
| Food Retail | 173,358 | 197,343 | 206,372 | 215,374 | 224,770 |
| Health Care | 670,349 | 760,275 | 785,504 | 785,504 | 785,504 |
| Schools | 631,026 | 703,929 | 735,620 | 735,620 | 735,620 |
| Accomodations | 155,325 | 173,527 | 181,242 | 188,927 | 196,936 |
| University/College | 198,785 | 231,416 | 243,829 | 243,829 | 243,829 |
| Warehouse/Wholesale | 431,856 | 477,745 | 502,304 | 526,924 | 552,752 |
| Small Commercial | 1,368,078 | 1,542,560 | 1,621,353 | 1,700,320 | 1,783,132 |
| Other Buildings | 1,025,539 | 1,109,234 | 1,162,766 | 1,216,272 | 1,272,240 |
| Non-Buildings | | | | | |
| Isolated Buldings | | | | | |
| Other Institutional | 2,488,528 | 2,488,528 | 2,488,528 | 2,488,528 | 2,488,528 |
| Total | 8,371,081 | 9,035,722 | 9,338,436 | 9,571,706 | 9,815,719 |

*Note: Any differences in totals are due to rounding.*

## 3.5 SUMMARY OF MODEL RESULTS – REFERENCE CASE

The Reference Case results for the two service regions are presented in Exhibits 3.7 and 3.8. As illustrated, the Reference Case indicates that, in the absence of new utility-based CDM initiatives, total Commercial sector electricity consumption for the Island and Isolated service region is expected to increase from 1,881 GWh/yr. in the Base Year to approximately 2,233 GWh/yr. in 2026, an increase of about 19%. For the Labrador Interconnected service region, consumption is forecast to grow from 201 GWh/yr. to 240 GWh/yr. over the study period, an increase of approximately 20%.

Highlights:

**Reference Case Electricity use by Sub Sector**

- In the Island and Isolated service region, Isolated Buildings show the greatest increase in electricity consumption over the study period (31%), followed by Office (24%) and Schools (24%). These changes are primarily driven by increases in sub sector building stock.

- Small Commercial buildings have the greatest increase in consumption (27%), followed by Food Retail (26%). Similarly, these increases are primarily driven by growth levels in sub sector building stock.

**Reference Case Electricity use by End Use**

- In the Island and Isolated Service Region, space cooling has the greatest increase over the study period (53%), followed by computers and plug loads (39% and 36% respectively). Increased space cooling electricity consumption is primarily due to an expected increase in cooling saturation, while the computer and plug loads increase is due to an expected increase in equipment density.

- In the Labrador Interconnected Service Region, space cooling again has the greatest increase over the study period (91%), followed by computers and plug loads (40% and 36% respectively). These increases are expected for similar reasons to those stated above.

Further detail is provided below.

- Exhibit 3.7 presents the Reference Case for the Island and Isolated service region, with the results broken out by building sub sector, end use and milestone year.

- Exhibit 3.8 presents the Reference Case for the Labrador Interconnected service region, with the results broken out by building sub sector, end use and milestone year.

# Exhibit 3.7: Reference Case for Annual Electricity Consumption in the Island and Isolated Service Region, (GWh/yr.)[18]

| Building Type | Milestone Year | GWh/yr | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Total | General Lighting | Secondary Lighting | Outdoor Lighting | Computer Equipment | Other Plug Loads | Food Service Equipment | Refrigeration | Elevators | Miscellaneous | Space Heating | Space Cooling | HVAC Fans & Pumps | Domestic Hot Water | Streetlighting |
| Office | 2006 | 318 | 69.5 | 20.1 | 5.3 | 33.8 | 8.7 | 1.3 | 1.3 | 1.2 | 6.3 | 96.6 | 11.6 | 55.2 | 7.1 | |
| | 2011 | 335 | 70.9 | 20.2 | 5.9 | 37.0 | 9.6 | 1.3 | 1.3 | 1.2 | 6.6 | 102.9 | 12.5 | 58.0 | 7.5 | |
| | 2016 | 352 | 72.2 | 20.2 | 6.5 | 40.5 | 10.4 | 1.4 | 1.4 | 1.2 | 7.0 | 109.2 | 13.4 | 60.9 | 8.0 | |
| | 2021 | 373 | 73.9 | 20.4 | 7.2 | 44.5 | 11.5 | 1.5 | 1.5 | 1.2 | 7.4 | 116.7 | 14.4 | 64.4 | 8.5 | |
| | 2026 | 395 | 75.6 | 20.5 | 7.9 | 48.8 | 12.6 | 1.6 | 1.6 | 1.2 | 7.9 | 124.6 | 15.5 | 68.0 | 9.1 | |
| Non-food Retail | 2006 | 120 | 50.4 | 4.6 | 3.8 | 3.9 | 2.8 | 1.1 | 1.0 | 0.0 | 1.1 | 23.1 | 4.1 | 22.6 | 1.9 | |
| | 2011 | 125 | 51.0 | 4.7 | 4.1 | 4.2 | 3.0 | 1.2 | 1.0 | 0.0 | 1.2 | 24.6 | 4.3 | 23.5 | 2.0 | |
| | 2016 | 129 | 51.6 | 4.7 | 4.3 | 4.6 | 3.3 | 1.2 | 1.1 | 0.0 | 1.2 | 26.1 | 4.6 | 24.5 | 2.1 | |
| | 2021 | 135 | 52.4 | 4.8 | 4.7 | 5.0 | 3.6 | 1.3 | 1.1 | 0.0 | 1.3 | 27.9 | 4.9 | 25.7 | 2.3 | |
| | 2026 | 141 | 53.1 | 4.8 | 5.0 | 5.5 | 3.9 | 1.4 | 1.2 | 0.0 | 1.4 | 29.7 | 5.2 | 26.9 | 2.4 | |
| Food Retail | 2006 | 131 | 21.2 | 3.1 | 3.1 | 2.1 | 2.0 | 3.7 | 73.0 | 0.0 | 0.6 | 8.0 | 1.2 | 10.6 | 2.1 | |
| | 2011 | 136 | 21.5 | 3.1 | 3.2 | 2.2 | 2.1 | 3.8 | 76.1 | 0.0 | 0.6 | 8.6 | 1.4 | 11.0 | 2.3 | |
| | 2016 | 142 | 21.7 | 3.2 | 3.4 | 2.4 | 2.3 | 4.0 | 79.2 | 0.0 | 0.7 | 9.2 | 1.5 | 11.5 | 2.5 | |
| | 2021 | 148 | 22.1 | 3.2 | 3.5 | 2.6 | 2.5 | 4.2 | 82.9 | 0.0 | 0.7 | 9.8 | 1.7 | 12.0 | 2.6 | |
| | 2026 | 155 | 22.5 | 3.2 | 3.7 | 2.9 | 2.7 | 4.4 | 86.8 | 0.0 | 0.7 | 10.5 | 1.9 | 12.6 | 2.8 | |
| Health | 2006 | 101 | 4.3 | 21.2 | 3.3 | 4.2 | 6.6 | 7.8 | 1.5 | 0.8 | 1.0 | 17.6 | 2.8 | 26.0 | 3.8 | |
| | 2011 | 104 | 4.3 | 21.1 | 3.4 | 4.5 | 7.0 | 8.0 | 1.5 | 0.8 | 1.0 | 19.1 | 2.8 | 26.5 | 4.1 | |
| | 2016 | 107 | 4.3 | 20.9 | 3.4 | 4.7 | 7.3 | 8.1 | 1.5 | 0.8 | 1.0 | 20.5 | 2.9 | 27.0 | 4.5 | |
| | 2021 | 110 | 4.3 | 20.7 | 3.5 | 5.0 | 7.7 | 8.2 | 1.5 | 0.8 | 1.0 | 22.0 | 2.9 | 27.5 | 4.8 | |
| | 2026 | 113 | 4.2 | 20.5 | 3.6 | 5.2 | 8.2 | 8.4 | 1.6 | 0.8 | 1.0 | 23.6 | 3.0 | 28.1 | 5.2 | |
| Schools | 2006 | 114 | 28.9 | 8.5 | 4.2 | 6.1 | 1.0 | 1.0 | 0.7 | 0.0 | 0.7 | 52.8 | 0.0 | 5.9 | 3.7 | |
| | 2011 | 120 | 29.6 | 8.6 | 4.3 | 6.6 | 1.1 | 1.0 | 0.8 | 0.0 | 0.8 | 56.4 | 0.1 | 6.4 | 4.0 | |
| | 2016 | 126 | 30.2 | 8.7 | 4.4 | 7.2 | 1.2 | 1.1 | 0.8 | 0.0 | 0.8 | 60.0 | 0.3 | 6.8 | 4.3 | |
| | 2021 | 133 | 31.0 | 8.9 | 4.6 | 7.9 | 1.4 | 1.2 | 0.9 | 0.0 | 0.9 | 64.3 | 0.4 | 7.3 | 4.6 | |
| | 2026 | 141 | 31.9 | 9.0 | 4.8 | 8.7 | 1.5 | 1.2 | 0.9 | 0.0 | 0.9 | 68.7 | 0.6 | 7.8 | 4.9 | |
| Accomodations | 2006 | 112 | 13.1 | 14.9 | 2.1 | 2.6 | 2.3 | 6.1 | 3.6 | 0.5 | 1.2 | 27.8 | 1.5 | 10.8 | 25.2 | |
| | 2011 | 117 | 13.3 | 15.2 | 2.2 | 2.8 | 2.5 | 6.2 | 3.7 | 0.5 | 1.3 | 29.5 | 1.7 | 11.3 | 26.9 | |
| | 2016 | 122 | 13.4 | 15.5 | 2.3 | 3.0 | 2.7 | 6.3 | 3.8 | 0.5 | 1.3 | 31.3 | 2.0 | 11.8 | 28.5 | |
| | 2021 | 129 | 13.6 | 15.9 | 2.4 | 3.3 | 3.0 | 6.5 | 3.9 | 0.5 | 1.4 | 33.3 | 2.2 | 12.4 | 30.5 | |
| | 2026 | 136 | 13.7 | 16.3 | 2.5 | 3.6 | 3.2 | 6.7 | 4.0 | 0.6 | 1.5 | 35.5 | 2.5 | 13.0 | 32.5 | |
| University/College | 2006 | 120 | 40.3 | 6.2 | 3.2 | 10.5 | 4.8 | 2.9 | 3.8 | 0.7 | 1.9 | 6.2 | 0.9 | 36.1 | 2.4 | |
| | 2011 | 121 | 39.6 | 6.1 | 3.3 | 11.0 | 5.0 | 2.9 | 3.8 | 0.7 | 1.9 | 7.1 | 1.1 | 36.3 | 2.4 | |
| | 2016 | 123 | 38.9 | 6.0 | 3.3 | 11.5 | 5.2 | 2.9 | 3.9 | 0.7 | 1.9 | 7.9 | 1.3 | 36.5 | 2.5 | |
| | 2021 | 124 | 38.1 | 5.9 | 3.3 | 12.0 | 5.5 | 2.9 | 3.9 | 0.8 | 1.9 | 8.9 | 1.5 | 36.7 | 2.6 | |
| | 2026 | 126 | 37.4 | 5.8 | 3.3 | 12.6 | 5.7 | 2.9 | 3.9 | 0.8 | 2.0 | 9.8 | 1.8 | 36.9 | 2.6 | |
| Warehouse/ Wholesale | 2006 | 53 | 18.8 | 2.8 | 1.7 | 1.7 | 3.1 | 0.4 | 5.9 | 0.0 | 1.0 | 12.9 | 0.1 | 3.6 | 1.5 | |
| | 2011 | 55 | 19.0 | 2.8 | 1.7 | 1.9 | 3.4 | 0.4 | 6.1 | 0.0 | 1.0 | 13.7 | 0.1 | 3.7 | 1.5 | |
| | 2016 | 57 | 19.2 | 2.7 | 1.8 | 2.0 | 3.6 | 0.4 | 6.3 | 0.0 | 1.0 | 14.6 | 0.2 | 3.8 | 1.6 | |
| | 2021 | 60 | 19.5 | 2.7 | 1.8 | 2.1 | 3.9 | 0.4 | 6.5 | 0.0 | 1.1 | 15.6 | 0.2 | 4.0 | 1.7 | |
| | 2026 | 62 | 19.8 | 2.7 | 1.9 | 2.3 | 4.2 | 0.5 | 6.8 | 0.0 | 1.1 | 16.7 | 0.2 | 4.1 | 1.8 | |
| Small Commercial | 2006 | 534 | 150.0 | 28.5 | 13.2 | 25.4 | 11.5 | 9.8 | 43.2 | 0.5 | 5.2 | 134.3 | 8.4 | 84.2 | 20.0 | |
| | 2011 | 563 | 152.8 | 29.0 | 14.2 | 27.9 | 12.7 | 10.3 | 45.5 | 0.5 | 5.4 | 144.9 | 10.1 | 88.6 | 21.4 | |
| | 2016 | 593 | 155.5 | 29.4 | 15.3 | 30.6 | 13.9 | 10.8 | 47.8 | 0.6 | 5.7 | 155.7 | 11.9 | 93.0 | 22.9 | |
| | 2021 | 619 | 157.1 | 29.6 | 16.2 | 33.2 | 15.0 | 11.3 | 49.9 | 0.6 | 6.0 | 165.5 | 13.7 | 97.0 | 24.2 | |
| | 2026 | 648 | 158.9 | 29.9 | 17.2 | 36.0 | 16.3 | 11.8 | 52.1 | 0.6 | 6.3 | 175.9 | 15.6 | 101.2 | 25.7 | |
| Other Buildings | 2006 | 143 | 49.3 | 8.6 | 5.1 | 2.7 | 1.0 | 3.4 | 3.0 | 0.0 | 2.0 | 38.2 | 1.4 | 25.4 | 2.8 | |
| | 2011 | 148 | 49.5 | 8.5 | 5.3 | 2.9 | 1.1 | 3.5 | 3.1 | 0.0 | 2.0 | 41.0 | 1.7 | 26.2 | 3.0 | |
| | 2016 | 153 | 49.7 | 8.5 | 5.5 | 3.1 | 1.2 | 3.7 | 3.2 | 0.0 | 2.1 | 43.8 | 1.9 | 27.0 | 3.2 | |
| | 2021 | 159 | 50.1 | 8.4 | 5.8 | 3.3 | 1.3 | 3.8 | 3.4 | 0.0 | 2.2 | 47.0 | 2.2 | 27.9 | 3.5 | |
| | 2026 | 165 | 50.5 | 8.4 | 6.1 | 3.6 | 1.4 | 3.9 | 3.5 | 0.0 | 2.3 | 50.4 | 2.5 | 28.9 | 3.7 | |
| Non Buildings | 2006 | 82 | | | | | | | | | | | | | | |
| | 2011 | 84 | | | | | | | | | | | | | | |
| | 2016 | 87 | | | | | | | | | | | | | | |
| | 2021 | 91 | | | | | | | | | | | | | | |
| | 2026 | 94 | | | | | | | | | | | | | | |
| Isolated Buildings | 2006 | 15 | 6.1 | 1.4 | 0.7 | 0.9 | 0.6 | 0.4 | 3.0 | 0.0 | 0.0 | 0.5 | 0.0 | 1.0 | 0.1 | |
| | 2011 | 16 | 6.6 | 1.5 | 0.7 | 1.1 | 0.7 | 0.5 | 3.4 | 0.0 | 0.0 | 0.6 | 0.0 | 1.2 | 0.1 | |
| | 2016 | 17 | 6.8 | 1.6 | 0.8 | 1.2 | 0.8 | 0.5 | 3.6 | 0.0 | 0.0 | 0.6 | 0.0 | 1.3 | 0.2 | |
| | 2021 | 18 | 7.0 | 1.6 | 0.9 | 1.3 | 0.9 | 0.6 | 3.9 | 0.0 | 0.0 | 0.6 | 0.0 | 1.4 | 0.2 | |
| | 2026 | 19 | 7.2 | 1.6 | 0.9 | 1.5 | 1.0 | 0.6 | 4.1 | 0.0 | 0.0 | 0.7 | 0.0 | 1.6 | 0.2 | |
| Streetlighting | 2006 | 39 | | | | | | | | | | | | | | 39.4 |
| | 2011 | 39 | | | | | | | | | | | | | | 39.4 |
| | 2016 | 39 | | | | | | | | | | | | | | 39.4 |
| | 2021 | 39 | | | | | | | | | | | | | | 39.5 |
| | 2026 | 40 | | | | | | | | | | | | | | 39.5 |
| Total | 2006 | 1,881 | 452 | 120 | 46 | 94 | 45 | 38 | 140 | 4 | 21 | 418 | 32 | 282 | 71 | 39 |
| | 2011 | 1,965 | 458 | 121 | 48 | 102 | 48 | 39 | 146 | 4 | 22 | 448 | 36 | 293 | 75 | 39 |
| | 2016 | 2,048 | 463 | 121 | 51 | 111 | 52 | 40 | 153 | 4 | 23 | 479 | 40 | 304 | 80 | 39 |
| | 2021 | 2,138 | 469 | 122 | 54 | 120 | 56 | 42 | 159 | 4 | 24 | 512 | 44 | 316 | 85 | 39 |
| | 2026 | 2,233 | 475 | 123 | 57 | 131 | 61 | 43 | 167 | 4 | 25 | 546 | 49 | 329 | 91 | 40 |

*Note: Any differences in totals are due to rounding.*

[18] Results are measured at the customer's point-of-use and do not include line losses. This chart presents percentage of electricity consumption by end use for buildings only; the sub sector Non-Buildings is included in the total load, but is not broken down by end use.

## Exhibit 3.8: Reference Case for Annual Electricity Consumption in the Labrador Interconnected Service Region, (GWh/yr.)[19]

| | | GWh/yr | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Building Type | Milestone Year | Total | General Lighting | Secondary Lighting | Outdoor Lighting | Computer Equipment | Other Plug Loads | Food Service Equipment | Refrigeration | Elevators | Miscellaneous | Space Heating | Space Cooling | HVAC Fans & Pumps | Domestic Hot Water | Streetlighting |
| Office | 2006 | 9 | 1.8 | 0.5 | 0.1 | 0.9 | 0.2 | 0.0 | 0.0 | 0.0 | 0.2 | 4.0 | 0.1 | 0.7 | 0.2 | |
| | 2011 | 10 | 1.9 | 0.5 | 0.2 | 1.0 | 0.3 | 0.0 | 0.0 | 0.0 | 0.2 | 4.4 | 0.1 | 0.8 | 0.2 | |
| | 2016 | 10 | 1.9 | 0.5 | 0.2 | 1.1 | 0.3 | 0.0 | 0.0 | 0.0 | 0.2 | 4.6 | 0.2 | 0.8 | 0.2 | |
| | 2021 | 11 | 1.9 | 0.5 | 0.2 | 1.2 | 0.3 | 0.0 | 0.0 | 0.0 | 0.2 | 4.8 | 0.2 | 0.9 | 0.2 | |
| | 2026 | 11 | 2.0 | 0.5 | 0.2 | 1.3 | 0.3 | 0.0 | 0.0 | 0.0 | 0.2 | 5.0 | 0.2 | 0.9 | 0.3 | |
| Non-Food Retail | 2006 | 27 | 9.8 | 0.9 | 0.8 | 0.8 | 0.6 | 0.2 | 0.2 | 0.0 | 0.2 | 10.7 | 0.2 | 2.3 | 0.4 | |
| | 2011 | 30 | 10.3 | 1.0 | 0.9 | 0.9 | 0.7 | 0.3 | 0.2 | 0.0 | 0.3 | 11.6 | 0.3 | 2.7 | 0.5 | |
| | 2016 | 31 | 10.5 | 1.0 | 1.0 | 1.0 | 0.7 | 0.3 | 0.2 | 0.0 | 0.3 | 12.1 | 0.4 | 2.9 | 0.5 | |
| | 2021 | 32 | 10.6 | 1.0 | 1.0 | 1.1 | 0.8 | 0.3 | 0.2 | 0.0 | 0.3 | 12.5 | 0.5 | 3.1 | 0.5 | |
| | 2026 | 33 | 10.7 | 1.0 | 1.1 | 1.2 | 0.8 | 0.3 | 0.3 | 0.0 | 0.3 | 13.0 | 0.5 | 3.3 | 0.6 | |
| Food Retail | 2006 | 10 | 1.4 | 0.2 | 0.2 | 0.2 | 0.1 | 0.3 | 4.5 | 0.0 | 0.0 | 2.6 | 0.0 | 0.4 | 0.2 | |
| | 2011 | 11 | 1.6 | 0.2 | 0.3 | 0.2 | 0.2 | 0.3 | 5.1 | 0.0 | 0.1 | 2.7 | 0.0 | 0.5 | 0.3 | |
| | 2016 | 12 | 1.6 | 0.2 | 0.3 | 0.2 | 0.2 | 0.3 | 5.3 | 0.0 | 0.1 | 2.8 | 0.0 | 0.6 | 0.3 | |
| | 2021 | 12 | 1.6 | 0.2 | 0.3 | 0.2 | 0.2 | 0.3 | 5.6 | 0.0 | 0.1 | 2.9 | 0.1 | 0.7 | 0.3 | |
| | 2026 | 13 | 1.7 | 0.2 | 0.3 | 0.2 | 0.2 | 0.3 | 5.8 | 0.0 | 0.1 | 2.9 | 0.1 | 0.7 | 0.3 | |
| Health | 2006 | 20 | 0.8 | 3.8 | 0.6 | 0.7 | 1.2 | 1.4 | 0.3 | 0.1 | 0.2 | 6.8 | 0.1 | 2.1 | 2.2 | |
| | 2011 | 24 | 0.9 | 4.1 | 0.7 | 0.9 | 1.4 | 1.6 | 0.3 | 0.1 | 0.2 | 8.3 | 0.3 | 2.6 | 2.6 | |
| | 2016 | 25 | 0.9 | 4.1 | 0.7 | 0.9 | 1.5 | 1.6 | 0.3 | 0.1 | 0.2 | 8.8 | 0.3 | 2.8 | 2.6 | |
| | 2021 | 25 | 0.9 | 4.0 | 0.7 | 1.0 | 1.5 | 1.6 | 0.3 | 0.1 | 0.2 | 8.8 | 0.3 | 2.8 | 2.6 | |
| | 2026 | 25 | 0.8 | 3.9 | 0.7 | 1.0 | 1.6 | 1.6 | 0.3 | 0.1 | 0.2 | 8.8 | 0.3 | 2.8 | 2.6 | |
| Schools | 2006 | 10 | 2.2 | 0.6 | 0.3 | 0.4 | 0.1 | 0.1 | 0.0 | 0.0 | 0.0 | 5.1 | 0.0 | 0.8 | 0.3 | |
| | 2011 | 11 | 2.3 | 0.7 | 0.3 | 0.5 | 0.1 | 0.1 | 0.0 | 0.0 | 0.1 | 5.8 | 0.0 | 0.9 | 0.3 | |
| | 2016 | 11 | 2.3 | 0.7 | 0.3 | 0.5 | 0.1 | 0.1 | 0.0 | 0.0 | 0.1 | 6.1 | 0.0 | 0.9 | 0.4 | |
| | 2021 | 11 | 2.3 | 0.7 | 0.3 | 0.5 | 0.1 | 0.1 | 0.0 | 0.0 | 0.1 | 6.1 | 0.0 | 0.9 | 0.4 | |
| | 2026 | 11 | 2.2 | 0.6 | 0.3 | 0.5 | 0.1 | 0.1 | 0.0 | 0.0 | 0.1 | 6.2 | 0.0 | 0.9 | 0.4 | |
| Accomodations | 2006 | 5 | 0.4 | 0.5 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.0 | 0.0 | 1.8 | 0.0 | 0.3 | 1.0 | |
| | 2011 | 5 | 0.5 | 0.5 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.0 | 0.0 | 2.0 | 0.1 | 0.4 | 1.2 | |
| | 2016 | 5 | 0.5 | 0.5 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.0 | 0.0 | 2.1 | 0.1 | 0.4 | 1.2 | |
| | 2021 | 5 | 0.5 | 0.6 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.0 | 0.0 | 2.2 | 0.1 | 0.4 | 1.3 | |
| | 2026 | 6 | 0.5 | 0.6 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.0 | 0.1 | 2.3 | 0.1 | 0.4 | 1.3 | |
| University/College | 2006 | 5 | 1.1 | 0.2 | 0.1 | 0.3 | 0.1 | 0.1 | 0.1 | 0.0 | 0.2 | 2.4 | 0.0 | 0.6 | 0.1 | |
| | 2011 | 6 | 1.2 | 0.2 | 0.1 | 0.3 | 0.2 | 0.1 | 0.1 | 0.0 | 0.2 | 2.6 | 0.1 | 0.8 | 0.1 | |
| | 2016 | 6 | 1.2 | 0.2 | 0.1 | 0.4 | 0.2 | 0.1 | 0.1 | 0.0 | 0.2 | 2.7 | 0.1 | 0.8 | 0.2 | |
| | 2021 | 6 | 1.2 | 0.2 | 0.1 | 0.4 | 0.2 | 0.1 | 0.1 | 0.0 | 0.2 | 2.7 | 0.1 | 0.8 | 0.2 | |
| | 2026 | 6 | 1.2 | 0.2 | 0.1 | 0.4 | 0.2 | 0.1 | 0.1 | 0.0 | 0.2 | 2.7 | 0.1 | 0.8 | 0.2 | |
| Warehouse/ Wholesale | 2006 | 9 | 2.1 | 0.3 | 0.2 | 0.2 | 0.4 | 0.0 | 0.7 | 0.0 | 0.1 | 4.6 | 0.0 | 0.6 | 0.2 | |
| | 2011 | 10 | 2.3 | 0.3 | 0.2 | 0.2 | 0.4 | 0.0 | 0.7 | 0.0 | 0.1 | 5.0 | 0.0 | 0.6 | 0.2 | |
| | 2016 | 11 | 2.4 | 0.3 | 0.2 | 0.2 | 0.4 | 0.1 | 0.8 | 0.0 | 0.1 | 5.2 | 0.0 | 0.7 | 0.2 | |
| | 2021 | 11 | 2.5 | 0.3 | 0.2 | 0.3 | 0.5 | 0.1 | 0.8 | 0.0 | 0.1 | 5.3 | 0.0 | 0.7 | 0.3 | |
| | 2026 | 11 | 2.5 | 0.3 | 0.2 | 0.3 | 0.5 | 0.1 | 0.9 | 0.0 | 0.1 | 5.5 | 0.0 | 0.7 | 0.3 | |
| Small Commercial | 2006 | 36 | 8.5 | 1.6 | 0.8 | 1.4 | 0.7 | 0.5 | 2.2 | 0.0 | 0.3 | 16.1 | 0.3 | 2.6 | 1.4 | |
| | 2011 | 41 | 9.2 | 1.7 | 0.9 | 1.6 | 0.8 | 0.6 | 2.4 | 0.0 | 0.3 | 17.9 | 0.5 | 3.1 | 1.6 | |
| | 2016 | 43 | 9.4 | 1.7 | 1.0 | 1.8 | 0.9 | 0.6 | 2.6 | 0.0 | 0.4 | 18.7 | 0.5 | 3.3 | 1.7 | |
| | 2021 | 44 | 9.5 | 1.8 | 1.1 | 1.9 | 0.9 | 0.7 | 2.7 | 0.0 | 0.4 | 19.6 | 0.6 | 3.6 | 1.7 | |
| | 2026 | 46 | 9.7 | 1.8 | 1.1 | 2.1 | 1.0 | 0.7 | 2.8 | 0.0 | 0.4 | 20.5 | 0.7 | 3.8 | 1.8 | |
| Other Buildings | 2006 | 22 | 5.2 | 0.9 | 0.5 | 0.3 | 0.1 | 0.4 | 0.3 | 0.0 | 0.2 | 11.4 | 0.1 | 2.2 | 0.5 | |
| | 2011 | 24 | 5.4 | 0.9 | 0.6 | 0.3 | 0.1 | 0.4 | 0.3 | 0.0 | 0.2 | 12.2 | 0.1 | 2.4 | 0.5 | |
| | 2016 | 25 | 5.5 | 0.9 | 0.6 | 0.4 | 0.1 | 0.4 | 0.4 | 0.0 | 0.2 | 12.7 | 0.1 | 2.5 | 0.5 | |
| | 2021 | 25 | 5.6 | 0.9 | 0.7 | 0.4 | 0.1 | 0.4 | 0.4 | 0.0 | 0.3 | 13.2 | 0.1 | 2.7 | 0.6 | |
| | 2026 | 26 | 5.7 | 0.9 | 0.7 | 0.4 | 0.2 | 0.5 | 0.4 | 0.0 | 0.3 | 13.8 | 0.1 | 2.8 | 0.6 | |
| Non Buildings | 2006 | 7 | | | | | | | | | | | | | | |
| | 2011 | 8 | | | | | | | | | | | | | | |
| | 2016 | 8 | | | | | | | | | | | | | | |
| | 2021 | 9 | | | | | | | | | | | | | | |
| | 2026 | 9 | | | | | | | | | | | | | | |
| Other Institutional Buildings | 2006 | 39 | 10.7 | 3.8 | 1.2 | 1.0 | 1.7 | 0.5 | 1.5 | 0.0 | 0.7 | 8.4 | 0.2 | 6.9 | 2.0 | |
| | 2011 | 39 | 10.4 | 3.7 | 1.2 | 1.1 | 1.8 | 0.5 | 1.5 | 0.0 | 0.7 | 8.9 | 0.2 | 6.9 | 2.1 | |
| | 2016 | 39 | 10.2 | 3.7 | 1.2 | 1.1 | 1.9 | 0.5 | 1.5 | 0.0 | 0.7 | 9.4 | 0.2 | 6.9 | 2.3 | |
| | 2021 | 40 | 9.9 | 3.6 | 1.2 | 1.1 | 1.9 | 0.5 | 1.5 | 0.0 | 0.7 | 9.9 | 0.2 | 6.9 | 2.4 | |
| | 2026 | 40 | 9.7 | 3.5 | 1.2 | 1.2 | 2.0 | 0.5 | 1.5 | 0.0 | 0.7 | 10.4 | 0.2 | 6.9 | 2.5 | |
| Streetlighting | 2006 | 2 | | | | | | | | | | | | | | 1.6 |
| | 2011 | 2 | | | | | | | | | | | | | | 1.6 |
| | 2016 | 2 | | | | | | | | | | | | | | 1.6 |
| | 2021 | 2 | | | | | | | | | | | | | | 1.6 |
| | 2026 | 2 | | | | | | | | | | | | | | 1.6 |
| Total | 2006 | 201 | 44 | 13 | 5 | 6 | 5 | 4 | 10 | 0 | 2 | 74 | 1 | 20 | 9 | 2 |
| | 2011 | 220 | 46 | 14 | 5 | 7 | 6 | 4 | 11 | 0 | 2 | 82 | 2 | 22 | 10 | 2 |
| | 2016 | 227 | 46 | 14 | 6 | 8 | 6 | 4 | 11 | 0 | 2 | 85 | 2 | 23 | 10 | 2 |
| | 2021 | 233 | 46 | 14 | 6 | 8 | 7 | 4 | 12 | 0 | 2 | 88 | 2 | 23 | 10 | 2 |
| | 2026 | 240 | 47 | 14 | 6 | 9 | 7 | 4 | 12 | 0 | 3 | 91 | 2 | 24 | 11 | 2 |

*Note: Any differences in totals are due to rounding.*

[19] Results are measured at the customer's point-of-use and do not include line losses. This chart presents percentage of electricity consumption by end use for buildings only; the sub sector Non-Buildings is included in the total load, but is not broken down by end use.

# 4. CONSERVATION & DEMAND MANAGEMENT (CDM) MEASURES

## 4.1 INTRODUCTION

This section identifies and assesses the economic attractiveness of the selected energy-efficiency and peak load reduction measures for the Commercial sector. The discussion is organized and presented as follows:

- Methodology for assessment of energy-efficiency measures
- Description of energy-efficiency measures
- Summary of energy-efficiency results
- Peak load reduction measures.

## 4.2 METHODOLOGY FOR ASSESSMENT OF ENERGY-EFFICIENCY MEASURES

The following steps were employed to assess the energy-efficiency measures:

- Select candidate energy-efficiency measures
- Establish technical performance for each option within a range of applicable load sizes and/or service region conditions (e.g., degree days)
- Establish the capital, installation and operating costs for each option
- Calculate the cost of conserved energy (CCE) for each measure.

A brief discussion of each step is outlined below.

***Step 1 Select Candidate Measures***

The candidate measures were selected in close collaboration with the Utilities' personnel and from a literature review and previous study team experience. The selected measures are all considered to be technically proven and commercially available, even if only at an early stage of market entry. Technology costs, which will be addressed in this section, were not a factor in the initial selection of candidate technologies.

***Step 2 Establish Technical Performance***

Information on the performance improvements provided by each measure was compiled from available secondary sources, including the experience and on-going research work of study team members.

***Step 3 Establish Capital, Installation and Operating Costs for Each Measure***

Information on the cost of implementing each measure was also compiled from secondary sources, including the experience and on-going research work of study team members.

The incremental cost is applicable when a measure is installed in a new facility, or at the end of its useful life in an existing facility; in this case, incremental cost is defined as the cost difference for the energy-efficiency measure relative to the "baseline" technology. The full cost is applicable when an operating piece of equipment is replaced with a more efficient model prior to the end of its useful life.

In both cases, the costs and savings are annualized, based on the number of years of equipment life and the discount rate, and the costs incorporate applicable changes in annual O&M costs. All costs are expressed in constant (2007) dollars.

***Step 4 Calculate CCE for Each Measure***

One of the important sets of information provided in this section is the CCE associated with each energy-efficiency measure. The CCE for an energy-efficient measure is defined as the annualized incremental cost of the upgrade measure divided by the annual energy savings achieved, excluding any administrative or program costs required to achieve full use of the technology or measure. All cost information presented in this section and in the accompanying tables (see Appendix B) are expressed in constant (2007) dollars.

The CCE provides a basis for the subsequent selection of measures to be included in the Economic Potential Forecast (see Section 5.0). The CCE is calculated according to the following formula:

$$\frac{C_A + M}{S}$$

Where:

$C_A$ is the annualized installed cost
$M$ is the incremental annual cost of O&M
$S$ is the annual kWh energy savings.

And $A$ is the annualization factor.

Where: $$A = \frac{i(1+i)^n}{(1+i)^n - 1}$$

$i$ is the discount rate
$n$ is the life of the measure.

The detailed CCE tables (see Appendix B) show both "incremental" and "full" installed costs for the energy-efficiency measures, as applicable. If the measure or technology is installed in a new facility, or at the point of natural replacement in an existing facility, then the "incremental" cost of the measure versus the cost of the baseline technology is used.

If, prior to the end of its life, an operating piece of equipment is replaced with a more efficient model, then the "full" cost of the measure is used. In both cases, the costs of the measures are annualized, based on the number of years of equipment life and the discount rate, and the costs incorporate applicable changes in annual O&M costs.

The annual saving associated with the efficiency measure is the difference in annual electricity consumption with and without the measure.

The CCE calculation is sensitive to the chosen discount rate. In the CCE calculations, three discount rates are shown: 4%, 6% and 8%. Based on the Utilities' recommendation, the 6% (net-of-inflation) discount rate was used for the primary CCE calculation[20]. The CCEs were also calculated using the 4% and 8% discount rates to provide the sensitivity analysis.

Selection of the appropriate discount rate for this analysis was guided by the intended use of the study results. This study seeks to identify the economic potential for CDM in Newfoundland and Labrador from a provincial perspective. Therefore, the appropriate discount rate is the social opportunity cost of capital, which is the estimated average pre-tax rate of return on public and private investments in the provincial economy.

## 4.3 DESCRIPTION OF ENERGY-EFFICIENCY MEASURES

The list of energy-efficiency measures and technologies considered in this study is presented in Exhibit 4.1 below.

**Exhibit 4.1: Energy-efficiency Measures and Technologies - Commercial Sector**

**Lighting**
- Standard T8 systems
- Low ballast-factor T8 systems
- High-performance T8 systems
- Fully integrated lighting and control systems
- Lighting redesign
- Occupancy sensors
- Induction lamps
- Compact fluorescents lamps
- White LED lamps
- Halogen infrared lamps
- Ceramic metal halide lamps
- LED exit signs
- Pulse-start metal halide systems
- T5 high-intensity fluorescent systems

**Heating, Ventilating, and Air-Conditioning**
- Low-temperature air source heat pumps
- Ground source heat pumps
- Water loop heat pumps
- Infrared heaters
- High-efficiency chillers
- High-efficiency rooftop AC units
- Adjustable speed drives
- Premium efficiency motors
- Advanced building automation systems
- Building recommissioning
- Advanced building automation systems
- Programmable thermostats

**Refrigeration**
- ENERGY STAR refrigerators & freezers
- High-efficiency supermarket refrigeration

**Domestic Hot Water**
- Low-flow faucet aerators and shower heads
- Grey water heat recovery
- Tankless water heaters
- Heat pump water heaters

**Computer Equipment**
- ENERGY STAR computers
- ENERGY STAR office equipment
- Energy-efficient server technologies

**Building Envelope**
- High-performance glazing systems
- Upgrade wall insulation
- Upgrade roof insulation
- Air curtains

**New Construction**
- New construction - 25% more efficient
- New construction - 40% more efficient

**Street Lighting**
- Electrodeless induction lighting
- Dimming controls

[20] This discount rate allows for analytic consistency with the earlier NERA Marginal Cost Study, which used a nominal discount rate of 8.4% (approximately 6% real, i.e. net of inflation). NLH lowered its nominal discount rate in the summer of 2007 to 7.75%; however, this change has no material impact on the results of this study.

Energy-efficiency improvement opportunities are presented along with a brief description of the technology, savings relative to the baseline, typical installed costs, applicability and co-benefits. A detailed list of the results of the economic assessment of all measures is provided in Exhibit 4.2. The discussion of measures is organized by end use and sub sector.[21]

The following subsections provide a summary of the results of the technical and economic analysis of each measure. The measures are organized and presented according to the format in which they were evaluated. Refer to Appendix B for details and assumptions related to the analyses.

### 4.3.1 Lighting

The discussion of the analysis of lighting measures is organized by major lighting type and presented as follows:

- Fluorescent lighting upgrades
- Incandescent lighting upgrades
- High-intensity discharge (HID) lighting upgrades.

❑ **Fluorescent Lighting Upgrades**

Fluorescent lighting in the commercial building stock is typically a mix of T12 magnetic and T8 electronic fluorescent lighting systems. The study therefore considered upgrades to both T12 and T8 fluorescent systems.

***T12 Fluorescent Upgrades***

Six energy-efficiency upgrade measures were evaluated for T12 lighting systems:

- Standard T8 lighting systems
- Low ballast factor T8 lighting systems
- High-performance T8 lighting systems
- Redesign with standard T8 lighting systems
- Redesign with high-performance T8 lighting systems
- Redesign with fully integrated lighting and control systems.

These measures are applicable to existing buildings with T12 lighting since new buildings are generally illuminated with T8 systems. Each measure was evaluated at 3,000 hours of operation and on both a full cost and incremental cost basis. The baseline technology used for the analysis is a standard fluorescent fixture equipped with two 34-Watt T12 lamps and magnetic ballast.

[21] Measure inputs not otherwise sourced are based on the consultants' recent work with BC Hydro and other utility clients.

### ❑ Standard T8 Lighting Systems

| Measure Profile | |
|---|---|
| Applicable Building Types | All |
| Vintage | Existing |
| Costs | Full $41/fixture; incremental $0 |
| Savings | 26% of lighting energy |
| Useful Life | 16 years |

Replacing existing T12 technology with T8 lamps and electronic ballasts reduces the connected lighting load for a two-lamp fixture from 80 Watts to 59 Watts, representing a savings of 26% over the baseline T12 systems. This measure typically results in increased light levels.

### ❑ Low Ballast Factor T8 Lighting Systems

| Measure Profile | |
|---|---|
| Applicable Building Types | All |
| Vintage | Existing |
| Costs | Full $41/fixture; incremental $0 |
| Savings | 36% of lighting energy |
| Useful Life | 16 years |

Similarly, replacing existing T12s with T8 lamps and low ballast factor electronic ballasts further reduces the connected lighting load for a two-lamp fixture from 80 Watts to 51 Watts, representing a savings of 36% over the baseline T12 systems, while providing an equivalent amount of light.

### ❑ High-performance T8 Lighting Systems

| Measure Profile | |
|---|---|
| Applicable Building Types | All |
| Vintage | Existing |
| Costs | Full $50/fixture; incremental $9/fixture |
| Savings | 39% of lighting energy |
| Useful Life | 16 years |

High-performance T8 lighting systems operate with an efficacy of 100 lumens per Watt and have a longer lamp life than standard T8 systems. For example, Sylvania's "Xtreme" system, with two high-performance T8 lamps, consumes 49 Watts per fixture, representing a savings of 39% over T12s, while providing the same light output.

- **Redesign with Standard T8 Lighting Systems**

| Measure Profile | |
|---|---|
| Applicable Building Types | All |
| Vintage | Existing |
| Costs | Full \$1.58/ft$^2$; incremental \$0.62/ft$^2$ |
| Savings | 54% of lighting energy |
| Useful Life | 16 years |

Some existing buildings are over-illuminated compared to current Illuminating Engineering Society of North America (IESNA) guidelines. The combination of lighting redesign to lower light levels and standard T8 lighting systems results in savings of 54% and a lower incremental cost (due to a requirement for fewer fixtures) relative to baseline T12 systems.

- **Redesign with High-performance T8 Lighting Systems**

| Measure Profile | |
|---|---|
| Applicable Building Types | All |
| Vintage | Existing |
| Costs | Full \$1.72/ft$^2$; incremental \$0.48/ft$^2$ |
| Savings | 62% of lighting energy |
| Useful Life | 16 years |

The combination of lighting redesign to lower light levels and next generation T8 lighting systems results in savings of 62% and a lower incremental cost (due to fewer fixtures) relative to baseline T12 systems.

- **Redesign with Fully Integrated Lighting and Control Systems**

| Measure Profile | |
|---|---|
| Applicable Building Types | Office |
| Vintage | Existing |
| Costs | Full \$6.67/ft$^2$; incremental \$4.47/ft$^2$ |
| Savings | 65% of lighting energy |
| Useful Life | 16 years |

In a typical configuration, an integrated lighting and control system features a pendant-mounted three-lamp T8 direct/indirect fixture and integrated controls including occupancy, daylight dimming and personal controls. One lamp illuminates the ceiling, while two down lamps illuminate the work surface. Occupancy sensors control the down lamps to reduce their operating hours, while daylight sensors provide dimming. Using a networked computer, individuals can adjust the light levels at their workstation. The system can also be centrally controlled in response to time-of-day schedules and peak load signals.

Fully integrated lighting and control systems can achieve savings of 65% relative to the T12 baseline and are primarily applicable to office environments.

### *T8 Fluorescent Upgrades*

Four energy-efficiency upgrade measures were evaluated for standard T8 lighting systems:

- High-performance T8 lighting systems
- Redesign with high-performance T8 lighting systems
- Redesign with fully integrated lighting and control systems
- Occupancy sensors.

These measures are applicable to both existing buildings and new construction and were evaluated at 3,000 hours of operation and on both a full cost and incremental cost basis. The baseline technology used for the analysis is a standard fluorescent fixture equipped with two 32-Watt T8 lamps and electronic ballast.

- ❑ **High-performance T8 Lighting Systems**

| **Measure Profile** | |
|---|---|
| Applicable Building Types | All |
| Vintage | Existing & new |
| Costs | Full \$50/fixture; incremental \$9/fixture |
| Savings | 17% of lighting energy |
| Useful Life | 16 years |

This upgrade technology is the same as previously described in the T12 upgrades discussion above. In this case, however, the savings are 17% relative to the baseline standard T8 systems.

- ❑ **Redesign with High-performance T8 Lighting Systems**

| **Measure Profile** | |
|---|---|
| Applicable Building Types | All |
| Vintage | Existing & new |
| Costs | Full \$1.73/ft$^2$; incremental \$0.01/ft$^2$ |
| Savings | 48% of lighting energy |
| Useful Life | 16 years |

This technology upgrade is the same as previously described in the T12 upgrades discussion above. In this case, however, the savings are 48% relative to the baseline standard T8 systems.

- **Redesign with Fully Integrated Lighting and Control Systems**

| Measure Profile | |
|---|---|
| Applicable Building Types | All |
| Vintage | Existing & new |
| Costs | Full $6.67/ft$^2$; incremental $4.95/ft$^2$ |
| Savings | 53% of lighting energy |
| Useful Life | 16 years |

This technology upgrade is the same as previously described in the T12 upgrades discussion above. In this case, however, the savings are 53% relative to the baseline standard T8 systems.

- **Occupancy Sensors**

| Measure Profile | |
|---|---|
| Applicable Building Types | All |
| Vintage | Existing & new |
| Costs | Full $70/switch; incremental $48/switch |
| Savings | 30% of lighting energy |
| Useful Life | 10 years |

This upgrade consists of replacing a standard wall switch with passive infrared (PIR) sensors. Standard applications include spaces with variable occupancy patterns including offices, corridors, washrooms and utility spaces. There are two general types of occupancy sensors available in the market: ultrasonic sensors, which use an inaudible high frequency sound wave to sense movement, and PIR sensors, which sense heat radiated from the human body. Sensors are generally mounted on walls or ceilings, depending on the desired area of coverage. The full cost is estimated to be $70 per switch, the savings are estimated to be 30% of lighting energy and the service life is estimated to be 10 years.

### 4.3.2 Incandescent Lighting Upgrades

Incandescent lighting is typically used in architectural, display, task and signage applications and is commonly found in lobbies, corridors, utility spaces, hotel rooms, retail spaces and restaurants.

Six energy-efficiency upgrade measures were evaluated for incandescent lighting:

- Compact fluorescent lamp
- Electrodeless induction lamp
- White LED lamp
- Halogen infrared PAR lamp
- Ceramic metal halide PAR lamp
- LED exit sign.

These upgrade options are applicable to both existing buildings and new construction and were evaluated at 3,000 hours of operation per year and on both a full cost and incremental cost basis (except where noted). The baseline technologies used for the analysis include the following:

- 65 W incandescent reflector lamp
- 75 W halogen PAR 38 lamp
- 30 W incandescent exit sign.

### ❑ Compact Fluorescent Lamp

| **Measure Profile** | |
|---|---|
| Applicable Building Types | All |
| Vintage | Existing & new |
| Costs | Full $22/lamp; incremental $17/lamp |
| Savings | 69% of lighting energy |
| Useful Life | 3 years |

This upgrade is a CFL that displays 785 lumens and has a full cost of $22. Relamping a 65-Watt incandescent reflector flood with this upgrade results in savings of 69% while producing an equivalent amount of light. In addition, CFLs have a life of 10,000 hours compared to the shorter life of incandescent lamps, providing additional benefits in the form of lower maintenance and lamp replacement costs.

### ❑ Electrodeless Induction Lamp

| **Measure Profile** | |
|---|---|
| Applicable Building Types | Office, Retail, Accommodations |
| Vintage | Existing & new |
| Costs | Full $43/lamp; incremental $38/lamp |
| Savings | 65% of lighting energy |
| Useful Life | 5 years |

Electrodeless lamps are discharge lamps like fluorescents, but use magnetic induction to generate an electric field rather than a voltage drop across a pair of electrodes.

This upgrade is 23-Watt electrodeless induction lamp that displays 1,100 lumens and has a full cost of $43. Similar to a CFL and without electrodes, the self-ballasted reflector lamp is a direct replacement for incandescent reflector lamps. It has a high colour rendering index (CRI); however, one limitation is that the lamp cannot be dimmed.

Relamping a 65-Watt incandescent reflector flood with this upgrade results in savings of 65% while producing the equivalent amount of light. In addition, electrodeless induction lamps currently have a life of 15,000 hours compared to the shorter life of incandescent lamps, providing additional benefits in the form of lower maintenance and lamp replacement costs.

### White LED Lamp

| Measure Profile | |
|---|---|
| Applicable Building Types | Office, Retail, Accommodations |
| Vintage | Existing & new |
| Costs | Full $43/lamp; incremental $38/lamp |
| Savings | 75% of lighting energy |
| Useful Life | 12 years |

This upgrade is a white light-emitting diode (LED) array that displays 800 lumens at 50 lumens per Watt and has a full cost of $43. Relamping a 65-Watt incandescent reflector lamp with this upgrade results in savings of 75% while producing an equivalent amount of light. In addition, white LEDs currently have a life of 35,000 hours compared to the shorter life of incandescent lamps, providing additional benefits in the form of lower maintenance and lamp replacement costs. However, this technology is in the early stages of market entry and therefore improvements to the technology in terms of cost and efficacy should be expected in the coming years.

### Halogen IR PAR Lamp

| Measure Profile | |
|---|---|
| Applicable Building Types | Retail, Office, Accommodations |
| Vintage | Existing & new |
| Costs | Full $15/lamp; incremental $6/lamp |
| Savings | 33% of lighting energy |
| Useful Life | 1.5 years |

This upgrade is a 50-Watt halogen infrared (IR) lamp that displays 970 lumens and has a full cost of $15. Relamping a 75-Watt halogen PAR 38 with this upgrade results in savings of 33% while producing an equivalent amount of light. In addition, halogen IR lamps have a life of 4,200 hours compared to the shorter life of halogen lamps, providing additional benefits in the form of lower maintenance and lamp replacement costs.

### Ceramic MH PAR Lamp

| Measure Profile | |
|---|---|
| Applicable Building Types | Retail, Office, Accommodations |
| Vintage | Existing & new |
| Costs | Full $38/lamp; incremental $29/lamp |
| Savings | 53% of lighting energy |
| Useful Life | 3.5 years |

This upgrade is a 25-Watt integrated ceramic metal halide (MH) lamp/ballast that displays 1,200 initial lumens and has a full cost of $38. Relamping a 75-Watt halogen PAR 38 with this technology results in savings of 53% while producing an equivalent amount of light. In addition, ceramic MH lamps have a life of 10,500 hours compared to the shorter life of halogen lamps, providing additional benefits in the form of lower maintenance and lamp replacement costs.

- **LED Exit Sign**

| **Measure Profile** | |
|---|---|
| Applicable Building Types | All |
| Vintage | Existing |
| Costs | Full $70/fixture |
| Savings | 93% of lighting energy |
| Useful Life | 11 years |

This upgrade is a 2-Watt LED exit sign that has a full cost of $70. Replacing a 30-Watt incandescent exit sign with this upgrade results in savings of 93% while producing an equivalent amount of light. In addition, LED exit signs have a life of 100,000 hours compared to the shorter life of incandescent lamps, providing additional benefits in the form of lower maintenance and lamp replacement costs. This upgrade is applicable to the existing building stock since incandescent exit signs are no longer available for sale in Canada. This measure was therefore evaluated on a full-cost basis at 8,760 hours per year.

### 4.3.3 High-intensity Discharge Lighting Upgrades

High-intensity discharge (HID) lighting such as metal halide is commonly used to illuminate high-ceilinged spaces such as warehouses, retail stores and gymnasiums and in outdoor lighting applications.

Two energy-efficiency upgrade options were evaluated for HID lighting:

- Pulse-start metal halide
- T5 high-intensity fluorescent.

These upgrade options are applicable to both existing buildings and new construction and were evaluated at 3,000 hours of operation and on both a full cost and incremental cost basis. The baseline technology for high-bay lighting is a standard 400-Watt metal halide high-bay fixture.

- **Pulse-start Metal Halide**

| **Measure Profile** | |
|---|---|
| Applicable Building Types | All buildings, outdoor and roadway lighting |
| Vintage | Existing & new |
| Costs | Full $325/fixture; incremental $10/fixture |
| Savings | 21% of lighting energy |
| Useful Life | 16 years |

This upgrade is a pulse-start metal halide high-bay luminaire featuring a 320-Watt lamp, 40-Watt ballast, 26,000 mean lumens, service life of 20,000 hours and a full cost of $325. Compared to traditional metal halides, a change in the lamp and ballast construction allows pulse-start metal halide lamps to start using a high-voltage ignitor in the ballast instead of a starting electrode in the lamp. The result is high lumen output, less lumen degradation, improved colour uniformity and quick start capabilities.

Replacing a standard 400-Watt metal halide luminaire with this upgrade results in savings of 21% while producing an equivalent amount of light. Pulse-start metal halide systems can be used for all traditional metal halide applications including high-bay, outdoor and roadway lighting.

- **T5 High-intensity Fluorescent**

| **Measure Profile** | |
|---|---|
| Applicable Building Types | Warehouse, Retail, School |
| Vintage | Existing & new |
| Costs | Full $350/fixture; incremental $35/fixture |
| Savings | 53% of lighting energy |
| Useful Life | 16 years |

This upgrade is a high-intensity fluorescent fixture equipped with four F54T5 high-output lamps and an occupancy sensor. This luminaire draws 239 Watts and displays 20,000 initial lumens, has a 20,000-hour lamp life and a full cost of $350.

Improvements in fluorescent lamps and the emergence of high-intensity fluorescent fixtures has made fluorescent lighting the most cost-effective choice for lighting high indoor spaces. These high-intensity fluorescent systems are more energy efficient than traditional HID fixtures and feature lower lumen depreciation, occupancy control, dimming options, instant start-up and better colour rendition.

Replacing a standard 400-Watt metal halide luminaire with this upgrade results in savings of 53% while producing an equivalent amount of light.

### 4.3.3 Heating, Ventilating and Air conditioning

Eleven energy-efficiency upgrade measures were evaluated for building heating, ventilating and air conditioning (HVAC) systems:

- Low-temperature heat pumps
- Ground source heat pumps
- Water loop heat pumps
- Infrared heaters
- High-efficiency chillers
- High-efficiency rooftop AC units
- Adjustable speed drives
- Premium efficiency motors
- Building recommissioning
- Advanced building automation systems
- Programmable thermostats.

As applicable, HVAC upgrade measures were evaluated at both low and high heating/cooling loads to reflect the range of building types and climate regions found in Newfoundland and Labrador.

- **Low-temperature Air Source Heat Pumps**

| **Measure Profile** | |
|---|---|
| Applicable Building Types | Small Commercial |
| Vintage | Existing and new |
| Costs | \$1.80 to \$2.50/ft$^2$ incremental cost |
| Savings | 56% to 59% of space heating and cooling energy |
| Useful Life | 15 years |

When outdoor air temperatures drop below freezing, standard air source heat pump systems switch to auxiliary electric resistance heaters to meet the space heating requirements. This limitation has served to minimize the penetration of air source heat pumps in cold climates. However, a low-temperature air source heat pump (LTHP) developed by Hallowell International[22] is capable of operating at 0°F with a coefficient of performance (COP) of greater than 2. At this temperature, standard air source heat pumps operate less efficiently, produce less than half their rated capacity and rely primarily on backup electric resistance heaters to maintain comfort.

The LTHP features a two-speed, two-cylinder compressor for efficient operation, a back-up booster compressor that allows the system to operate efficiently down to 15ºF and a plate heat exchanger called an "economizer" that further extends the performance of the heat pump to well below 0ºF.

This measure involves upgrading a standard HVAC system with an equivalent LTHP system. The target market is both residential and small commercial buildings and the baseline is electric- resistance heating and direct expansion cooling. This technology is applicable to existing buildings (at the end of HVAC life cycle) and new construction. The incremental cost ranges between \$1.80 and \$2.50 per square foot, the savings range between 56% and 59% of space heating and cooling energy and the service life is 15 years.

Currently, the LTHP is available only as a 3.0 and 3.5 ton split system, however Hallowell International expects to launch an expanded product line targeting the commercial market, including a packaged rooftop heat pump and a packaged terminal heat pump (PTHP) as early as 2008.[23]

[22] http://www.gotohallowell.com.
[23] Conversation with James Bryant of Hallowell International. September 2007.

- **Ground Source Heat Pumps**

| Measure Profile | |
|---|---|
| Applicable Building Types | All |
| Vintage | Existing & new |
| Costs | $4.90/ft$^2$ incremental cost |
| Savings | 61% to 64% of heating & cooling energy |
| Useful Life | 20 years |

Ground source heat pump (GSHP) systems are more efficient than conventional heat pump systems, with higher COPs and EERs. GSHPs also replace the need for a boiler in winter by utilizing heat stored in the ground; this heat is upgraded by a vapour-compressor refrigeration cycle. In summer, heat from a building is rejected to the ground, eliminating the need for a cooling tower or a heat rejector. They also lower operating costs because the ground is cooler than the outdoor air.

Water-to-air heat pumps are typically installed throughout a building with duct work serving only the immediate zone; a two-pipe water distribution system conveys water to and from the ground source heat exchanger. The heat exchanger field consists of a grid of vertical boreholes with plastic u-tube heat exchangers connected in parallel.

This measure involves upgrading a standard HVAC system with a GSHP system and is applicable to existing buildings (at the end of HVAC life cycle) and new construction. The baseline is a commercial building with standard electric resistance heating and direct expansion cooling. The incremental cost is $4.90 per square foot, the savings range between 61% and 64% of heating and cooling energy and the service life is 20 years.

- **Water Loop Heat Pumps**

Water loop heat pump systems, also known as California heat pump systems, consist of several individual water source heat pumps installed in multiple building zones and connected to a single water loop. Each heat pump adds or removes heat from the circulating water as required. Heat pump loop systems are typically used in large buildings requiring concurrent heating and cooling in different zones, where they are used to recover heat from some zones and deliver it to others. When internal heat gains are insufficient to meet the heating load on the perimeter, an electric boiler would provide the necessary supplementary heating. Disadvantages include a high initial cost and maintenance costs.

Given the heating dominated climate and relatively small internal heat gains in most buildings, and consequently the requirement for supplemental electric heating, water loop heat pumps are unlikely to have significant market uptake in Newfoundland and Labrador and will not be considered any further in this study.

- **Infrared Heaters**

| Measure Profile | |
|---|---|
| Applicable Building Types | Warehouse |
| Vintage | Existing & new |
| Costs | Full & incremental cost $750/heater |
| Savings | 14% of space heating energy |
| Useful Life | 10 years |

Radiant infrared heaters can be used as primary heating sources or in applications where supplementary or spot heating is required. Radiant heating systems offer energy savings because building occupants feel comfortable at lower air temperatures in radiantly heated spaces.

This measure involves using infrared heaters to provide supplementary spot heating and maintaining a lower ambient air temperature in the space. It is applicable to both existing buildings and new construction and the baseline is a Warehouse heated with standard electric resistance heating. The cost is estimated to be $750 per heater, the savings are 14% of space heating energy and the service life is 10 years.

- **High-efficiency Chillers**

| Measure Profile | |
|---|---|
| Applicable Building Types | Large Commercial/Institutional |
| Vintage | Existing & new |
| Costs | 25% incremental cost |
| Savings | 29% of space cooling |
| Useful Life | 25 years |

High-efficiency chillers feature oil-free centrifugal compressors, magnetic bearings and variable speed drives to deliver better integrated part-load value (IPLV) efficiencies than conventional oil-lubricated centrifugal, scroll and screw compressors.

This measure involves upgrading a standard efficiency chiller with a high-efficiency chiller and is applicable to both existing buildings (at end of chiller life cycle) and new construction. The baseline is a large commercial building cooled with a standard efficiency chiller. The incremental cost is 25%, the savings are 29% of space cooling energy and the service life is 25 years.

- **High-efficiency Rooftop AC Units**

| Measure Profile | |
|---|---|
| Applicable Building Types | All |
| Vintage | Existing & new |
| Costs | 20% incremental cost |
| Savings | 24% of space cooling energy |
| Useful Life | 15 years |

Packaged rooftop air conditioning units dominate the market for small and medium low-rise buildings accounting for the majority of the space cooling energy in the Commercial sector. The most common sizes are 5 to 20 ton units. Rooftops are often purchased and installed to minimize first cost, with little consideration of energy and operating costs. High-efficiency rooftop units featuring more efficient compressors, fans, heat exchangers and controls are available on the market with EERs as high as 13.5.

This measure involves upgrading a standard packaged rooftop unit with an equivalent high-efficiency unit. It is applicable to both existing buildings (at end of rooftop life cycle) and new construction. The baseline is a commercial building cooled with standard packaged rooftop air conditioning units with a rated EER of 10.3. The incremental cost is estimated to be 20% more than a conventional rooftop air conditioner and the savings are 24% of space cooling energy. The cost of high-efficiency units is likely to reduce over the coming years as the market matures. The service life is estimated to be 15 years.

- **Adjustable Speed Drives**

| **Measure Profile** | |
|---|---|
| Applicable Building Types | Medium and Large Commercial |
| Vintage | Existing & new |
| Costs | Full cost of $2,750 (10-HP) |
| Savings | 30% of fan energy |
| Useful Life | 10 years |

Adjustable speed drives (ASD) allow induction motor-driven loads such as fans and pumps to operate in response to varying load requirements. ASDs increase efficiency, improve power factor and provide precise control.

This measure involves upgrading a motor-driven centrifugal fan with an ASD and controlling the speed of the fan in response to variable load requirements. It is applicable to both existing buildings and new construction and the baseline is a centrifugal fan equipped with inlet vanes operating at an average of 80% capacity. The full cost is estimated to be $2,750, the savings are 30% of fan motor energy and the service life is estimated to be 10 years.

- **Premium Efficiency Motors**

| **Measure Profile** | |
|---|---|
| Applicable Building Types | All |
| Vintage | Existing & new |
| Costs | 20% incremental cost |
| Savings | 1.4% |
| Useful Life | 10 years |

Premium efficiency motors typically have reduced losses of 10%-40%, thereby increasing motor efficiency by 1% to 10%.[24] In a retrofit situation, it is considered best

[24] BC Hydro. *Power Smart Tips & Practices*.

practice to replace failed motors with new premium efficiency motors rather than rewind them since motor rewinding often degrades motor efficiency by 1% to 3%.

This measure involves upgrading an induction motor with an equivalent premium efficiency motor. It is applicable to both existing buildings (at end of motor life cycle) and new construction. The baseline is a standard efficiency induction motor. The incremental cost is estimated to be 20% relative to a standard efficiency motor, the savings are 1.4% and the service life is 10 years.

- **Building Recommissioning**

| Measure Profile | |
|---|---|
| Applicable Building Types | All |
| Vintage | Existing |
| Costs | Full cost of $0.60/ft^2$ |
| Savings | 20% of HVAC energy use |
| Useful Life | 5 years |

Recommissioning is a quality assurance process for ensuring that a building's complex array of mechanical and electrical systems is operated to perform according to the design intent and current operational needs of the building. The process generally involves monitoring and simulation of building systems to gain a thorough understanding of current operation and possibilities for optimization. Energy savings generally result from equipment repairs, air and water rebalancing and control optimization.

Recommissioning is applicable to existing buildings only. The baseline is a typical Office building with an electricity intensity of 26 $kWh/ft^2yr$. The full cost is estimated to be $0.60/ft^2$, the savings are 20% of HVAC energy use and the service life is 5 years.

- **Advanced Building Automation Systems**

| Measure Profile | |
|---|---|
| Applicable Building Types | All |
| Vintage | Existing |
| Costs | Full cost of $0.90/ft^2$ |
| Savings | 10% of total energy use |
| Useful Life | 10 years |

Advanced building automation systems (BAS) are able to automatically detect anomalies in building operations and can automate building diagnostics as well. These systems typically take data on how energy systems are performing in a building, analyze them using logic and physical modelling to detect deviations from expected performance and use built-in logic to suggest the cause of the deviation.[25] In addition, advanced BAS have improved predictive, self-tuning control algorithms that help to minimize the need for bypass or override of the BAS. Energy savings generally result from re-instituting

[25] E Source E News. *Automated Building Diagnostics: Improving Electricity Performance and Occupant Comfort.* ER-01. November 18, 2001.

equipment scheduling, expanded control to lighting and VAV boxes, instituting integrated control strategies and improving self-tuning diagnostics.

This measure involves installing an advanced BAS or upgrading an existing BAS with an advanced BAS. It is applicable to existing buildings and the baseline is a typical Office building with an electricity intensity of 26 kWh/ft²yr. The full cost is estimated to be $0.90/ft^2$, the savings are 10% of total building energy use and the service life is 10 years.

- **Programmable Thermostats**

| Measure Profile | |
|---|---|
| Applicable Building Types | Small Commercial |
| Vintage | Existing & new |
| Costs | Full cost of $400/thermostat |
| Savings | 10% of HVAC energy use |
| Useful Life | 10 years |

The use of programmable thermostats with packaged HVAC equipment provides improved control, scheduling and setpoint reset capability.

This measure involves upgrading standard thermostats with programmable thermostats and scheduling the operation of the equipment based on occupancy requirements. It is applicable to both existing buildings and new construction and the baseline is a Small Commercial building with packaged rooftop units and standard thermostats. The full cost is estimated to be $400 per thermostat, the savings are 10% of HVAC energy use and the service life is 10 years.

### 4.3.5 Refrigeration

Commercial refrigeration generally consists of medium- and low-temperature applications including reach-in refrigerators and freezers, walk-in coolers and freezers, display cases and refrigerated rooms. The energy used by refrigeration systems includes compressors, evaporator and condenser fans, lighting and defrost and anti-sweat heaters.

Two energy-efficiency measures were evaluated for refrigeration:

- ENERGY STAR refrigerators and freezers
- High-efficiency supermarket refrigeration.

- **ENERGY STAR Refrigerators and Freezers**

| Measure Profile | |
|---|---|
| Applicable Building Types | Food Retail, Restaurant |
| Vintage | Existing & new |
| Costs | Incremental cost of 20% |
| Savings | 25% of refrigeration energy |
| Useful Life | 10 years |

Commercial self-contained, reach-in refrigerators and freezers are electrically-powered refrigerated cases with shelves and lighting and having up to three opaque or transparent doors. These appliances are used primarily in the retail sector by convenience stores, supermarkets, restaurants, pubs, cafeterias, flower shops, drug stores and others for storing or merchandising refrigerated or frozen products such as cold drinks, ice cube bags, frozen foods, etc. Canada has over 340,000 commercial reach-in refrigerators and freezers, and approximately 38,000 new units sell each year.26 A typical refrigerator consumes 4,300 kWh per year and a freezer 9,800 kWh per year.

On September 1, 2006, ENERGY STAR qualifying criteria for commercial solid door, self-contained refrigerators and freezers came into effect in Canada. ENERGY STAR qualified commercial solid door refrigerators and freezers use electronically commutated motors (ECM) for evaporator and condenser fans, hot gas anti-sweat heaters and high-efficiency compressors. These features make them considerably more energy efficient than standard appliances.

This measure involves upgrading a standard reach-in refrigerator or freezer with an equivalent ENERGY STAR appliance. It is applicable to both existing buildings (at end of refrigeration life cycle) and new construction. The incremental cost is 20%, the savings are 25% and the service life is 10 years.

- **High-efficiency Supermarket Refrigeration**

| **Measure Profile** | |
|---|---|
| Applicable Building Types | Large Food Retail |
| Vintage | Existing & new |
| Costs | Incremental cost of $2.70/ft^2$ |
| Savings | 25% of refrigeration energy |
| Useful Life | 10 years |

Supermarket refrigeration is divided into two distinct segments that have different technologies. The more visible part of these systems is the display cases that hold food for the self-service shopping style of supermarkets. The display cases have their own electric loads and are served by a central refrigeration system. The mechanical equipment, including compressors, condensers, and associated controls, is located in the machine room. The potential for energy consumption reductions associated with machine room equipment is limited to about 5% of overall supermarket refrigeration energy usage. Reduction of 1% of overall usage is possible with increased use of evaporative condensers, a technology which currently has little market penetration. Additional reductions of 4% could be achieved by further use of floating head pressure, mechanical subcooling and heat reclaim, technologies which currently have varying degrees of market penetration.

The potential for energy consumption reductions associated with display cases is about 20% of overall supermarket refrigeration energy usage. Savings of 12% can be achieved with high-efficiency evaporator fan motors and hot-gas defrost. Additional savings of 8%

[26] Natural Resources Canada. www.oee.nrcan.gc.ca/commercial/equipment/selfcontained-refrigerators-freezers.

can be achieved with liquid suction heat exchangers, anti-sweat control and defrost control.

This measure involves upgrading a standard supermarket refrigeration system with an equivalent high-efficiency refrigeration system. It is applicable to existing large Food Retail buildings (at end of refrigeration life cycle) and new construction. The baseline is a Food Retail building with a refrigeration energy intensity of 31 kWh/ft$^2$/yr. The incremental cost is estimated to be \$2.70/ft$^2$, savings are 25% of refrigeration energy use and the service life is 10 years.

### 4.3.6 Domestic Hot Water

Domestic hot water (DHW) is typically used in commercial buildings for hand washing, showers, cleaning and food preparation. Four DHW energy-efficiency upgrades were evaluated:

- Low-flow faucet aerators and shower heads
- Heat pump water heaters
- Grey water heat recovery
- Tankless water heaters.

#### ❑ Low-flow Faucet Aerators and Shower Heads

| Measure Profile | |
|---|---|
| Applicable Building Types | All |
| Vintage | Existing & New |
| Costs | $40/lavatory |
| Savings | 40% of domestic hot water energy use |
| Useful Life | 5 years |

Low-flow faucet aerators lower the water flow to 0.5 to 2 gallons per minute (gpm) by introducing air into the water stream. The aerator creates a fine water spray with a screen that is inserted in the faucet head. Similarly, low-flow shower heads use the same principle as faucet aerators to achieve flow rates in the range of 1.5 to 2.2 gpm.

This measure involves upgrading faucet aerators and shower heads with equivalent water efficient units. It is applicable to existing buildings and new construction. The baseline is a standard shower head with a flow rate of 2.5 to 3 gpm and a standard faucet aerator with a flow rate of 2 to 3 gpm. The cost is estimated to be $40 per lavatory (four sinks and one shower stall), the savings are estimated to be 40% and the service life is 5 years.

#### ❑ Heat Pump Water Heaters

Heat pump water heaters extract heat from the surrounding air to heat hot water. During the heating season the surrounding air will have to be re-heated. Given the 9-month heating season in Newfoundland and Labrador, this technology is not a practical solution and would provide very little economic benefit. Therefore, it is recommended that this technology not be considered any further in this study.

- **Grey Water Heat Recovery**

Grey water heat recovery systems (GWHR) capture energy from warm wastewater to pre-heat incoming water for a DHW tank. GWHR is most effective in buildings with large, sustained DHW requirements such as laundries, gymnasiums and restaurants. As the opportunity for this measure is restricted to niche applications within sub sectors, it will not be considered as an individual measure in the present study. It is recognized, however, that GWHR will be applicable in some new building construction and will, therefore, be considered to be among the family of DHW efficiency measures captured in the measure *New Commercial Building – 40% More Efficient than Current Standards* in Section 4.10 below.

- **Tankless Water Heaters**

| **Measure Profile** | |
|---|---|
| Applicable Building Types | All |
| Vintage | Existing & New |
| Costs | Incremental cost of $5,600 |
| Savings | 7% of domestic hot water energy use |
| Useful Life | 10 years |

Tankless water heaters, also known as instantaneous water heaters, provide hot water without using a storage tank. Like tank water heaters, tankless water heaters use electricity to operate. Cold water travels through a pipe into the unit, and an electric element heats the water. Tankless water heaters can be supplementary units placed at the point of use or can replace conventional tank water heaters. Electric tank water heaters have an energy factor of about 0.91 compared with 0.98 for electric tankless water heaters.

Electric heating elements for tankless water heaters are much larger than for storage water heaters because the heater must be sized for the peak instantaneous. For example, a typical residential electric storage water heater draws at most 7,000 Watts, a whole-house electric tankless heater can draw as much as 19,200 Watts, and may require a larger electrical service.

This measure involves upgrading a central DHW tank heater with multiple point-of-use tankless heaters. It is applicable to existing buildings (at end of tank life cycle) and new construction. The incremental cost is estimated to be $5,600, the savings are 7% and the service life is 10 years.

### 4.3.7 Computer Equipment

Computer equipment typically includes computers, monitors, servers, printers, copiers and fax machines. Three computer equipment energy-efficiency upgrades were evaluated:

- ENERGY STAR computer and monitor
- ENERGY STAR office equipment

- Energy-efficient server technologies.

- **ENERGY STAR Computer and Monitor**

| **Measure Profile** | |
|---|---|
| Applicable Building Types | All |
| Vintage | Existing & new |
| Costs | Incremental cost of $0/unit |
| Savings | 75% of unit energy consumption |
| Useful Life | 5 years |

Beginning on July 20, 2007, ENERGY STAR's new specifications for computers went into effect. Only the market's most energy-efficient computing products will qualify for the ENERGY STAR label. Qualified products must now meet energy use guidelines in three distinct operating modes: standby, sleep mode and while computers are being used, and will include a more efficient internal power supply.

This measure involves upgrading a standard computer and monitor with an equivalent ENERGY STAR unit. It is applicable to both existing and new buildings at the end of the computer life cycle. The baseline is a standard desktop computer equipped with a 17" liquid crystal display (LCD) monitor and operating under default power management settings. The system is assumed to be on for approximately 40% of the time drawing 93 Watts and 4 Watts while turned off.

The upgrade is a comparable ENERGY STAR rated computer and monitor (17" LCD) operating with ENERGY STAR power management settings. The savings are estimated to be 75%, the incremental cost is zero[27] and the service life is 5 years.

- **ENERGY STAR Office Equipment**

| **Measure Profile** | |
|---|---|
| Applicable Building Types | All |
| Vintage | Existing & new |
| Costs | Incremental cost $0/unit |
| Savings | 40% of unit energy consumption |
| Useful Life | 5 years |

This measure involves upgrading a standard photocopier with an equivalent ENERGY STAR rated unit. It is applicable to both existing and new buildings at the end of the computer life cycle. The baseline is a standard medium speed copier (21-44 copies per minute) operating under default power management settings. The system is assumed to be on for approximately 50% of the time drawing 177 Watts, on standard for 35% of the time drawings 163 Watts and 14 Watts while turned off. The results of this analysis can be extrapolated to other types of office equipment such as faxes and printers.

The upgrade is a comparable ENERGY STAR rated photocopier featuring reduced standby and off mode consumption as well as enabled ENERGY STAR power

[27] http://www.energystar.gov.

management settings. The savings are estimated to be 40%, the incremental cost is zero[28] and the service life is 5 years.

- **Energy-efficient Server Technologies**

| Measure Profile | |
|---|---|
| Applicable Building Types | All |
| Vintage | Existing & new |
| Costs | $50/server |
| Savings | 40% of server energy |
| Useful Life | 5 years |

This upgrade features two server technologies: server virtualization and energy-efficient servers, however the savings are not additive. The measures apply to both existing and new buildings at the end the server life cycle. The baseline server draws 217 Watts[29] based on the weighted average of the top three servers in the U.S. by shipment volume in 2005.

**Server Virtualization.** Servers are "virtualized" using software that allows a server to run multiple operating systems or instances of the same operating system concurrently. This allows for server consolidation resulting in a reduced number of servers required for operations. Potential energy savings are 40% in applications where many servers are used, such as data centres. Software and installation costs are estimated at $50/unit.[30]

**Energy-efficient Servers.** Servers using "multi-threaded" technology perform multiple parallel operations, achieving a higher performance per Watt than conventional servers. Potential energy savings are 35% and equipment costs are comparable to traditional servers.[31]

### 4.3.8 Building Envelope

Building envelope measures improve the thermal performance of a building's walls, windows and roof.

Four energy-efficiency upgrade options were evaluated for the building envelope:

- High-performance glazing systems
- Upgrade wall insulation
- Upgrade roof insulation
- Air curtains.

Each measure is evaluated at a low- and high-heating load to reflect the range of climate conditions found in Newfoundland and Labrador.

[28] http://www.energystar.gov.
[29] J.G. Koomey. *Estimating Total Power Consumption by Servers in the U.S. and the World*. 2007.
[30] http://www.microsoft.com.
[31] http://www.sun.com.

## ❑ High-performance Glazing Systems

| Measure Profile | |
|---|---|
| Applicable Building Types | All |
| Vintage | Existing and new |
| Costs | $2.00/ft$^2$ (floor area) incremental cost |
| Savings | 28% to 34% of heating and cooling energy |
| Useful Life | 20 years |

High-performance glazing systems consist of low-e coated films suspended inside an insulating glass unit. These units can be incorporated into both window and curtain wall systems. In addition to superior insulating performance and lower energy costs, the co-benefits include enhanced comfort, noise reduction, the elimination of perimeter heating and reduced HVAC equipment costs.

Visionwall window and curtain wall systems manufactured by Visionwall Corporation[32] have thermal resistance R-values ranging from 3 to 7 hr.ft$^2$.$^o$F/Btu, low shading coefficients and high visible light transmission. The highest performing product on the market is Superglass Quad (R-value 12.5 hr.ft$^2$.$^o$F/Btu) manufactured by Southwall Technologies.[33] It features two films suspended inside an insulating glass unit creating three krypton-filled air spaces. A tape system is used for gas retention and a thermally broken insolating spacer stops the conduction through the edge of the glass.

This upgrade is a high-performance glazing system with an overall U-value of 0.25 Btu/hr.ft$^2$.$^o$F (R-4). It is applicable to both existing buildings (at end of window life cycle) and new construction. The baseline is an electrically-heated commercial building with standard double-glazed windows with an overall U-value of 0.45 Btu/hr.ft$^2$.$^o$F (R-2.2). The incremental cost is $2 per square foot of floor area, the savings range from 28% to 34% of the heating and cooling energy and the service life is 20 years.

## ❑ Upgrade Wall Insulation

| Measure Profile | |
|---|---|
| Applicable Building Types | All |
| Vintage | Existing and new |
| Costs | $1.38/ft$^2$ (floor area) incremental cost |
| Savings | 18% of heating energy |
| Useful Life | 25 years |

Various insulating materials and methods can be used to upgrade wall insulation including applying rigid polystyrene board to the exterior of a building or installing fibreglass batts between interior wall studs.

This measure involves upgrading wall insulation to R-24. It is applicable to both existing buildings (at time of recladding) and new construction. The baseline is an electrically-

[32] http://www.visionwall.com.
[33] http://www.southwall.com.

heated commercial building with R-12 wall insulation. The incremental cost is $1.38 per square foot of floor area, the savings are 18% of heating energy and the service life is 25 years.

- **Upgrade Roof Insulation**

| Measure Profile | |
|---|---|
| Applicable Building Types | All |
| Vintage | Existing and new |
| Costs | $1/ft$^2$ (floor area) incremental cost |
| Savings | 13% of heating energy |
| Useful Life | 25 years |

Upgrading insulation on a built-up roofing system typically involves adding additional layers of rigid insulation at the time of re-roofing.

This measure involves upgrading roof insulation to R-30. It is applicable to both existing buildings (at time of re-roofing) and new construction. The baseline is an electrically-heated commercial building with R-20 roof insulation. The incremental cost is $1 per square foot of floor area, the savings are 13% of heating energy and the service life is 25 years.

- **Air Curtains**

| Measure Profile | |
|---|---|
| Applicable Building Types | Retail, Warehouse |
| Vintage | Existing & new |
| Costs | Full $2,150 per double door |
| Savings | 9% of space heating energy |
| Useful Life | 15 years |

Air curtain systems use a fan to generate a laminar air flow across an open doorway. This mass flow of air acts as a barrier, reducing outside air infiltration by approximately 90%, thus preventing unwanted heat transfer both at the building envelope and between rooms within buildings. Typical applications include entrances to buildings in the Retail sub sector, overhead garage doors, loading docks and refrigerated rooms. The co-benefits include protecting employees from adverse environmental conditions such as cold drafts and dust.

This upgrade involves the installation of an air curtain to a double door entrance. It is applicable to both existing buildings and new construction and the baseline is a Non-food Retail building with a double door entrance. The full cost is $2,150 per double door, the savings are 9% of the space heating energy and the service life is estimated to be 15 years.

### 4.3.9 New Construction

New construction refers to new high-efficiency buildings designed using the integrated design process that achieve substantial improvements over conventional new buildings through the application and integration of energy-efficiency technologies and design approaches.

Baseline new construction is assumed to follow the MNECB and ASHRAE 90.1 - 1999 standards.

Two energy-efficiency upgrade options were evaluated for new construction:

- New Commercial Building - 25% more efficient than current standards
- New Commercial Building - 40% more efficient than current standards.

- **New Commercial Building - 25% More Efficient than Current Standards**

| **Measure Profile** | |
|---|---|
| Applicable Building Types | All |
| Vintage | New |
| Costs | $1/ft^2$ incremental cost |
| Savings | 25% |
| Useful Life | 30 years |

The integrated design approach (IDA) to new building design is predicated on a systematic application of energy measures to all end uses at the design stage. This includes targeting the building envelope, lighting, HVAC equipment (fans and pumps) and, finally, the heating and cooling plants. Savings of 25% are achievable at an average incremental cost of $1/ft^2$.

- **New Commercial Building - 40% More Efficient than Current Standards**

| **Measure Profile** | |
|---|---|
| Applicable Building Types | All |
| Vintage | New |
| Costs | $4.50/ft^2$ incremental cost |
| Savings | 40% |
| Useful Life | 30 years |

A new commercial building that is 40% more efficient than current design practice will require a very high-performance design, equivalent to C-2000 levels. This requires a full IDA that takes advantage of costs trade-offs from equipment downsizing. The design will require the most energy-efficient technologies, extremely efficient lighting designs and heating/cooling plants with very high part-load efficiencies. Savings of 40% are achievable at an average incremental cost of $4.50/ft^2$.

### 4.3.10 Street Lighting

Street lighting refers to all outdoor and roadway lighting intended to illuminate municipal streets and highways. Street lighting is dominated by high-pressure sodium lamps at approximately 85%, followed by metal halide at approximately 15%.

Two energy-efficiency upgrade options were evaluated for this end use:

- Electrodeless induction lighting
- Dimming controls.

**Electrodeless Induction Lighting**

| Measure Profile | |
|---|---|
| Applicable Building Types | Street Lighting |
| Vintage | Existing and new |
| Costs | $300/fixture incremental cost |
| Savings | 25% |
| Useful Life | 16 years |

Induction lighting uses a magnetic field instead of electrodes to produce the electric field that excites the gas to emit light. This technology was first introduced in Europe in 1991 but has been slow to catch on in North America. Induction lighting has numerous benefits, the most important being an exceptionally long life, rated at 100,000 hours. Other benefits include instant-on capabilities, a high colour rendering index (CRI) of approximately 80 and an efficacy of 60-80 lumens per Watt. The drawbacks to this technology are that the capital cost is high, the technology does not work with dimmers, the lamps are large and not compatible with existing fixtures and the lamps do not work in temperatures above 35ºC to 40ºC.

Currently, Philips and OSRAM/Sylvania are the only manufacturers that have available products. The Philips Quality Light (QL) product line includes 55-, 85- and 165-Watt systems. OSRAM/Sylvania has a 100- and 150-Watt version called the Icetron.

Experts are mixed on the future of this technology. However, at a minimum, it is expected that these lamps will find a niche in areas where long life is a critical factor, such as in hard to reach areas and areas where maintenance costs would be high, e.g., in tunnels and over bridges.

This upgrade involves retrofitting of a 175-Watt metal halide with an equivalent 150-Watt induction luminaire. The incremental cost is $300 per luminaire,[34] the savings are 25% and the service life is 16 years.

[34] Bonneville Power Administration. http://www.bpa.gov/Energy/N.

### ❑ Dimming Controls

| Measure Profile | |
|---|---|
| Applicable Building Types | Street Lighting |
| Vintage | Existing and new |
| Costs | Full $220/fixture |
| Savings | 30% |
| Useful Life | 16 years |

Dimming controls (sometimes called adaptive lighting) have the potential to reduce annual energy use by 20% to 40% by lowering light levels during periods of low activity. Several companies are currently investigating different approaches to the application of this technology. In one configuration, the controls are incorporated as an add-on device to an existing magnetic ballast. In a second configuration, the technology is combined with advanced monitoring and wireless, computer enabled controls to further increase savings.

Currently, there is very little dimming being used in outdoor lighting in Canada. Issues related to safety and possible liability arising from the lower light levels, have made lighting designers and policy makers reluctant change the status quo. However, many industry experts believe that this technology could have a significant impact on the market if the issues of safety and liability can be adequately addressed.

This upgrade involves adding dimming controls to street lighting to reduce or shut off lighting during silent periods. The savings are estimated to be 30%, the full cost is $220[35] per luminaire and the service life is 16 years.

## 4.4 SUMMARY OF ENERGY-EFFICIENCY RESULTS

The energy-efficiency measures and their associated CCEs are summarized in Exhibit 4.2. Note that the negative values shown for selected lighting upgrades indicate that the annualized capital cost of the energy-efficiency measure is less expensive than the baseline technology.

[35] Average cost including hardware, controls and estimated installation costs. Streetlight Intelligence Ltd.

## Exhibit 4.2: Commercial Energy-efficiency Technologies and Measures – Cost of Conserved Energy

| Measure/Technology | | | Sub Sector | Vintage | CCEs (¢/kWh) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 4.0% DR | | 6.0% DR | | 8.0% DR | |
| | | | | | Full | Incr. | Full | Incr. | Full | Incr. |
| Lighting | T12 | Standard T8s | All | Existing | 5.4 | 0.0 | 6.3 | 0.0 | 7.2 | 0.0 |
| Lighting | T12 | Low BF T8s | All | Existing | 3.9 | 0.0 | 4.6 | 0.0 | 5.2 | 0.0 |
| Lighting | T12 | High-performance T8s | All | Existing | 4.2 | 0.5 | 4.9 | 0.7 | 5.7 | 0.8 |
| Lighting | T12 | Redesign with standard T8s | All | Existing | 5.1 | -2.0 | 5.9 | -2.3 | 6.8 | -2.6 |
| Lighting | T12 | Redesign with high-performance T8s | All | Existing | 4.9 | -1.3 | 5.6 | -1.6 | 6.4 | -1.8 |
| Lighting | T12 | Fully integrated lighting and controls | All | Existing | 17.7 | 11.9 | 20.5 | 13.7 | 23.5 | 15.8 |
| Lighting | T8 | High-performance T8s | All | Existing & New | 13.1 | 1.7 | 15.3 | 2.1 | 17.6 | 2.5 |
| Lighting | T8 | Redesign with high-performance T8s | All | Existing & New | 8.4 | 0.0 | 9.8 | 0.0 | 11.2 | 0.0 |
| Lighting | T8 | Fully integrated lighting and controls | All | Existing & New | 29.6 | 22.0 | 34.3 | 25.4 | 39.3 | 29.2 |
| Lighting | T8 | Occupancy sensors | All | Existing & New | 6.0 | 4.3 | 6.6 | 4.7 | 7.2 | 5.1 |
| Lighting | Inc | Compact fluorescent lamps | All | Existing & New | 2.7 | -1.1 | 2.9 | -1.0 | 3.2 | -0.8 |
| Lighting | Inc | Induction lighting | Retail | Existing & New | 4.5 | 0.4 | 4.9 | 0.7 | 5.4 | 1.1 |
| Lighting | Inc | White LEDs | All | Existing & New | 0.1 | -3.5 | 0.4 | -3.2 | 0.8 | -2.8 |
| Lighting | Inc | Halogen IR | All | Existing & New | 10.1 | -4.8 | 10.5 | -4.7 | 10.8 | -4.6 |
| Lighting | Inc | Ceramic metal halide | Retail | Existing & New | 4.7 | -4.6 | 5.1 | -4.4 | 5.6 | -4.1 |
| Lighting | Inc | LED exit signs | All | Existing | 1.7 | na | 2.0 | na | 2.4 | na |
| Lighting | HID | Pulse-start metal halide | All, outdoor, roadway | Existing & New | 9.5 | 0.3 | 10.9 | 0.3 | 12.5 | 0.4 |
| Lighting | HID | High intensity fluorescents | Warehouse, retail, school | Existing & New | 4.1 | 0.4 | 4.8 | 0.5 | 5.4 | 0.5 |
| HVAC | | Low temperature heat pumps - Island | Small commercial | Existing & New | na | 5.5 | na | 6.0 | na | 6.6 |
| HVAC | | Low temperature heat pumps - Labrador | Small commercial | Existing & New | na | 4.8 | na | 5.3 | na | 5.8 |
| HVAC | | Ground source heat pumps - Island | All | Existing & New | na | 6.2 | na | 7.3 | na | 8.6 |
| HVAC | | Ground source heat pumps - Labrador | All | Existing & New | na | 4.5 | na | 5.4 | na | 6.3 |
| HVAC | | Infrared heaters - Island | Retail, warehouse | Existing & New | 6.7 | 6.7 | 7.4 | 7.4 | 8.1 | 8.1 |
| HVAC | | Infrared heaters - Labrador | Retail, warehouse | Existing & New | 4.8 | 4.8 | 5.3 | 5.3 | 5.8 | 5.8 |
| HVAC | | High-efficiency chillers - Island | Large commercial | Existing & New | na | 6.1 | na | 7.4 | na | 8.9 |
| HVAC | | High-efficiency chillers - Labrador | Large commercial | Existing & New | na | 8.1 | na | 9.9 | na | 11.8 |
| HVAC | | High-efficiency AC units - Island | All | Existing & New | na | 11.3 | na | 12.9 | na | 14.7 |
| HVAC | | High-efficiency AC units - Labrador | All | Existing & New | na | 18.7 | na | 21.5 | na | 24.3 |
| HVAC | | Adjustable speed drives | All | Existing & New | 5.0 | 5.0 | 5.6 | 5.6 | 6.1 | 6.1 |
| HVAC | | Premium efficiency motors | All | Existing & New | 19.5 | 2.9 | 21.5 | 3.2 | 23.5 | 3.6 |
| HVAC | | Building recommissioning | All | Existing | 4.0 | na | 4.3 | na | 4.5 | na |
| HVAC | | Advanced BAS | All | Existing & New | 4.3 | na | 4.7 | na | 5.1 | na |
| HVAC | | Programmable thermostats - Island | Small commercial | Existing & New | 1.8 | 0.9 | 2.0 | 1.0 | 2.2 | 1.1 |
| HVAC | | Programmable thermostats - Labrador | Small commercial | Existing & New | 1.6 | 0.8 | 1.8 | 0.9 | 1.9 | 1.0 |
| Refrigeration | | ENERGY STAR refrigerators & freezers | Food retail, restaurant | Existing & New | na | 6.7 | na | 7.3 | na | 8.0 |
| Refrigeration | | HE supermarket refrigeration | Food retail | Existing & New | na | 4.3 | na | 4.7 | na | 5.2 |
| DHW | | Low-flow aerators & shower heads | All | Existing & New | 2.6 | na | 2.8 | na | 2.9 | na |
| DHW | | Tankless water heaters | All | Existing & New | na | 37.4 | na | 41.2 | na | 45.2 |
| Computer Equipment | | ENERGY STAR computers | All | Existing & New | na | 0.0 | na | 0.0 | na | 0.0 |
| Computer Equipment | | ENERGY STAR office equipment | All | Existing & New | na | 0.0 | na | 0.0 | na | 0.0 |
| Computer Equipment | | High-efficiency servers | All | Existing & New | na | 1.5 | na | 1.6 | na | 1.7 |
| Building Envelope | | High-performance glazings - Island | All | Existing & New | na | 5.5 | na | 6.5 | na | 7.5 |
| Building Envelope | | High-performance glazings - Labrador | All | Existing & New | na | 3.3 | na | 4.0 | na | 4.6 |
| Building Envelope | | Wall insulation - Island | All | Existing & New | na | 6.0 | na | 7.4 | na | 8.8 |
| Building Envelope | | Wall insulation - Labrador | All | Existing & New | na | 4.2 | na | 5.1 | na | 6.1 |
| Building Envelope | | Roof insulation - Island | All | Existing & New | na | 6.9 | na | 8.5 | na | 10.1 |
| Building Envelope | | Roof insulation - Labrador | All | Existing & New | na | 4.4 | na | 5.3 | na | 6.4 |
| Building Envelope | | Air curtains - Island | Warehouse, retail | Existing & New | 5.1 | 5.1 | 5.8 | 5.8 | 6.6 | 6.6 |
| Building Envelope | | Air curtains - Labrador | Warehouse, retail | Existing & New | 3.3 | 3.3 | 3.8 | 3.8 | 4.3 | 4.3 |
| New Construction | | New buildings - 25% more efficient | All | New | na | 0.9 | na | 1.1 | na | 1.4 |
| New Construction | | New buildings - 40% more efficient | All | New | na | 2.5 | na | 3.1 | na | 3.8 |
| Streetlighting | | Induction lighting | | Existing & New | na | 10.4 | na | 12.3 | na | 14.4 |
| Streetlighting | | Dimming controls | | Existing & New | 5.0 | 5.0 | 5.8 | 5.8 | 6.6 | 6.6 |

## 4.5 PEAK LOAD REDUCTION MEASURES

### 4.5.1 Overview

Electric utilities are typically interested in peak load reduction measures as a means to avoid or defer the costs of capacity expansion. Capacity costs refer to a wide range of capital-based investments, including generating stations (new and upgraded), transmission lines, distribution lines, substations, transformers and other infrastructure required to deliver power.

From the customer's perspective, adoption of peak load reduction measures is typically dependent on the overall benefits to them, such as direct incentive payments or rate benefits. Although most medium and large commercial customers do pay a monthly demand charge that reflects their monthly peak, small commercial customers with a monthly demand of less than 10 kW are billed only for electricity (kWh) regardless of when it is used.

The current trend throughout much of the North American utility industry is towards more specific pricing such as time-of-use and even hourly pricing, or peak incentives that pass along some of the utility benefits to customers on a performance basis. These new pricing structures provide added incentive to larger commercial customers (who already pay a demand charge); they also provide an incentive for small commercial customers to implement measures or to participate in utility peak load reduction programs, as long as the differential between peak and off-peak prices is sufficient to provide a noticeable financial benefit to the customer.

Currently, several Canadian jurisdictions[36] are in the early stages of implementing pilot load reduction initiatives targeted to both commercial and residential customers. These initiatives are designed to test:

- New metering technologies, such as advanced meters (also referred to as "smart meters")
- New rate structures, such as real-time feedback, pay-as-you-go billing and critical peak pricing
- Direct load control.

Most conventional meters used in small commercial facilities monitor electricity consumption (kWh) but do not track *when* the electricity is used. Instead, conventional meters are occasionally read and reported to electric utilities, which then bill customers every one or two months. As a result, customers only find out their electricity usage after the fact.

In contrast, *advanced meters* (known in some industry circles as "smart meters") record how much electricity is used and when. Advanced meters, through their interval metering and two-way communications, allow the implementation of numerous utility programs

[36] Marbek Resource Consultants, *Technology & Market Assessment of Residential Electricity Advanced Metering In Canada*. Prepared for Natural Resources Canada, November 2006.

and services that encourage customers to reduce or shift (i.e., change the time of) their electricity consumption, particularly away from peak times when the cost of supply is becoming increasingly more expensive.

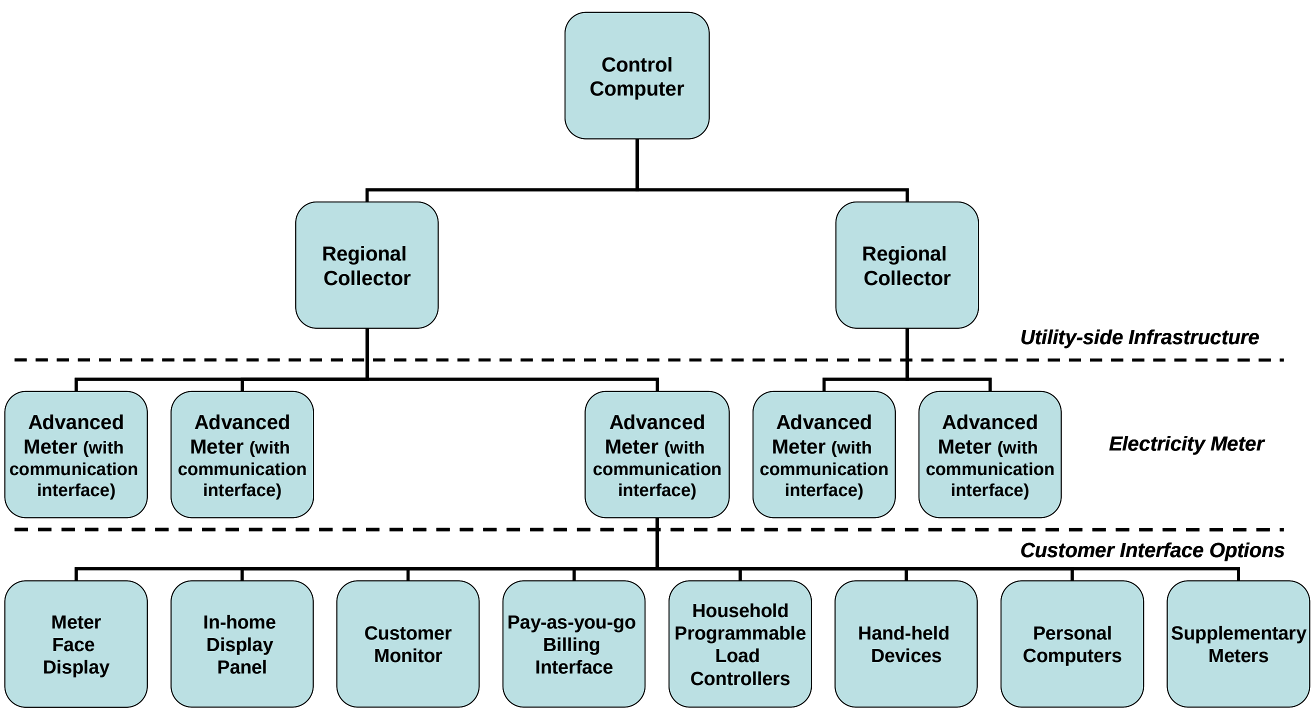
Exhibit 4.3 presents an illustrative schematic of an advanced metering system. As illustrated there are three major levels of system components:

- **Customer Interface Options** — The hardware interfaces that can be used for the advanced meter to communicate with the customer and, to a certain extent, any applicable electrical load controllers in the customer's household.

- **Electricity Meter** — The advanced meter itself, equipped with a communication interface to facilitate communication to other devices and the utility.

- **Utility-side Infrastructure** — The infrastructure required for two-way communication between the utility and the advanced meter.[37]

**Exhibit 4.3**
**Illustrative Schematic of an Advanced Metering System**




As illustrated in Exhibit 4.3, there is wide range of technical options available at each level in a typical advanced metering system. This is particularly the case at the customer interface level where there is a growing number of devices that can be used to provide real-time feedback to customers in a convenient and understandable manner. Typically, these devices provide a numerical or graphical display that is either wired into the same

[37] Ibid.

room as the meter, wired next to the main thermostat or is a wireless panel that can be placed anywhere in the home or commercial facility. However, alone, none of these devices save energy *per se*.

In summary, new electric metering and customer interface technologies, when combined with the applicable utility infrastructure, have the potential to support a wide range of utility-sponsored peak load reduction and load shifting initiatives via pricing and promotional initiatives. Within the agreed study scope, it is not feasible to provide further specific rate design or system infrastructure specifications. However, further information is provided below on selected direct load control options.

### 4.5.2 Peak Load Reduction Measures – Direct Load Control

Consistent with the agreed study scope, the information provided below is based on existing secondary data sources and does not include a detailed analysis of specific NLH/NP peak load conditions. Much of the information provided draws from work that the consultant team is currently undertaking for BC Hydro.[38] To that end, the material presented is intended to be indicative of general trends and costs but would need to be adjusted for specific application to NLH/NP peak load conditions.[39]

The remainder of this subsection provides an overview of the following Commercial sector peak load reduction measures:

- Utility-based control of space heating (HVAC) equipment using remote thermostat
- Utility-based control of space heating (HVAC) equipment using remote switch
- Utility-based control of hot water heater using remote switch.

❑ **Utility-Based Control of Space Heating (HVAC) Equipment Using Remote Thermostat[40]**

Thermostat-based load control is accomplished by the installation of a remote communicating thermostat that facilitates utility remote control of the thermostat (for space heating and/or, in some cases, space cooling). Utility control would occur under specific, pre-arranged, capacity-constrained conditions that would typically occur during a limited number of pre-specified hours during winter peak months.

The control options typically include thermostat setback (specific number of degrees) or cycling, whereby the units are limited to a fixed percentage of operating time per hour. These systems typically provide capability for local override by participants and are either one-way or two-way communicating systems. Two-way communicating systems also enable access by participants to their thermostats via the Internet, utility

[38] Marbek Resource Consultants and Applied Energy Group. *BC Hydro Conservation Potential Review – 2007*. Prepared for BC Hydro. In process, 2007.

[39] As both BC Hydro and NLH/NP are winter peaking utilities and both are hydro-based with fossil fuel plants serving peak load conditions, the information provided is expected to be generally applicable to the NLH/NP context.

[40] Op. cit., *BC Hydro Conservation Potential Review – 2007*, p. 109.

confirmation of communication during curtailments and collection of data on runtime[41] and temperature from the individual units.

Two-way communicating technology is commercially available and implemented in over 100,000 sites in the U.S. However, to date it has been primarily applied to central air conditioning equipment.

This measure is most applicable in buildings that have thermostat control of specific heating units (e.g., packaged rooftop units) rather than central heating systems such as those found in large buildings. In some cases, where multiple package systems are used in a single building, multiple thermostats, each controlling one package unit, could be accessed through a single data communications point or gateway and redistributed to the individual thermostats, rather than directly accessing each individual thermostat from the utility.

Experience in space heating load control is more limited than for air conditioning control. The BC Hydro study concluded that the potential peak load reductions for this measure are likely to vary widely depending on the type and size of commercial facility. Some of the particularly influential site-specific considerations include:

- Heating unit capacity (i.e., ability to restore temperature at the end of the control period)
- Facility thermal insulation levels (i.e., ability to maintain temperature during a control cycle)
- Occupancy patterns (i.e., are there periods of low occupancy that overlap with control periods such as the 4 to 8 pm period)
- Occupant comfort needs.

It was also noted that where occupants are not owners, they might not have access to the thermostats (which are often locked); this would preclude easy access to overrides if comfort is affected and would, consequently, adversely affect participation rates.

Subject to the preceding caveats, the BC Hydro study estimated that the potential peak load reduction (during the 8 am to 1 pm period on a typical BC winter peak day) would range between about 1.07 kW and 1.43 kW for a range of "typical" small (under 20,000 $ft^2$) commercial facilities such as Small Offices, Food Retail and Non-food Retail.

Large commercial facilities that have an existing building automation system (e.g., Large Offices) may offer a more attractive opportunity for this type of control option than smaller facilities. In some cases, it may be relatively easy for the utility to link into to existing building automation system and to cycle key HVAC loads such as heating equipment, fans, pumps, etc., during the control period. A typical load reduction for this type of site was not estimated. However, it was noted that this opportunity is increasingly attractive if load control is desired in the early evening winter period hours (e.g., 4 to 8 pm), which is typical in many Canadian jurisdictions. At this time of day, many large

[41] Runtime data typically represents number of minutes that the unit operates each hour for a period of time (e.g., one week) that can be stored in the unit.

buildings are at, or near, the end of their daily full occupancy period but typically have not yet reduced their HVAC loads.

Based on a one-time cost of approximately $315 (one-way communication) to $500 (two-way communication), ongoing maintenance of 5% (about $12) for one-way systems to $25 (two-way systems) per year and estimated annual impacts of 1.07 kW-1.43 kW per site, the BC Hydro study estimated that the cost would be in the range of about $45-$60 per kW/year when applied to a small commercial facility with 100% electric fuel use.

Utility infrastructure costs as well as program administration, promotion and incentive costs are in addition. Additional costs would also include maintenance of a call centre to handle participant calls, including off-hours support and referrals to "on-call" installers.

***Caveats***

Although some pilot space heat control projects have been tested in the U.S., the experience with this technology has primarily been with central air conditioning loads. Because space heating is much less discretionary, customer acceptance of this type of measure remains uncertain.

- **Utility-Based Control of Space Heating (HVAC) Equipment Using Remote Switch**[42]

Switch-based heating unit load control is similar to the preceding measure except that a remote control switch is installed on the heating unit itself or on the circuits controlling the heating unit. As with the preceding measure, utility control would occur under specific, pre-arranged, capacity-constrained conditions that typically would occur during a limited number of pre-specified hours during winter peak months. Typically, units are not shut off for the entire control period but rather "cycled" to limit their on-time to a pre-determined number of minutes per control cycle. The technology is commercially available and has been implemented in millions of sites in the U.S. (primarily for central air conditioning and water heating).

This measure primarily addresses units where temperature control is on each room unit, without a central thermostat capability. Typically, this would include baseboard units with individual controls or where one or more units are controlled from an electrical circuit.

Costs are similar to one-way thermostat control presented in the preceding discussion. The installation cost is higher for the switch because it involves a high voltage connection and thus a higher skilled installer (in many locales a licensed electrician). Installation costs are the same in both new and existing buildings.

Electric peak load reduction would be comparable to the thermostat control systems. However, without two-way access or thermostats, it would be more difficult to predict the effect on comfort and there would be a higher risk of over-control and adverse comfort impacts.

[42] Op. cit., *BC Hydro Conservation Potential Review – 2007*, p. 114.

Unlike thermostat-based systems, a control switch would not provide customers with any ancillary benefits (e.g., a programmable thermostats for comfort and energy savings and remote/Internet access to the thermostat) and thus the only incentive for participation would be monetary in nature, adding to recurring program costs.

- **Utility Control of Domestic Hot Water Heater Using Remote Switch**[43]

Switch-based water heating load control is accomplished by the installation of a remote control switch on either the water heater itself or on the circuits controlling the water heater. In older systems, this type of control has been accomplished via radio frequency (RF) control. In the systems that are currently offered, pager-based communications is used.

Costs are reduced if a communications system already exists. For example, if space heat control already exists, water heat control can be added via a hard-wired or wireless connection. This can reduce the total cost of the water heat control by up to 40%.

Depending upon the length of the control period and the size of the water heater tank, units can be shut off for the entire control period or "cycled" to limit their operating time to a predetermined number of minutes per control cycle. Water heat control technology is commercially available and implemented in hundreds of thousands of sites in the U.S.

This measure is applicable to small commercial buildings that have an electric water heater with a minimum 40-gallon capacity. The size of the tank is important because it provides hot water during times when the control is in effect. The larger the water heater tank, the longer the control can be in place without disrupting the customer's service.

Switches cost about $100 per unit, plus $150 for installation, plus maintenance. Costs are reduced to $150 (i.e., $50 incremental installation) if the control switch can be added to an existing control system at the same time, including one-way/two-way thermostats and switches for space heating. There is no savings in installation costs for a new facility.

Based on a one-time cost of approximately $250, ongoing maintenance of 5% (about $12/year) and estimated annual impacts of 0.39 kW to 0.46 kW per small commercial facility, the BC Hydro study estimated that the cost would be in the range of $75 - $88[44] per kW/year when applied to small commercial buildings with 4,000 annual kWh for electric DHW. Utility infrastructure costs as well as program administration, promotion and incentive costs are in addition.

[43] Op. cit., *BC Hydro Conservation Potential Review – 2007*, p. 120.
[44] Assumes 10-year life, 6% discount rate.

***Caveats***

This technology has a long history, going back at least 30 years on various types of equipment, including central air conditioners, water heaters and pool pumps.

Since the water heater switch uses a one-way communications-based system, it will require support analyses including the need for signal propagation studies and periodic sampling and re-estimation of reliability levels, accompanied by sufficient maintenance, to maintain an adequate level and accurate estimate of losses.

Experience in the utility industry has shown that performance is likely to erode significantly over time[45] if the system is not properly maintained.

The water heater control switch would not provide customers with any ancillary benefits and thus the only incentive for participation would be monetary in nature, likely on a per annum or per control event basis.

[45] Switch communications failures ranged from 10% to nearly 40% in utility reported data (Energy Pulse article by C. King – December 2005).

# 5. ECONOMIC POTENTIAL ELECTRICITY FORECAST

## 5.1 INTRODUCTION

This section presents the Commercial sector Economic Potential Forecast for the study period 2006 to 2026. The Economic Potential Forecast estimates the level of electricity consumption that would occur if all equipment and building envelopes were upgraded to the level that is cost effective against the long-run avoided cost of electricity in the Newfoundland and Labrador service area. In this study, "cost effective" means that the technology upgrade cost, referred to as the cost of conserved energy (CCE) in the preceding section, is equal to, or less than, the economic screen.[46]

The discussion in this section is organized according to the following subsections:

- Avoided Cost Used for Screening
- Major Modelling Tasks
- Technologies Included in Economic Potential Forecast
- Summary of Results
- CDM Measure Supply Curves.

## 5.2 AVOIDED COST USED FOR SCREENING

NLH has determined that the primary avoided costs of new electricity supply to be used for this analysis are $0.0980/kWh for the Island and Isolated service region and $0.0432/kWh for the Labrador Interconnected service region. These avoided costs represent a future in which the Lower Churchill project is not built and there is no DC link from Labrador to the Island.[47]

Therefore, the Economic Potential Forecast incorporates all the CDM measures reviewed in the preceding Section 4 that have a CCE equal to or less than the avoided costs.

NLH is currently studying the Lower Churchill/DC Link project. However, a decision on whether to proceed is not expected until 2009 and, even if the project proceeds, the earliest completion date would be in late 2014. This means that, regardless of the decision, the avoided cost values shown above will be in effect until the approximate mid point of the study period. If the Lower Churchill/DC Link project does proceed, the avoided costs presented above are expected to change. To provide insight into the potential impacts of the Lower Churchill/DC Link project on this study, it was agreed that the consultants would provide a high-level sensitivity analysis.

[46] Costs related to program design and implementation are not yet included.

[47] The avoided costs draw on the results of the earlier study conducted by NERA Economic Consulting, which is entitled: Newfoundland and Labrador Hydro. *Marginal Costs of Generation and Transmission*. May 2006. The avoided costs used in this study include generation, transmission and distribution.

## 5.3 MAJOR MODELLING TASKS

By comparing the results of the Commercial sector Economic Potential Electricity Forecast with the Reference Case, it is possible to determine the aggregate level of potential electricity savings within the Commercial sector, as well as identify which specific building types and end uses provide the most significant opportunities for savings.

To develop the Commercial sector Economic Potential Forecast, the following tasks were completed:

- The CCE for each of the energy-efficient upgrades presented in Exhibit 4.2 were reviewed, using the 6% (real) discount rate.[48]

- Technology upgrades that had a CCE equal to, or less than, the avoided cost threshold were selected for inclusion in the economic potential scenario, either on a "full cost" or "incremental" basis. It is assumed that technical upgrades having a "full cost" CCE that met the cost threshold were implemented in the first milestone year. It is assumed that those upgrades that only met the cost threshold on an "incremental" basis are being introduced more slowly as the existing stock reaches the end of its useful life.

- Electricity use within each of the building types was modelled with the same energy models that were used to generate the Reference Case. However, for this forecast, the remaining "baseline" technologies included in the Reference Case forecast were replaced with the most efficient "technology upgrade option" and associated performance efficiency that met the cost threshold of $0.0980/kWh for the Island and Isolated service region and $0.0432/kWh for the Labrador Interconnected service region.

- When more than one upgrade option was applied to a given end use, upgrades were applied in sequence. The general approach was to first reduce total end-use load, then to meet the remaining load with the most efficient technology that passed the economic screen. For example, measures to reduce the overall space heating load (e.g., envelope insulation) were applied before efficient heating plant measures (e.g., ground source heat pump).

- A sensitivity analysis was conducted using preliminary avoided cost values that assume development of the Lower Churchill/DC Link.

## 5.4 TECHNOLOGIES INCLUDED IN ECONOMIC POTENTIAL FORECAST

Exhibits 5.1 and 5.2 provide a list of the technologies selected for inclusion in this forecast for, respectively, the Island and Isolated and Labrador Interconnected service regions. In each case, the exhibits show the following:

- End use affected
- Upgrade option(s) selected

[48] See Section 4.2.

- Building types to which the upgrade options were applied
- Rate at which the upgrade options were introduced into the stock.

### Exhibit 5.1: Technologies Included in Economic Potential Forecast for the Island and Isolated Service Region

| Category | Upgrade Technology/Measures | Applicability of Upgrade Options by Building Type | Vintage | Rate of Stock Introduction |
|---|---|---|---|---|
| Lighting | T12 baseline: Redesign with high-performance T8s | All | Existing | Immediate |
| | T8 baseline: Redesign with high-performance T8s | All | Existing | Immediate |
| | Occupancy sensors | All | Existing | Immediate |
| | Compact fluorescent lamps | All | Existing | Immediate |
| | Pulse-start metal halide | All | Existing | Rate of turnover |
| | High-intensity fluorescent | Retail, warehouse, school | Existing | Immediate |
| HVAC | Ground source heat pump | All | Existing | Rate of turnover |
| | High-efficiency chillers | Large commercial/institutional | Existing | Rate of turnover |
| | Adjustable speed drives | All | Existing | Immediate |
| | Premium efficiency motors | All | Existing | Rate of turnover |
| | Advanced BAS/Building recommissioning | All | Existing | Immediate |
| Refrigeration | ENERGY STAR Refrigerators and Freezers | All | Existing | Rate of turnover |
| | High-efficiency supermarket refrigeration | Food retail | Existing | Rate of turnover |
| DHW | Low-flow aerators & shower heads | All | Existing | Immediate |
| Computer Equipment | ENERGY STAR computers | All | Existing | Rate of turnover |
| | ENERGY STAR office equipment | All | Existing | Rate of turnover |
| | High-efficiency servers | All | Existing | Rate of turnover |
| Building Envelope | High-performance glazings | All | Existing | Rate of turnover |
| | Wall insulation | All | Existing | Rate of turnover |
| | Roof insulation | All | Existing | Rate of turnover |
| | Air curtains | Retail,warehouse | Existing | Immediate |
| New Construction | New buildings - 40% more efficient | All | New | Rate of construction |
| Streetlighting | Dimming controls | Streetlighting | Existing & New | Immediate |

### Exhibit 5.2: Technologies Included in Economic Potential Forecast for the Labrador Interconnected Service Region

| Category | Upgrade Technology/Measures | Applicability of Upgrade Options by Building Type | Vintage | Rate of Stock Introduction |
|---|---|---|---|---|
| Lighting | T12 baseline: Redesign with high-performance T8s | All | Existing | Rate of turnover |
| | T8 baseline: Redesign with high-performance T8s | All | Existing | Rate of turnover |
| | Compact fluorescent lamps | All | Existing | Immediate |
| | High-intensity fluorescent | Retail, warehouse, school | Existing | Rate of turnover |
| HVAC | Premium efficiency motors | All | Existing | Rate of turnover |
| | Advanced BAS/Building recommissioning | All | Existing | Immediate |
| DHW | Low-flow aerators & shower heads | All | Existing | Immediate |
| Computer Equipment | ENERGY STAR computers | All | Existing | Rate of turnover |
| | ENERGY STAR office equipment | All | Existing | Rate of turnover |
| | High-efficiency servers | All | Existing | Rate of turnover |
| Building Envelope | High-performance glazings | All | Existing | Rate of turnover |
| | Air curtains | Retail,warehouse | Existing | Immediate |
| New Construction | New buildings - 40% more efficient | All | New | Rate of construction |

*Note: Individually, advanced BAS fails the economic screen for the Labrador Interconnected service region, while building recommissioning passes. The combined measure, advanced BAS/building recommissioning has a CCE below the Labrador threshold of $0.0432 and is, therefore, included in the Economic Potential Forecast.*

## 5.5 SUMMARY OF RESULTS[49]

This section compares the Reference Case and Economic Potential Electricity Forecast levels of commercial electricity consumption for the two service regions. In each case, the results are presented as electricity savings that would occur at the customer's point-of-use. The results are presented in the following exhibits:

- Exhibit 5.3 shows the electricity savings for the Island and Isolated service region over the study period. As illustrated, under the Reference Case commercial electricity use would grow from the Base Year level of 1,881 GWh/yr. to approximately 2,233 GWh/yr. by 2026. This contrasts with the Economic Potential Forecast in which electricity use would increase to approximately 1,541 GWh/yr. by 2026, approximately 692 GWh/yr. (31%) below the Reference Case consumption.

- Exhibit 5.4 shows the electricity savings for the Labrador Interconnected service region over the study period. As illustrated, under the Reference Case commercial electricity use would grow from the Base Year level of 201 GWh/yr. to approximately 240 GWh/yr. by 2026. This contrasts with the Economic Potential Forecast in which electricity use would increase to approximately 197 GWh/yr. for the same period, approximately 43 GWh/yr. (18%) below the Reference Case consumption.

- Exhibits 5.5 and 5.6 present the results by end use, building type and milestone year for, respectively, the Island and Isolated and Labrador Interconnected service regions.

- Exhibits 5.7 and 5.8 show the 2026 savings by major end use and building type for, respectively, the Island and Isolated and Labrador Interconnected service regions.

- Exhibits 5.9 and 5.10 show 2026 savings by major end use and vintage for, respectively, the Island and Isolated and Labrador Interconnected service regions.

[49] All results are reported at the customer's point-of-use and do not include line losses.

**Exhibit 5.3: Reference Case versus Economic Potential Electricity Consumption in Commercial Sector, (GWh/yr.) for the Island and Isolated Service Region**

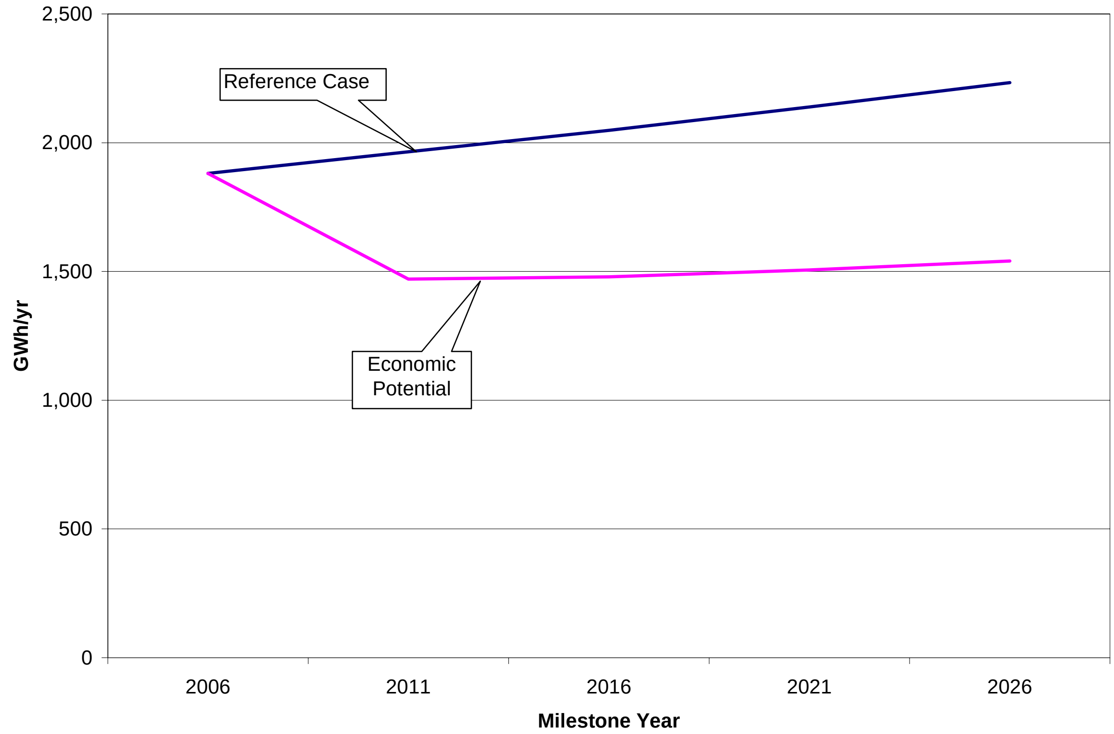



**Exhibit 5.4: Reference Case versus Economic Potential Electricity Consumption in Commercial Sector, (GWh/yr.) for the Labrador Interconnected Service Region**

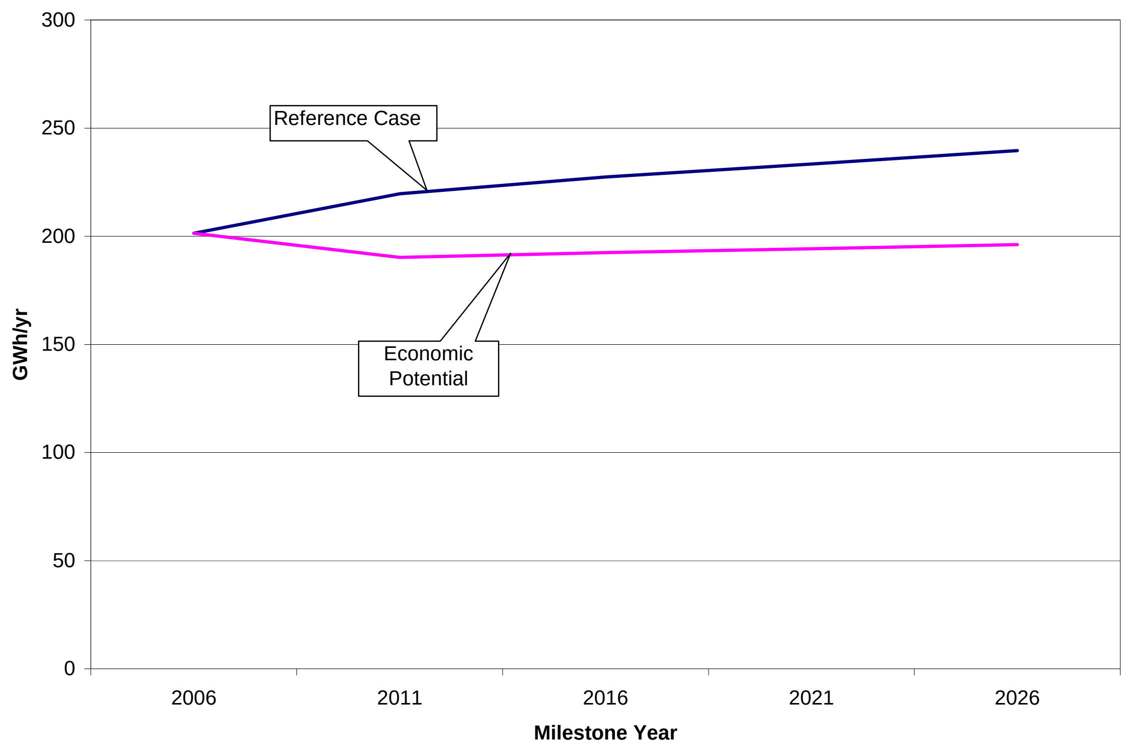


**Exhibit 5.5: Total Potential Electricity Savings by End Use, Building Type and Milestone Year for the Island and Isolated Service Region (GWh/yr.)**

| Building Type | Milestone Year | Total | General Lighting | Secondary Lighting | Outdoor Lighting | Computer Equipment | Other Plug Loads | Food Service Equipment | Refrigeration | Elevators | Miscellaneous | Space Heating | Space Cooling | HVAC Fans and Pumps | Domestic Hot Water | Street Lighting |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Office | 2011 | 122.9 | 40.6 | 11.0 | 0.7 | 21.9 | 0.0 | 0.0 | 0.2 | 0.0 | 0.1 | 14.2 | 5.0 | 26.7 | 2.7 | |
| | 2016 | 146.4 | 41.1 | 11.1 | 1.0 | 23.7 | 0.0 | 0.0 | 0.3 | 0.0 | 0.1 | 32.8 | 5.6 | 27.7 | 2.9 | |
| | 2021 | 169.0 | 41.8 | 11.3 | 1.3 | 25.8 | 0.0 | 0.0 | 0.4 | 0.0 | 0.2 | 49.7 | 6.3 | 28.9 | 3.2 | |
| | 2026 | 190.1 | 42.5 | 11.5 | 1.7 | 28.1 | 0.0 | 0.1 | 0.4 | 0.0 | 0.3 | 64.9 | 6.9 | 30.2 | 3.5 | |
| Non-food Retail | 2011 | 48.1 | 27.5 | 2.7 | 0.5 | 2.0 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 3.9 | 3.3 | 7.3 | 0.7 | |
| | 2016 | 53.8 | 27.6 | 2.7 | 0.7 | 2.2 | 0.0 | 0.0 | 0.3 | 0.0 | 0.0 | 8.3 | 3.5 | 7.6 | 0.8 | |
| | 2021 | 59.2 | 27.9 | 2.8 | 0.9 | 2.4 | 0.0 | 0.0 | 0.3 | 0.0 | 0.0 | 12.3 | 3.6 | 8.0 | 0.8 | |
| | 2026 | 64.2 | 28.2 | 2.9 | 1.1 | 2.6 | 0.0 | 0.0 | 0.3 | 0.0 | 0.0 | 15.9 | 3.8 | 8.5 | 0.9 | |
| Food Retail | 2011 | 26.9 | 10.0 | 1.1 | 0.2 | 1.1 | 0.0 | 0.0 | 10.3 | 0.0 | 0.0 | 0.0 | 0.6 | 2.8 | 0.8 | |
| | 2016 | 40.1 | 10.1 | 1.2 | 0.4 | 1.1 | 0.0 | 0.1 | 20.6 | 0.0 | 0.0 | 2.1 | 0.6 | 3.0 | 0.9 | |
| | 2021 | 44.3 | 10.4 | 1.2 | 0.5 | 1.2 | 0.1 | 0.1 | 22.0 | 0.0 | 0.0 | 3.9 | 0.7 | 3.2 | 1.0 | |
| | 2026 | 48.3 | 10.6 | 1.3 | 0.6 | 1.4 | 0.1 | 0.1 | 23.5 | 0.0 | 0.0 | 5.4 | 0.8 | 3.4 | 1.1 | |
| Healthcare | 2011 | 28.4 | 2.1 | 9.0 | 0.5 | 2.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 5.4 | 0.6 | 7.0 | 1.5 | |
| | 2016 | 31.0 | 2.1 | 8.9 | 0.6 | 2.5 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 7.3 | 0.8 | 7.2 | 1.6 | |
| | 2021 | 33.7 | 2.0 | 8.8 | 0.7 | 2.6 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 9.2 | 1.0 | 7.4 | 1.7 | |
| | 2026 | 36.5 | 2.0 | 8.7 | 0.8 | 2.7 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 11.3 | 1.2 | 7.6 | 1.9 | |
| Schools | 2011 | 30.1 | 8.9 | 1.5 | 0.5 | 4.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 11.2 | 0.0 | 2.5 | 1.4 | |
| | 2016 | 39.3 | 9.4 | 2.6 | 0.7 | 4.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 18.0 | 0.0 | 2.7 | 1.5 | |
| | 2021 | 48.6 | 9.9 | 3.7 | 0.9 | 4.7 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 24.7 | 0.0 | 2.9 | 1.7 | |
| | 2026 | 57.5 | 10.5 | 4.7 | 1.1 | 5.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 31.0 | 0.0 | 3.0 | 1.8 | |
| Accomodations | 2011 | 33.9 | 8.4 | 10.3 | 0.2 | 1.5 | 0.0 | 0.0 | 0.5 | 0.0 | 0.0 | -0.2 | 0.7 | 2.9 | 9.6 | |
| | 2016 | 41.5 | 8.4 | 10.4 | 0.3 | 1.6 | 0.0 | 0.1 | 1.0 | 0.0 | 0.0 | 5.5 | 0.8 | 3.1 | 10.4 | |
| | 2021 | 48.5 | 8.4 | 10.5 | 0.4 | 1.7 | 0.0 | 0.1 | 1.0 | 0.0 | 0.0 | 10.8 | 1.0 | 3.3 | 11.4 | |
| | 2026 | 55.3 | 8.5 | 10.6 | 0.5 | 1.9 | 0.0 | 0.1 | 1.0 | 0.0 | 0.1 | 15.6 | 1.1 | 3.5 | 12.4 | |
| University/College | 2011 | 34.7 | 11.2 | 2.8 | 0.2 | 6.1 | 0.0 | 0.0 | 0.5 | 0.0 | 0.0 | 0.4 | 0.3 | 12.4 | 0.9 | |
| | 2016 | 36.9 | 11.1 | 2.7 | 0.4 | 6.4 | 0.0 | 0.0 | 1.0 | 0.0 | 0.0 | 1.6 | 0.4 | 12.4 | 0.9 | |
| | 2021 | 38.7 | 10.9 | 2.7 | 0.5 | 6.7 | 0.0 | 0.0 | 1.0 | 0.0 | 0.0 | 3.0 | 0.5 | 12.5 | 0.9 | |
| | 2026 | 40.6 | 10.8 | 2.6 | 0.6 | 7.0 | 0.0 | 0.0 | 1.0 | 0.0 | 0.0 | 4.4 | 0.6 | 12.6 | 1.0 | |
| Warehouse/Wholesale | 2011 | 13.6 | 8.4 | 1.1 | 0.2 | 1.1 | 0.0 | 0.0 | 0.8 | 0.0 | 0.0 | -0.1 | 0.1 | 1.5 | 0.5 | |
| | 2016 | 17.2 | 8.5 | 1.1 | 0.3 | 1.2 | 0.0 | 0.0 | 1.6 | 0.0 | 0.0 | 2.3 | 0.1 | 1.5 | 0.6 | |
| | 2021 | 20.0 | 8.7 | 1.1 | 0.4 | 1.2 | 0.0 | 0.0 | 1.6 | 0.0 | 0.0 | 4.6 | 0.1 | 1.6 | 0.6 | |
| | 2026 | 22.7 | 8.9 | 1.1 | 0.5 | 1.3 | 0.0 | 0.0 | 1.7 | 0.0 | 0.0 | 6.8 | 0.1 | 1.6 | 0.7 | |
| Small Commercial | 2011 | 120.1 | | | | | | | | | | | | | | |
| | 2016 | 126.6 | | | | | | | | | | | | | | |
| | 2021 | 133.3 | | | | | | | | | | | | | | |
| | 2026 | 139.2 | | | | | | | | | | | | | | |
| Other Buildings | 2011 | 21.4 | | | | | | | | | | | | | | |
| | 2016 | 22.2 | | | | | | | | | | | | | | |
| | 2021 | 22.9 | | | | | | | | | | | | | | |
| | 2026 | 23.8 | | | | | | | | | | | | | | |
| Non Buildings | 2011 | 0.0 | | | | | | | | | | | | | | |
| | 2016 | 0.0 | | | | | | | | | | | | | | |
| | 2021 | 0.0 | | | | | | | | | | | | | | |
| | 2026 | 0.0 | | | | | | | | | | | | | | |
| Isolated Buildings | 2011 | 1.9 | | | | | | | | | | | | | | |
| | 2016 | 2.2 | | | | | | | | | | | | | | |
| | 2021 | 2.4 | | | | | | | | | | | | | | |
| | 2026 | 2.5 | | | | | | | | | | | | | | |
| Streetlighting | 2011 | 11.8 | | | | | | | | | | | | | | 11.8 |
| | 2016 | 11.8 | | | | | | | | | | | | | | 11.8 |
| | 2021 | 11.8 | | | | | | | | | | | | | | 11.8 |
| | 2026 | 11.9 | | | | | | | | | | | | | | 11.9 |
| Total | 2011 | 493.9 | 117.0 | 39.4 | 3.0 | 40.0 | 0.0 | 0.1 | 12.4 | 0.0 | 0.1 | 34.7 | 10.6 | 63.1 | 18.2 | 11.8 |
| | 2016 | 569.0 | 118.3 | 40.7 | 4.2 | 43.0 | 0.0 | 0.3 | 24.7 | 0.0 | 0.2 | 77.9 | 11.8 | 65.3 | 19.6 | 11.8 |
| | 2021 | 632.4 | 120.1 | 42.1 | 5.5 | 46.5 | 0.1 | 0.4 | 26.3 | 0.0 | 0.4 | 118.2 | 13.2 | 67.8 | 21.4 | 11.8 |
| | 2026 | 692.5 | 121.9 | 43.4 | 6.9 | 50.1 | 0.1 | 0.6 | 28.0 | 0.0 | 0.5 | 155.2 | 14.7 | 70.5 | 23.2 | 11.9 |

*Notes: 1) Savings are at customer's point-of-use. 2) Any differences in totals are due to rounding.*

# Exhibit 5.6: Total Potential Electricity Savings by End Use, Building Type and Milestone Year for the Labrador Interconnected Service Region (GWh/yr.)

| Building Type | Milestone Year | Total | General Lighting | Secondary Lighting | Outdoor Lighting | Computer Equipment | Other Plug Loads | Food Service Equipment | Refrigeration | Elevators | Miscellaneous | Space Heating | Space Cooling | HVAC Fans and Pumps | Domestic Hot Water | Street Lighting |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Office | 2011 | 1.2 | 0.2 | 0.0 | 0.0 | 0.6 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.3 | 0.1 | |
| | 2016 | 1.9 | 0.3 | 0.0 | 0.0 | 0.7 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.4 | 0.0 | 0.3 | 0.1 | |
| | 2021 | 2.6 | 0.5 | 0.0 | 0.0 | 0.7 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.9 | 0.1 | 0.3 | 0.1 | |
| | 2026 | 3.3 | 0.6 | 0.0 | 0.0 | 0.8 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.4 | 0.1 | 0.3 | 0.1 | |
| Non-food Retail | 2011 | 6.4 | 4.3 | 0.1 | 0.1 | 0.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | 0.2 | 0.7 | 0.2 | |
| | 2016 | 7.6 | 4.7 | 0.1 | 0.2 | 0.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.8 | 0.3 | 0.8 | 0.2 | |
| | 2021 | 8.8 | 5.0 | 0.1 | 0.2 | 0.6 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.5 | 0.3 | 0.9 | 0.2 | |
| | 2026 | 10.0 | 5.4 | 0.1 | 0.2 | 0.6 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 2.1 | 0.4 | 0.9 | 0.2 | |
| Food Retail | 2011 | 1.5 | 0.4 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.2 | 0.0 | 0.0 | 0.5 | 0.0 | 0.1 | 0.1 | |
| | 2016 | 1.9 | 0.5 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.3 | 0.0 | 0.0 | 0.6 | 0.0 | 0.1 | 0.1 | |
| | 2021 | 2.2 | 0.6 | 0.1 | 0.0 | 0.1 | 0.0 | 0.0 | 0.4 | 0.0 | 0.0 | 0.6 | 0.0 | 0.2 | 0.1 | |
| | 2026 | 2.5 | 0.8 | 0.1 | 0.1 | 0.1 | 0.0 | 0.0 | 0.5 | 0.0 | 0.0 | 0.6 | 0.0 | 0.2 | 0.1 | |
| Healthcare | 2011 | 3.3 | 0.2 | 0.9 | 0.1 | 0.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | 0.0 | 0.5 | 0.9 | |
| | 2016 | 4.2 | 0.2 | 1.1 | 0.1 | 0.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.6 | 0.1 | 0.6 | 0.9 | |
| | 2021 | 4.7 | 0.3 | 1.2 | 0.1 | 0.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.9 | 0.1 | 0.6 | 0.9 | |
| | 2026 | 5.1 | 0.3 | 1.3 | 0.2 | 0.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.2 | 0.1 | 0.6 | 0.9 | |
| Schools | 2011 | 1.3 | 0.2 | 0.1 | 0.0 | 0.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.3 | 0.0 | 0.3 | 0.1 | |
| | 2016 | 1.8 | 0.4 | 0.1 | 0.0 | 0.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.5 | 0.0 | 0.3 | 0.1 | |
| | 2021 | 2.1 | 0.5 | 0.1 | 0.1 | 0.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.6 | 0.0 | 0.3 | 0.1 | |
| | 2026 | 2.3 | 0.6 | 0.2 | 0.1 | 0.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.7 | 0.0 | 0.3 | 0.1 | |
| Accomodations | 2011 | 1.0 | 0.3 | 0.3 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | -0.1 | 0.0 | 0.1 | 0.4 | |
| | 2016 | 1.3 | 0.3 | 0.3 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 | 0.1 | 0.4 | |
| | 2021 | 1.5 | 0.3 | 0.3 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.3 | 0.0 | 0.1 | 0.5 | |
| | 2026 | 1.8 | 0.3 | 0.3 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.5 | 0.0 | 0.1 | 0.5 | |
| University/College | 2011 | 0.7 | 0.1 | 0.0 | 0.0 | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | -0.1 | 0.0 | 0.3 | 0.1 | |
| | 2016 | 1.1 | 0.2 | 0.0 | 0.0 | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 | 0.3 | 0.1 | |
| | 2021 | 1.3 | 0.3 | 0.0 | 0.0 | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.3 | 0.0 | 0.3 | 0.1 | |
| | 2026 | 1.5 | 0.3 | 0.0 | 0.0 | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.4 | 0.0 | 0.3 | 0.1 | |
| Warehouse/Wholesale | 2011 | 0.8 | 0.3 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | -0.1 | 0.0 | 0.2 | 0.1 | |
| | 2016 | 1.2 | 0.6 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | 0.1 | |
| | 2021 | 1.6 | 0.9 | 0.0 | 0.1 | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 | 0.2 | 0.1 | |
| | 2026 | 2.0 | 1.1 | 0.1 | 0.1 | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | 0.0 | 0.2 | 0.1 | |
| Small Commercial | 2011 | 5.3 | | | | | | | | | | | | | | |
| | 2016 | 5.9 | | | | | | | | | | | | | | |
| | 2021 | 6.2 | | | | | | | | | | | | | | |
| | 2026 | 6.5 | | | | | | | | | | | | | | |
| Other Buildings | 2011 | 2.2 | | | | | | | | | | | | | | |
| | 2016 | 2.3 | | | | | | | | | | | | | | |
| | 2021 | 2.4 | | | | | | | | | | | | | | |
| | 2026 | 2.5 | | | | | | | | | | | | | | |
| Non Buildings | 2011 | 0.0 | | | | | | | | | | | | | | |
| | 2016 | 0.0 | | | | | | | | | | | | | | |
| | 2021 | 0.0 | | | | | | | | | | | | | | |
| | 2026 | 0.0 | | | | | | | | | | | | | | |
| Other Institutional | 2011 | 5.7 | | | | | | | | | | | | | | |
| | 2016 | 5.7 | | | | | | | | | | | | | | |
| | 2021 | 5.8 | | | | | | | | | | | | | | |
| | 2026 | 5.8 | | | | | | | | | | | | | | |
| Streetlighting | 2011 | 0.0 | | | | | | | | | | | | | | 0.0 |
| | 2016 | 0.0 | | | | | | | | | | | | | | 0.0 |
| | 2021 | 0.0 | | | | | | | | | | | | | | 0.0 |
| | 2026 | 0.0 | | | | | | | | | | | | | | 0.0 |
| Total | 2011 | 29.4 | 6.0 | 1.4 | 0.4 | 2.4 | 0.0 | 0.1 | 0.3 | 0.0 | 0.0 | 1.0 | 0.4 | 2.5 | 1.9 | 0.0 |
| | 2016 | 34.9 | 7.3 | 1.7 | 0.5 | 2.6 | 0.0 | 0.1 | 0.4 | 0.0 | 0.0 | 3.2 | 0.4 | 2.7 | 2.0 | 0.0 |
| | 2021 | 39.2 | 8.3 | 1.9 | 0.6 | 2.7 | 0.0 | 0.1 | 0.5 | 0.0 | 0.0 | 5.2 | 0.5 | 2.9 | 2.1 | 0.0 |
| | 2026 | 43.4 | 9.3 | 2.1 | 0.7 | 2.9 | 0.0 | 0.1 | 0.6 | 0.0 | 0.0 | 7.2 | 0.6 | 3.0 | 2.1 | 0.0 |

*Notes: 1) Savings are at customer's point-of-use. 2) Any differences in totals are due to rounding.*

**Exhibit 5.7: Savings by Major End Use and Building Type for the Island and Isolated Service Region, 2026**

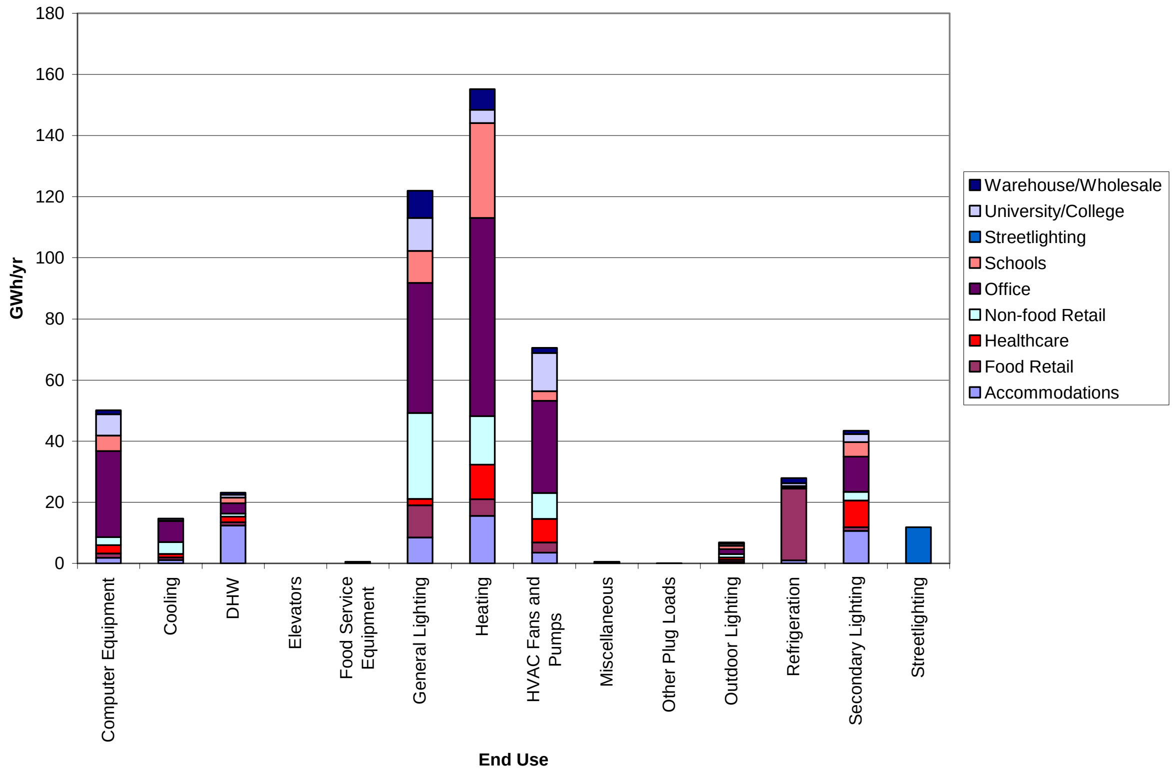



**Exhibit 5.8: Savings by Major End Use and Building Type for the Labrador Interconnected Service Region, 2026**

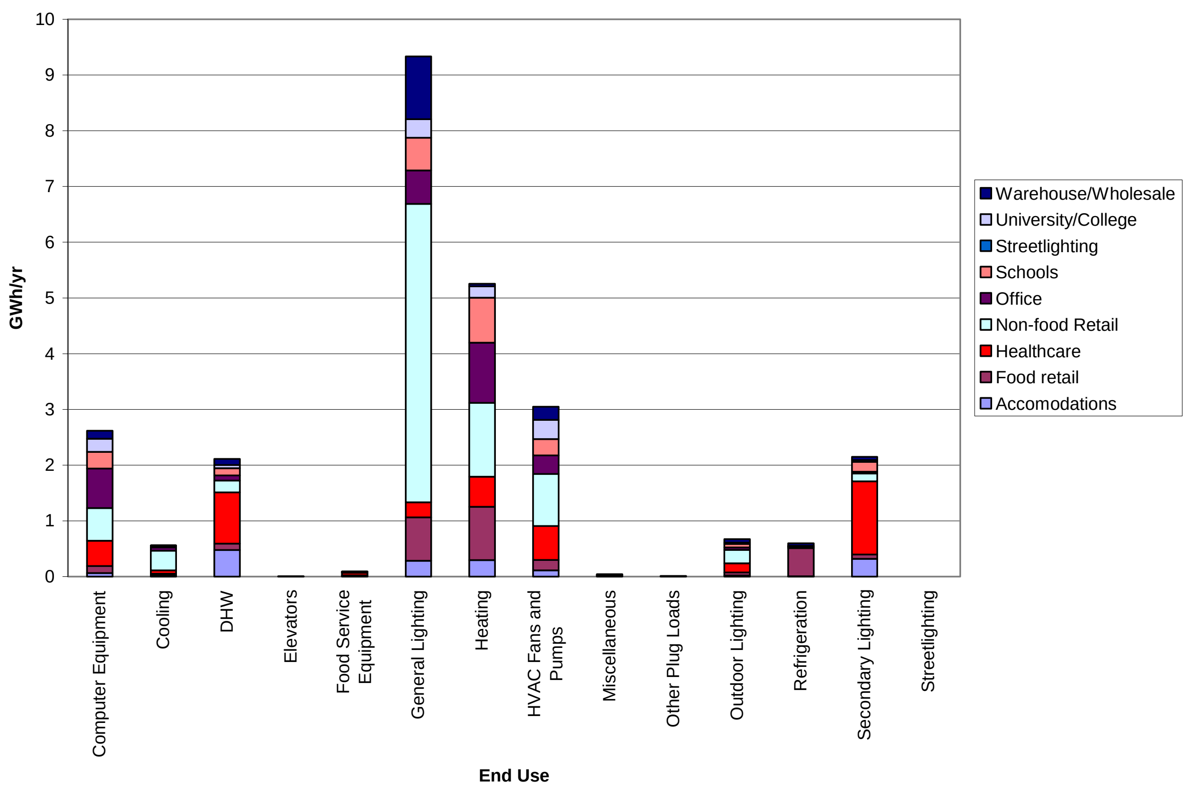


**Exhibit 5.9: Savings by Major End Use and Vintage for the Island and Isolated Service Region, 2026**

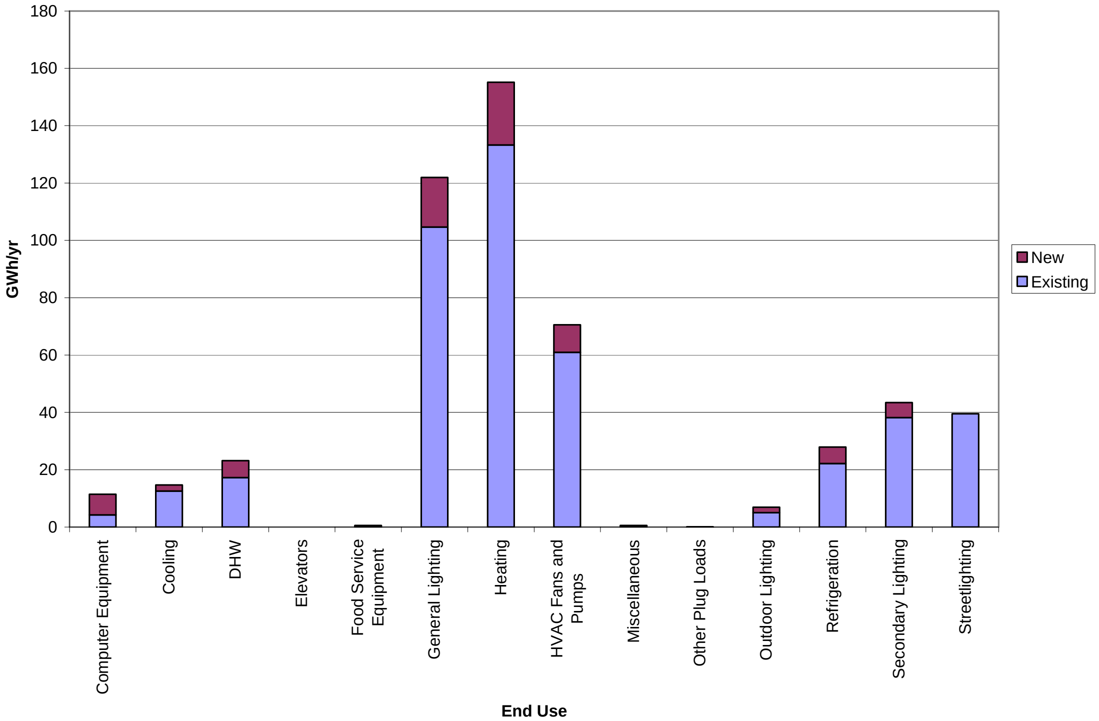
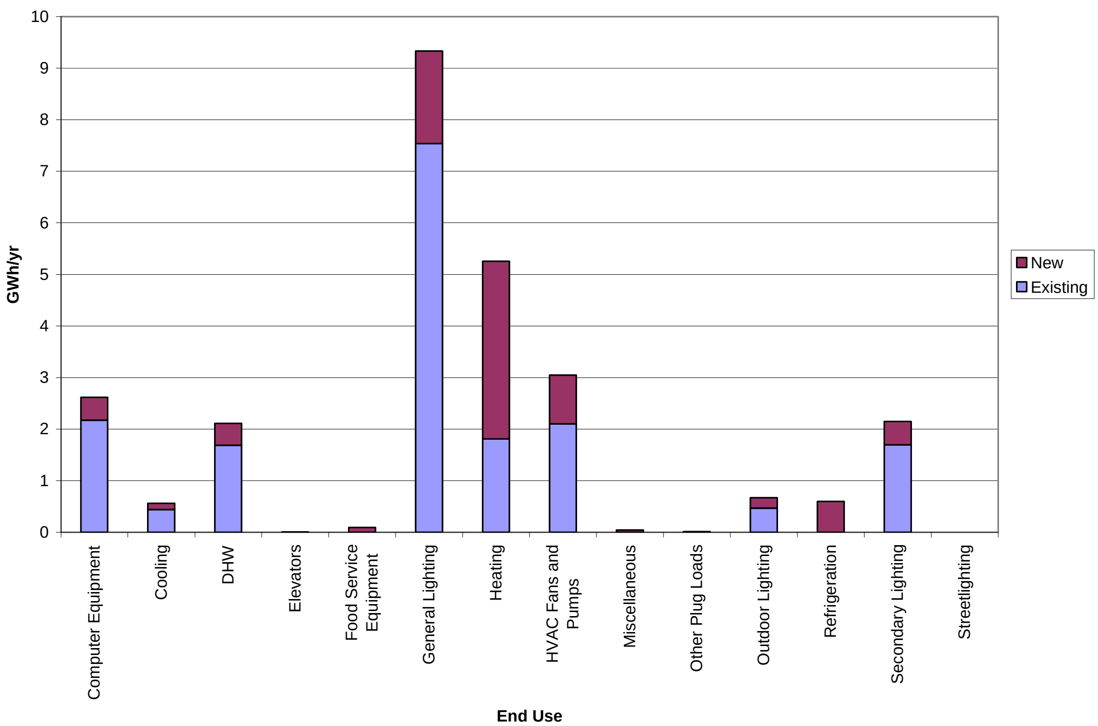



**Exhibit 5.10: Savings by Major End Use and Vintage for the Labrador Interconnected Service Region, 2026**



### 5.5.1 Interpretation of Results

Highlights:

- **Electricity Savings by Service Region**

The Island and Isolated service region has the largest economic potential savings at approximately 94% of the total, followed by the Labrador Interconnected service region at 6% in 2026.

- **Electricity Savings by Sub Sector**

In the Island and Isolated service region, the Office sub sector has the largest economic potential at approximately 27% of the total in 2026, followed by Small Commercial at 20%, Non-food Retail at 9% and Schools and Accommodations at 8%.

In the Labrador Interconnected service region, the Non-food Retail sub sector has the largest economic potential at 22% of the total in 2026, followed by Small Commercial at 16%, Other Institutional at 14% and Healthcare at 11%.

- **Electricity Savings by End Use**

In the Island and Isolated service region, the space heating end use has the largest economic potential at approximately 29% of the total in 2026, followed by general lighting at 23%, HVAC fans and pumps at 12% and computer equipment at 10%.

In the Labrador Interconnected service region, the general lighting end use has the largest economic potential at approximately 35% of the total in 2026, followed by space heating at 20%, HVAC fans and pumps at 13% and computer equipment at 10%.

*Note 1: In some cases, the space heating savings are negative due to a reduction in internal heat gains associated with lighting, computer equipment and HVAC efficiency measures.*

*Note 2: As shown in Exhibit 5.10, in the Labrador Interconnected service region, space heating savings in existing buildings represent a small proportion of the total space heating savings. This is due to the fact that few space heating measures for existing buildings pass the economic screen.*

### 5.5.2 Caveats

A systems approach was used to model the energy impacts of the CDM measures presented in the preceding section. In the absence of a systems approach, there would be double counting of savings and an accurate assessment of the total contribution of the energy-efficient upgrades would not be possible. More specifically, there are two particularly important considerations:

- **More than one upgrade may affect a given end use**. For example, improved insulation reduces space heating electricity use, as does the installation of a heat pump. On their own, each measure will reduce overall space heating electricity use. However, the two savings are not additive. The order in which some upgrades are introduced is also important. In this study, the approach has been to select and model the impact of “bundles of measures” that reduce the load for a given end use (e.g., wall insulation and window upgrades that reduce the space heating load) and then to introduce measures that meet the remaining load more efficiently (e.g., a high-efficiency space heating system).

- **There are interactive effects among end uses**. For example, the electricity savings from more efficient lighting results in reduced heat generation. During the space heating season, internal heat gains lower the amount of heat that must be provided by the space heating system and, conversely, increase the amount of heat that must be removed by the space cooling system. For instance, in a typical commercial building, a measure with a 25% reduction in lighting energy would result in a 2% to 4% increase in space heating energy. Interactive effects have been analyzed using CEEAM for each measure and are included in the Economic and Achievable Forecasts.

### 5.5.3 Sensitivity Analysis – Alternative Avoided Costs

A sensitivity analysis was conducted using preliminary avoided cost values that assume development of the Lower Churchill/DC link. The analysis reviewed the scope of measures that would pass or fail the economic screen under the changed avoided costs. Based on the preliminary avoided cost values assessed, the analysis concluded that any impacts would be modest.

## 5.6 CDM MEASURE SUPPLY CURVES

A supply curve was constructed for each of the service regions based on the economic potential savings associated with the above measures. The following approach was followed:

- Measures are introduced in sequence to see incremental impact and cost
- Sequence is determined by principle of 1) reduce load, then 2) meeting residual load with most efficient technology
- Is organized by CCE levels.

Exhibits 5.11 and 5.12 show the supply curves for, respectively, the Island and Isolated and the Labrador Interconnected service regions. Exhibits 5.13 and 5.14 show the measures included in each of the supply curves.

*Note: The average CCE is the weighted average of all sub sector CCEs for a particular measure. It is calculated by adding measure costs for all sub sectors and dividing the result by total electricity saving, inclusive of interactive effects across all sub sectors. The following exhibits may include measures with a CCE that exceeds the study's avoided cost threshold. This increased CCE is due to the impact of interactive effects. The measures shown maintain consistency with previous exhibits.*

**Exhibit 5.11: Supply Curve for Commercial Sector, Island and Isolated Service Region, 2026**

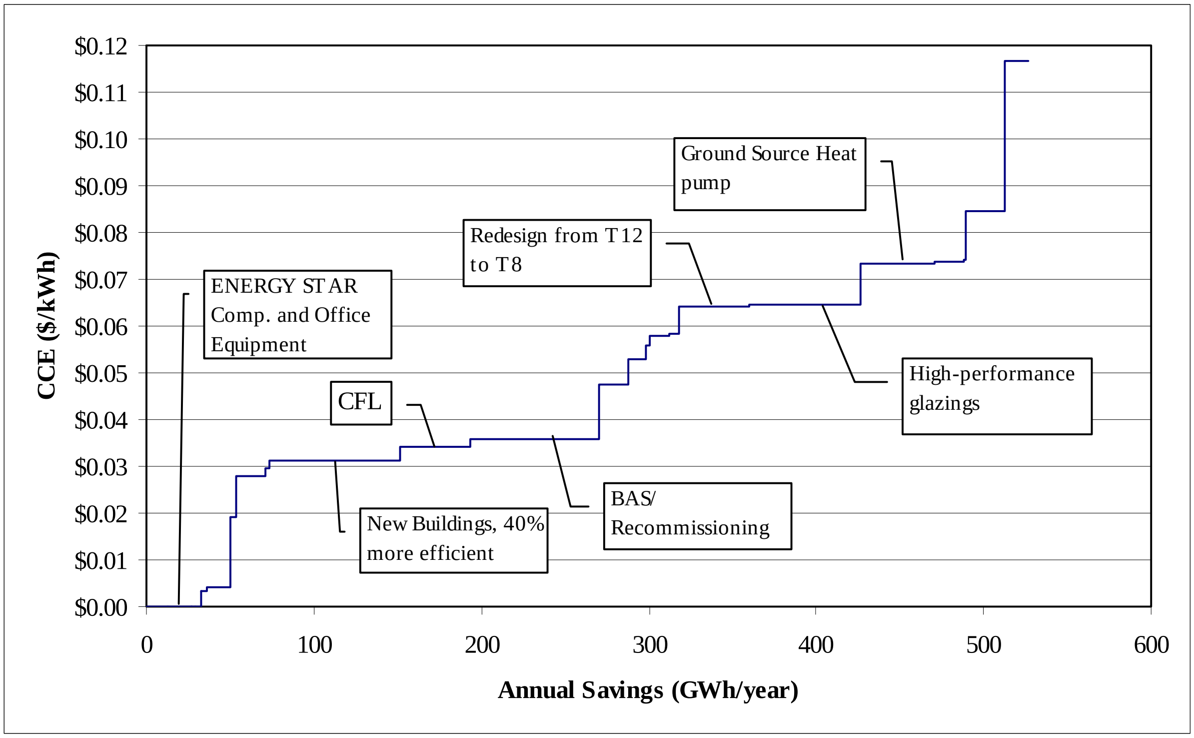
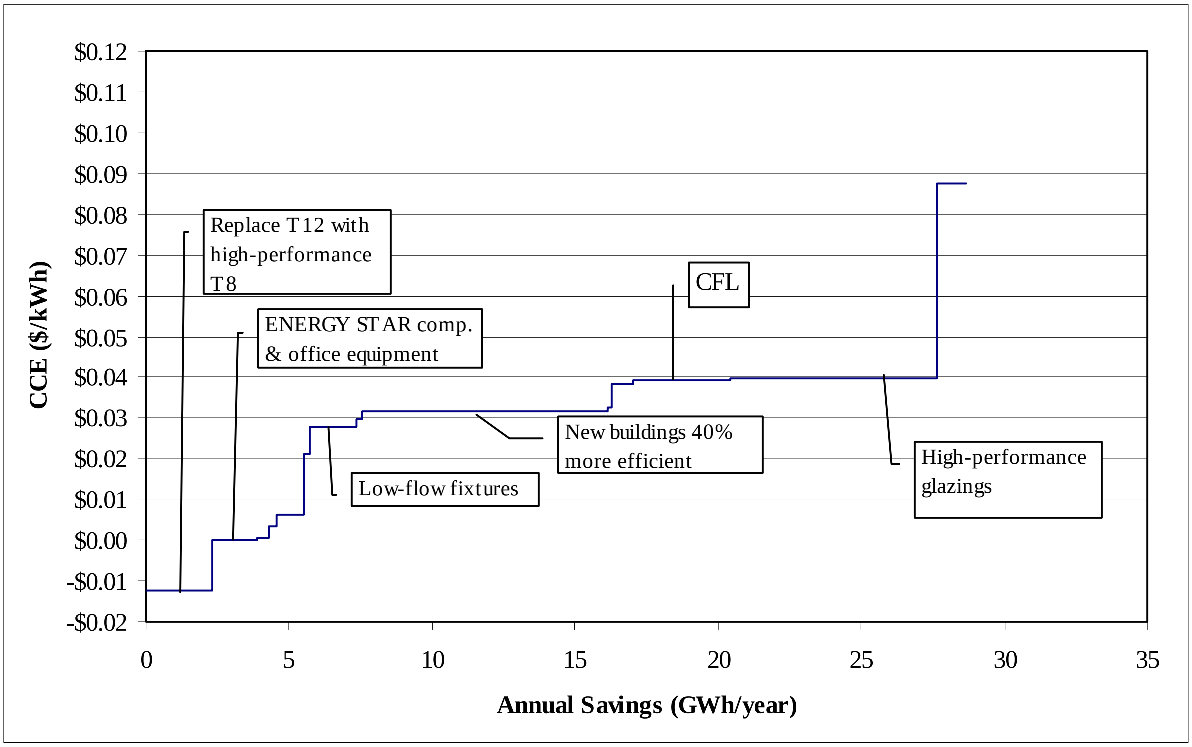


**Exhibit 5.12: Supply Curve for Commercial Sector, Labrador Interconnected Service Region, 2026**



## Exhibit 5.13: Summary of Commercial Sector Energy-efficiency Measures, Island and Isolated Service Region 2026

| Measure | Average* CCE ($/kWh) | Annual Savings (GWh/yr) |
|---|---|---|
| ENERGY STAR computers | $0.000 | 26 |
| ENERGY STAR office equipment | $0.000 | 6 |
| Pulse-start metal halide | $0.003 | 3 |
| High-intensity fluorescent | $0.004 | 15 |
| High-efficiency servers | $0.019 | 4 |
| Low-flow aerators & shower heads | $0.028 | 17 |
| Compact fluorescent lamps (Outdoor) | $0.029 | 2 |
| New buildings - 40% more efficient | $0.031 | 78 |
| Compact fluorescent lamps | $0.034 | 42 |
| Advanced BAS/Recommissioning | $0.036 | 76 |
| HE supermarket refrigeration | $0.047 | 18 |
| Occupancy sensors | $0.053 | 10 |
| Adjustable speed drives | $0.056 | 2 |
| Dimming controls | $0.058 | 12 |
| Air curtains | $0.058 | 6 |
| T12 Baseline - Redesign with high-performance T8s | $0.064 | 42 |
| High-performance glazings | $0.065 | 66 |
| ENERGY STAR refrigerators & freezers | $0.073 | 4 |
| Ground source heat pumps | $0.073 | 40 |
| Wall insulation | $0.074 | 17 |
| High-efficiency chillers | $0.074 | 1 |
| Roof insulation | $0.085 | 24 |
| T8 Baseline - Redesign with high-performance T8s | $0.117 | 14 |

## Exhibit 5.14: Summary of Commercial Sector Energy-efficiency Measures, Labrador Interconnected Service Region 2026

| Measure | Average* CCE ($/kWh) | Annual Savings (GWh/yr) |
|---|---|---|
| T12 baseline - redesign with high-performance T8s | -$0.012 | 2.3 |
| ENERGY STAR computers | $0.000 | 1.3 |
| ENERGY STAR office equipment | $0.000 | 0.3 |
| T8 baseline - redesign with high-performance T8s | $0.000 | 0.4 |
| Pulse-start metal halide | $0.003 | 0.3 |
| High-intensity fluorescents | $0.006 | 0.9 |
| High-efficiency servers | $0.021 | 0.2 |
| Low-flow aerators & shower heads | $0.028 | 1.7 |
| Compact fluorescent lamps (Outdoor) | $0.029 | 0.2 |
| New buildings - 40% more efficient | $0.031 | 8.6 |
| Premium efficiency motors | $0.032 | 0.1 |
| Air curtains | $0.038 | 0.7 |
| Compact fluorescent lamps | $0.039 | 3.4 |
| High-performance glazings | $0.040 | 7.2 |
| Advanced BAS/Recommissioning | $0.088 | 1.0 |

# 6. ACHIEVABLE POTENTIAL

## 6.1 INTRODUCTION

This section presents the Commercial sector Achievable Potential electricity savings for the study period. The Achievable Potential is defined as the proportion of the savings identified in the Economic Potential Forecast that could realistically be achieved within the study period.

The remainder of this discussion is organized into the following subsections:

- Description of Achievable Potential
- Approach to the estimation of Achievable Potential
- Workshop results
- Summary of Achievable electricity savings
- Peak load impacts.

## 6.2 DESCRIPTION OF ACHIEVABLE POTENTIAL

Achievable Potential recognizes that it is difficult to induce all customers to purchase and install all the electrical efficiency technologies that meet the criteria defined by the Economic Potential Forecast. For example, customer decisions to implement energy-efficient measures can be constrained by important factors such as:

- Higher first cost of efficient product(s)
- Need to recover investment costs in a short period (payback)
- Lack of product performance information
- Lack of product availability
- Consumer awareness.

The rate at which customers accept and purchase energy-efficient products can be influenced by a variety of factors including, the level of financial incentives, information and other measures put in place by the utilities, governments and the private sector to remove barriers such as those noted above.

Exhibit 6.1 presents the level of electricity consumption that is estimated in the Achievable Potential scenarios. As illustrated, the Achievable Potential scenarios are "banded" by the two forecasts presented in previous sections, namely the Economic Potential Forecast and the Reference Case.

Electricity savings under Achievable Potential are typically less than in the Economic Potential Forecast. In the Economic Potential Forecast, efficient new technologies are assumed to fully penetrate the market as soon as it is financially attractive to do so. However, the Achievable Potential recognizes that under "real world" conditions, the rate at which customers are likely to implement new technologies will be influenced by additional practical considerations and will, therefore, occur more slowly than under the assumptions employed in the Economic Potential Forecast. Exhibit 6.1 also shows that future electricity consumption under the Reference Case is greater than in either of the two Achievable Potential Forecasts. This is because the Reference

Case represents a "worst case" situation in which there are no additional utility market interventions and hence no additional electricity savings beyond those that occur "naturally."

Exhibit 6.1 presents the achievable results as a band of possibilities, rather than a single line. This recognizes that any estimate of Achievable Potential over a 20-year period is necessarily subject to uncertainty and that there are different levels of potential CDM program intervention.

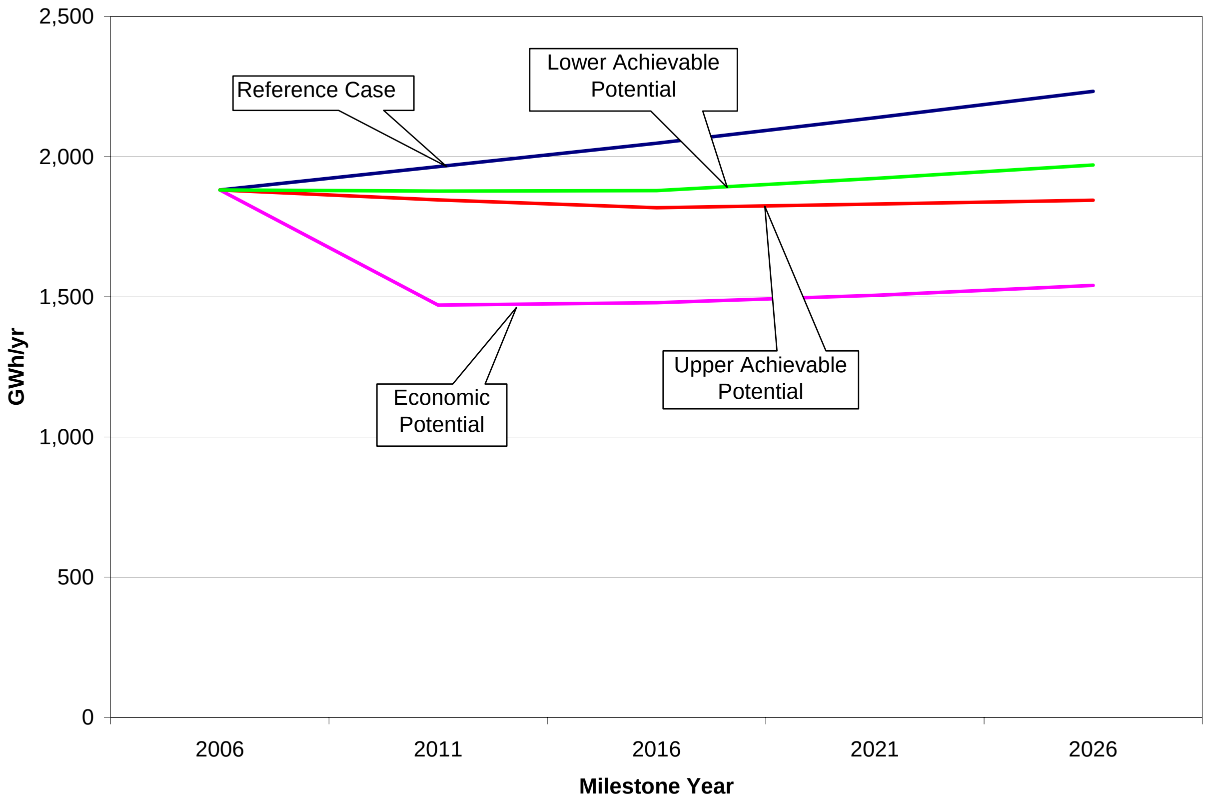
- **The Upper Achievable Potential** assumes both an aggressive program approach and a very supportive context, e.g., healthy economy, very strong public commitment to climate change mitigation, etc.

  However, the Upper Achievable Potential scenario also recognizes that there are limits to the scope of influence of any electric utility. It recognizes that some markets or submarkets may be so price sensitive or constrained by market barriers beyond the influence of CDM programs that they will only fully act if forced to by legal or other legislative means. It also recognizes that there are practical constraints related to the pace that existing inefficient equipment can be replaced by new, more efficient models or that existing building stock can be retrofitted to new energy performance levels.

  For the purposes of this study, the Upper Achievable Potential can, informally, be described as: "*Economic Potential less those customers that "can't" or "won't" participate."*

- **The Lower Achievable Potential** assumes that existing CDM programs and the scope of technologies addressed are expanded, but at a more modest level than in the Upper Achievable Potential. Market interest and customer commitment to energy efficiency and sustainable environmental practices remain approximately as current. Similarly, federal, provincial and municipal government energy-efficiency and GHG mitigation efforts remain similar to the present.

**Exhibit 6.1: Annual Electricity Consumption – Illustration of Achievable Potential Relative to Reference Case and Economic Potential Forecast for the Commercial Sector (GWh/yr.)**



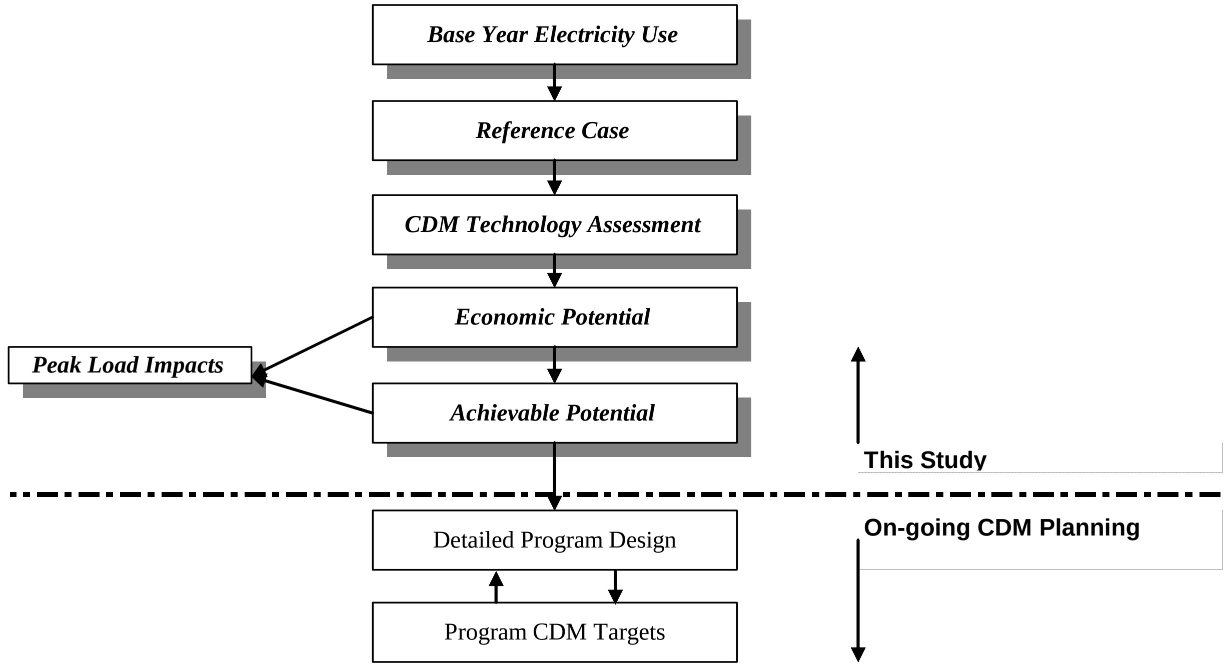

## Achievable Potential versus Detailed Program Design

It should be emphasized that the estimation of Achievable Potential is not synonymous with either the setting of specific program targets or with program design. While both are closely linked to the discussion of Achievable Potential, they involve more detailed analysis that is beyond the scope of this study.[50]

Exhibit 6.2 illustrates the relationship between Achievable Potential and the more detailed program design.

[50] The Achievable Potential savings assume program start-up in 2007. Consequently, electricity savings in the first milestone year of 2011 will need to be adjusted to reflect actual program initiation dates. This step will occur during the detailed program design phase, which will follows this study.

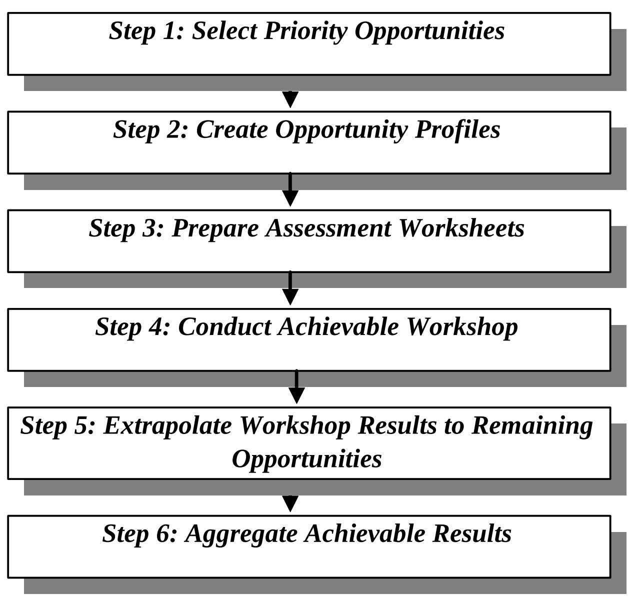
**Exhibit 6.2: Achievable Potential versus Detailed Program Design**




## 6.3 APPROACH TO THE ESTIMATION OF ACHIEVABLE POTENTIAL

Achievable Potential was estimated in a six-step approach. A schematic showing the major steps is shown in Exhibit 6.3 and each step is discussed below.

**Exhibit 6.3: Approach to Estimating Achievable Potential**



### Step 1: Select Priority Opportunities

The first step in developing the Achievable Potential estimates required that the energy-saving opportunities identified in the Economic Potential Forecasts be "bundled" into a set of opportunity areas that would facilitate the subsequent assessment of their potential market penetration.

The amount of time available in the Achievable Potential workshop for the discussion of energy-efficiency opportunities was limited. Consequently, the energy-efficiency opportunity areas shown in Exhibit 6.4 were selected based primarily on the basis that they represent a significant portion of the energy savings potential identified in the Economic Potential Forecast. Where two or more opportunities offered similar levels of potential energy savings, consideration was also given to whether discussion of the selected opportunity area in the workshop would provide insights into the participation rates to be used for related opportunities that could not be covered during the workshop.

Eight energy-efficiency opportunity areas were selected for discussion in the Commercial sector workshop that was held on October 31, 2007. Exhibit 6.4 identifies the opportunity areas and shows the approximate percentage that each represents of the total Commercial sector potential contained in the Economic Potential Forecast.

**Exhibit 6.4: Commercial Sector Opportunity Areas**

| Opportunity Area | Title | Approximate % of Economic Potential Savings |
|---|---|---|
| **C1** | T8 Fluorescent Upgrades (T12 Baseline) | 8% |
| **C2** | T8 Fluorescent Upgrades (T8 Baseline) | 3% |
| **C3** | Incandescent Upgrades | 8% |
| **C4** | Building Envelope Measures | 20% |
| **C5** | Building Recommissioning & Advanced BAS | 14% |
| **C6** | Ground Source Heat Pumps | 8% |
| **C7** | Advanced New Commercial Building Construction | 15% |
| **C8** | ENERGY STAR Computer Equipment | 7% |
| | **Total** | 83% |

### Step 2: Create Opportunity Profiles

The next step involved the development of brief profiles for the priority opportunity areas noted in Exhibit 6.4. A sample profile for Opportunity C1: T8 Fluorescent Upgrade (T12 baseline) is presented in Exhibit 6.5; the remaining Opportunity Profiles are provided in Appendix C.

The purpose of the Opportunity Profiles was to provide a "high-level" logic framework that would serve as a guide for participant discussions in the workshop. The intent was to define a broad rationale and direction without getting into the much greater detail required of program design, which, as noted previously, is beyond the scope of this project.

## Exhibit 6.5: Sample Opportunity Profile

### Opportunity Profile

### C1 – T8 Fluorescent Upgrades (T12 Baseline)

***Overview:***

- General lighting in the commercial building stock is typically a mix of fluorescent T12 and T8 lighting systems.
- This Opportunity Profile covers the replacement of T12 lighting systems with advanced T8 technologies in commercial buildings.
- Our discussion will be based on Office buildings and will focus on the three standard approaches to achieving lighting energy savings:
    - Redesign with advanced T8s (new layout, fewer fixtures, lower light levels)
    - Retrofit with advanced T8s (relamp/reballast)
    - Occupancy controls (occupancy sensors, time-of day scheduling, etc.)
- The target market is the remaining stock of T12 lighting

***Target Technologies and Building Types:***

- The target technologies include: redesign with advanced T8s, retrofit with advanced T8s and controls as outlined above.
- The target market includes all existing commercial buildings with T12 lighting; however, the focus of our discussion is Office buildings (> 40,000 $ft^2$) in Newfoundland.
- The penetration of T12 lighting is estimated to be 60%

***Opportunity Costs and Savings Profile:***

- Redesign with advanced T8s: full cost \$1.7/$ft^2$; savings 62%; CCE \$0.056/kWh; simple payback 6 years.
- Retrofit with advanced T8s: full cost \$1.0/$ft^2$; savings 39%; CCE \$0.049/kWh; simple payback 6 years.
- Occupancy controls: full cost \$0.5/$ft^2$; savings 30%; CCE \$0.066 cents/kWh; simple payback 5 years.

***Target Audience(s) & Potential Delivery Allies:***

- Owners, developers, facility managers, BOMA members
- Lighting manufacturers and suppliers
- Lighting designers, IESNA
- Electrical maintenance contractors
- NRCan and Ministry of Energy re: lighting standards and regulations
- Performance contractors
- Commercial renovation contractors

***Constraints & Challenges:***

- The most significant barriers are:
    - Lack of customer awareness, e.g., energy savings, improved light quality, productivity, longer life
    - Split incentive, e.g., lease arrangements – commercial "triple net lease" discourages owner participation
    - High paybacks, particularly for the redesign upgrades
    - Financing, e.g., access to capital
    - Lack of standards to differentiate "advanced" T8, manufacturer sets own protocol

***Opportunities & Synergies:***

- Phasing out of T12s through regulations
- Trade ally alliances, tying trade "partners" to qualified leads
- Opportunities for work environment improvements, customized to work function needs
- Link to renovation upgrades, building sales

As illustrated in Exhibit 6.5, each Opportunity Profile addresses the following areas:

- ***Overview*** – provides a summary statement of the broad goal and rationale for the opportunity.
- ***Target Technologies and Building Types*** **–** highlights the major technologies and the sub sectors where the most significant opportunities have been identified in the Economic Potential Forecast.
- ***Opportunity Costs and Savings Profile*** – provides information on the financial attractiveness of the opportunity from the perspective of both the customer and NLH or NP.
- ***Target Audiences and Potential Delivery Allies*** – identifies key market players that would be expected to be involved in the actual delivery of services. The list of stakeholders shown is intended to be "indicative" and is by no means comprehensive.
- ***Constraints and Challenges*** **–** identifies key market barriers that are currently constraining the increased penetration of energy-efficient technologies or measures. Interventions for addressing the identified barriers are noted. Again, it is recognized that the interventions are not necessarily comprehensive; rather, their primary purpose was to help guide the workshop discussions.
- ***Opportunities and Synergies*** **–** identifies information or possible synergies with other opportunities that may affect workshop participant views on possible customer participation rates.

**Step 3: Prepare Draft Opportunity Assessment Worksheets**

A draft Assessment Worksheet was prepared for each Opportunity Profile in advance of the workshop. The Assessment Worksheets complemented the information contained in the Opportunity Profiles by providing quantitative data on the potential energy savings for each opportunity, as well as providing information on the size and composition of the eligible population of potential participants. Energy impacts and population data were taken from the detailed modelling results contained in the Economic Potential Forecast.

A sample Assessment Worksheet for Opportunity C3 – Incandescent Upgrades is presented in Exhibit 6.6 (worksheets for the remaining opportunity areas are provided in Appendix D). As illustrated in Exhibit 6.6, each Assessment Worksheet addresses the following areas:

- ***Total Economic Savings Potential*** **–** shows the yearly total of economically attractive potential for electricity savings, by milestone period, for the measures included in the opportunity area.
- ***Market Size*** **–** shows the total population of potential participants that could theoretically take part in the opportunity area. Numbers shown are from the eligible populations used in the Economic Potential Forecasts. The definition of "participant" varies by opportunity

area. In the example shown, a participant is defined as an equivalent 40,000 $ft^2$ Office building.

- ***Major Technologies and Contribution to Savings –*** shows the technical components of each opportunity area and its approximate contribution to the economic potential savings of the opportunity area as a whole.

- ***Approximate CCE*** – shows the approximate CCE for the measure(s) included within each opportunity area. Where multiple measures are included, a weighted average value is presented. The CCE provides an indication of the relative economic attractiveness of the energy-efficiency measures from the utility's perspective. For the purposes of the workshop, this information provided participants with an indication of the scope for using financial incentives to influence customer participation rates. The CCE value, combined with the preceding customer payback information, provided an important reference point for the workshop participants when considering potential participation rates. The combined information enabled participants to "roughly" estimate the level of financial incentives that could be employed to increase the opportunity's attractiveness to customers without making the measures economically unattractive to NLH or NP.

- ***Approximate Payback*** – shows the simple payback from the customer's perspective for the package of energy-efficiency measures included in the opportunity area. This information provided an indication of the level of attractiveness that the opportunity measures would present to customers.

- ***Participation Rates, By Year –*** show the percentage of economic savings that workshop participants concluded could be achievable in each milestone period. As noted in the introduction to this section, two Achievable scenarios are shown: Lower and Upper. For example, Exhibit 6.6 shows a participation rate of 90% (Lower) and 98% (Upper) for the measure "Relamp incandescent with CFL" in existing offices by the year 2026. This means that, by 2026, between 90% and 98% of the potential savings contained in the Economic Potential Forecast could be achieved.

- ***Savings, By Year –*** shows the calculated electricity savings in each milestone period based on the savings and participation rates presented in the preceding columns of the Assessment Worksheet.

### Exhibit 6.6: Sample Commercial Sector Opportunity Assessment Worksheet

## Commercial Sector -- C3 -- Incandescent Upgrades

| Sub Sector | | Office - Existing | | | |
|---|---|---|---|---|---|
| **Total Economic Savings Potential (GWh/yr) in 2026** | General and Secondary Lighting | 10 | | | |
| **Market Size** | # of sites (approx.) | 381 | | | |
| | ft2 (approx.) | 15,250,000 | | | |
| | % eligible | 50% | Approx. 60% for LED exit sign | | |
| | # eligible sites | 191 | | | |
| **Major Technologies & Approx. Contribution to Economic Potential Savings** | CFL | 100% | | | |
| | LED Exit Sign | 0% | | | |
| | Other Technologies | 0% | | | |
| | *Sub total:* | 100% | | | |
| **Approx CCE (c/kWh)** | CFL | 2.9 | Full Cost | | |
| | LED Exit Sign | 2.0 | Full Cost | | |
| | Other Technologies | 0.5 - 5.0 | Full Cost | | |
| **Approx payback (years)** | CFL | 1.4 | | | |
| | LED Exit Sign | 3 | | | |
| | Other Technologies | 1 - 3 | | | |
| **Participation Rates, by Year (% of Eligible Sites)** | | ***2011*** | ***2016*** | ***2021*** | ***2026*** |
| ***Relamp Incandescent with CFL*** | *Lower* | | | | 90% |
| | *Upper* | | | | 98% |
| ***Incandescent to LED Exit Sign*** | *Lower* | | | | 95% |
| | *Upper* | | | | 98% |
| **Savings, by Year (GWh/yr)** | | ***2011*** | ***2016*** | ***2021*** | ***2026*** |
| ***Relamp Incandescent with CFL*** | *Lower* | | | | 8 |
| | *Upper* | | | | 9 |
| ***Incandescent to LED Exit Sign*** | *Lower* | | | | 1 |
| | *Upper* | | | | 1 |
| | | | | | |
| ***Total*** | *Lower* | | | | 9 |
| | *Upper* | | | | 10 |

**Step 4: Achievable Potential Workshop**

The most critical step in developing the estimates of Achievable Potential was the one-day workshop held October 31, 2007. Workshop participants consisted of core members of the consultant team, program personnel from NP and NLH and local trade allies.

The purpose of this workshop was twofold:

- Promote discussion regarding the technical and market conditions confronting the identified energy-efficiency opportunities

- Compile participant views related to how much of the identified economic savings could realistically be achieved over the study period.

The discussion of each opportunity area began with a brief consultant presentation. The floor was then opened to participant discussion. Key areas that were explored for each opportunity area included:

- Target audiences and potential delivery allies
- Constraints, barriers and challenges
- Potential opportunities and synergies
- Estimates of Lower Achievable and Upper Achievable for milestone years
- Guidelines for consultants for extrapolating to related sub sectors.

Following discussion of the broad market and intervention conditions affecting the opportunity areas, workshop participant views were recorded on Lower and Upper customer participation rates. To facilitate this portion, the discussion of the Commercial sector opportunity areas focused initially on Office buildings in the Island and Isolated service region. The following four-step process was employed:[51]

- The participation rate for the Upper Potential in 2026 was estimated. As noted previously, this participation rate was "roughly" defined as 100% of the Economic Potential minus the market share represented by the "can't" or 'won't" population.

- The shape of the adoption curve was selected for the Upper scenario. Rather than seek consensus on the specific values to be employed in each of the intervening milestone years, workshop participants selected one of four curve shapes that best matched their view of the appropriate "ramp-up" rate for each opportunity.

- The preceding process was repeated for the Lower scenario.

[51] Some minor variations on these steps occurred, depending on the specific opportunity area; however, the general approach was applied across the range of opportunity areas.

Exhibit 6.7 shows the four curves that were used in the workshop discussions.

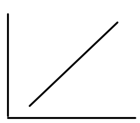
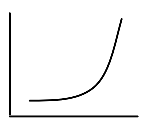
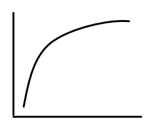
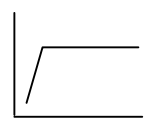
- **Curve A** represents a steady increase in the expected participation rate over the 20-year study period

- **Curve B** represents a relatively slow participation rate during the first half of the 20-year study period followed by a rapid growth in participation during the second half of the 20-year study period

- **Curve C** represents a rapid initial participation rate followed by a relatively slow growth in participation during the remainder of the 20-year study period

- **Curve D** represents a very rapid initial participation rate that results in virtual full saturation of the applicable market during the first milestone period of the 20-year study period.

**Exhibit 6.7: Adoption Curve Shapes (2006 to 2026)**

| Curve A | Curve B | Curve C | Curve D |
|---|---|---|---|
|  |  |  |  |

Finally, as applicable, workshop participants provided guidelines to the consultants for extrapolating the results of the workshop discussion to the remaining sub sectors and service regions.

**Step 5: Extrapolate Workshop Results to Remaining Opportunities**

As noted earlier, it was not possible to fully address all opportunities in the one-day workshop. Consequently, the workshop focused on the “big ticket” opportunities. Participation rates for the remaining opportunities were completed by the consultants, guided by the workshop results and discussions. The values shown in the summary tables and attached appendices incorporate the results of the two sets of inputs.

**Step 6: Aggregate Achievable Potential Results**

The final step involved aggregating the results of the individual opportunity areas to provide a view of the potential Achievable savings for the total Commercial sector.

## 6.4 WORKSHOP RESULTS

The following subsection provides a summary of the participation rates established by the workshop participants for each of the opportunity areas that were discussed during the workshop. As noted previously, the Commercial sector opportunity areas were:

- C1 - T8 Fluorescent Upgrades (T12 Baseline)
- C2 - T8 Fluorescent Upgrades (T8 Baseline)
- C3 - Incandescent Upgrades
- C4 - Building Envelope Measures
- C5 - Building Recommissioning & Advanced BAS
- C6 - Ground Source Heat Pumps
- C7 - Advanced New Building Construction
- C8 - ENERGY STAR Computer Equipment

Further detail on each of the above opportunity areas is provided below and, as applicable, the following information is provided for each:

- Summary of Upper and Lower Achievable participation rates
- Shape of Adoption Curve selected by the workshop participants
- Highlights of key issues arising during the workshop discussions
- Summary of major assumptions employed by the consultants for extrapolating the workshop results to other sub sectors.

### 6.4.1 C1 - T8 Fluorescent Upgrades (T12 Baseline)

Workshop participants concluded that, under the conditions represented by the Upper Achievable scenario, participation rates up to 74%[52] could be achieved in Office buildings in the Island and Isolated service region by 2026. Workshop participants agreed that Adoption Curve A represented the best fit with the pace of participation in the intervening years from 2007 to 2026 under this Upper Achievable scenario.

Under the more modest market conditions represented by the Lower Achievable scenario, participation rates up to 64% could be achieved in Office buildings in the Island and Isolated service region by 2026. Workshop participants agreed that Adoption Curve A represented the best fit with the pace of participation in the intervening years from 2007 to 2026 under this Lower Achievable scenario.

Based on the workshop discussions, it was assumed that participation rates would be directionally higher in institutional sub sectors (Health, Schools and University/College) and directionally lower in the primarily private sub sectors (Non-food Retail, Food Retail, Accommodations and Warehouse/Wholesale) when compared to the above values. Participation rates in the Labrador Interconnected service region were assumed to be similar to those for the Island and Isolated service region.

Selected highlights:

- Possible barriers discussed included limited capital resources for energy retrofits, increased space heating loads due to reduced internal heat gain and increased cost due to asbestos removal when undertaking redesign work in buildings older than approximately 30 years.

[52] Participation rates cited in this section are a weighted average of participation rates discussed for two separate but related measures during the workshop; “Redesign with high-performance T8” and “Retrofit with high-performance T8.”

- Potential positive influences on participation rates discussed included previous experience with fluorescent lighting program design and implementation in the early 1990's, co-benefits of increased chargeable rental rates in offices as a result of lighting retrofits and more attractive economics in buildings with high hours of use such as hospitals.
- Schools are presently undertaking T8 retrofits as part of ongoing electrical upgrades and repairs started in 2006.
- Labrador participation rates may be substantially lower if not driven by participation in government buildings.

The preceding results were used as a reference point for estimating participation rates related to other lighting opportunities in the Commercial sector.

Selected highlights:

- Participation rates for T8 upgrades from both T8 and T 12 baselines were taken into account when estimating rates for both pulse-start metal halide and high-intensity fluorescent lamps and fixtures.

### 6.4.2 C2 - T8 Fluorescent Upgrades (T8 Baseline)

Unlike opportunity C1, measures discussed within this opportunity were evaluated at incremental cost and applied at the rate of natural stock turnover.[53]

Workshop participants concluded that, under the conditions represented by the Upper Achievable scenario, participation rates up to 100%[54] could be achieved in Office buildings in the Island and Isolated service region in the year 2026. Workshop participants agreed that Adoption Curve C represented the best fit with the pace of participation in the intervening years from 2007 to 2026 under this Upper Achievable scenario. Occupancy sensors were also considered as part of this discussion. Upper Achievable participation rates were estimated at 98%.

Under the more modest market conditions represented by the Lower Achievable scenario, participation rates up to 82% could be achieved in Office buildings in the Island and Isolated service region in the year 2026. Workshop participants agreed that Adoption Curve C represented the best fit with the pace of participation in the intervening years from 2007 to 2026 under this Lower Achievable scenario. For occupancy sensors, Lower Achievable participation rates were estimated at 80%.

Since measures contained within this opportunity are applicable only at the time of stock turnover, lower participation rates in early milestone periods represent a lost savings opportunity that persists for the duration of the replaced equipment's service life. C2

[53] Fluorescent upgrades (T8 baseline) were evaluated at full cost with a CCE of $0.0979/kWh in the Economic Potential analysis. Because of unattractive customer paybacks and virtually zero opportunity for utility incentive under the CCE cutoff of $0.098/kWh, these measures are evaluated at incremental cost in the Achievable analysis.
[54] Participation rates cited in this section are a weighted average of participation rates discussed for two separate but related measures during the workshop: "Redesign with high-performance T8" and "Retrofit with high-performance T8."

participation rates, shown in Exhibits 6.8 and 6.9, represent the percentage of the *total stock* that would turn over to the evaluated technologies by 2026, under the two participation scenarios described above.

Based on the workshop discussions, it was assumed that participation rates would be directionally higher in institutional sub sectors (Health, Schools and University/College) and directionally lower in the primarily private sub sectors (Non-food Retail, Food Retail, Accommodations and Warehouse/Wholesale) when compared to the above values. Participation rates in the Labrador Interconnected service region were assumed to be similar those for the Island and Isolated service region.

Workshop participants identified potential barriers and positive influences on participation rates very similar to those listed in opportunity C1, above. In addition, workshop participants felt that customers with T8 fixtures already installed have been market leaders in the past and would likely continue to employ cutting-edge technology. There were also some concerns voiced about the present availability and consumer awareness of high-performance T8 systems.

The preceding results were used as a reference point for estimating participation rates related to other lighting opportunities in the Commercial sector.

Selected highlights:

- Participation rates for T8 upgrades from both T8 and T 12 baselines were taken into account when estimating rates for both pulse-start metal halide and high-intensity fluorescent lamps and fixtures.

### 6.4.4 C3 - Incandescent Upgrades

Workshop participants concluded that, under the conditions represented by the Upper Achievable scenario, participation rates up to 98% could be achieved in Office buildings in the Island and Isolated service region by 2026 for the measure “Relamp incandescent with CFL.” Workshop participants agreed that Adoption Curve D (reaching a maximum in 2016) represented the best fit with the pace of participation in the intervening years from 2007 to 2026 under this Upper Achievable scenario. LED exit signs were also considered as part of this discussion. Upper Achievable participation rates were estimated at 98%, following adoption curve C. A weighted average participation rate for these two measures is reported in Exhibit 6.8 below

Under the more modest market conditions represented by the Lower Achievable scenario, participation rates up to 90% could be achieved in Office buildings in the Island and Isolated service region by 2026 for “Relamp incandescent with CFL.” Workshop participants agreed that Adoption Curve D (reaching a maximum at 2016) represented the best fit with the pace of participation in the intervening years from 2007 to 2026 under this Lower Achievable scenario. For LED exit signs, Lower Achievable participation rates were estimated at 95% following adoption curve C. A weighted average participation rate for these two measures is reported in Exhibit 6.9 below.

Based on the workshop discussions, it was assumed that participation rates would be directionally higher in institutional sub sectors (Health, Schools and University/College) and directionally lower in the primarily private sub sectors (Non-food Retail, Food Retail, Accommodations and Warehouse/Wholesale) when compared to the above values. Participation rates in the Labrador Interconnected service region were assumed to be similar those for the Island and Isolated service region.

Selected highlights:

- Real and perceived issues regarding light quality and technical shortcomings may act as a barrier to uptake for CFL technologies.
- Increased consumer awareness (especially as it pertains to residential applications) and a possible phase-out of incandescent light bulbs by manufacturers or legislation may facilitate uptake.

### 6.4.5 C4 - Building Envelope Measures

This opportunity considered achievable participation rates for three building envelope measures: high-performance glazings, wall insulation and roof insulation. All of the measures discussed within this opportunity were evaluated at incremental cost and applied at the rate of natural stock turnover.

Workshop participants concluded that, under the conditions represented by the Upper Achievable scenario, participation rates of up to 13%, 13% and 21% for the respective measures listed above could be achieved in Office buildings in the Island and Isolated service region in the year 2026. Workshop participants agreed that Adoption Curve A represented the best fit for all three measures in the intervening years from 2007 to 2026 under this Upper Achievable scenario.

Under the more modest market conditions represented by the Lower Achievable scenario, participation rates up to 4%, 4% and 13% respectively could be achieved in Office buildings in the Island and Isolated service region in the year 2026. Workshop participants agreed that Adoption Curve A represented the best fit with the pace of participation in the intervening years from 2007 to 2026 under this Lower Achievable scenario.

Based on the workshop discussions, it was assumed that participation rates would be directionally higher in institutional sub sectors (Health, Schools and University/College) and directionally lower in the primarily private sub sectors (Non-food Retail, Food Retail, Accommodations and Warehouse/Wholesale) when compared to the above values. Participation rates in the Labrador Interconnected service region were assumed to be similar those for the Island and Isolated service region.

Since measures contained within this opportunity are applicable only at the time of stock turnover, lower participation rates in early milestone periods represent a lost savings opportunity that persists for the duration of the replaced equipment's service life. C4 participation rates shown in Exhibits 6.8 and 6.9 represent the percentage of the *total* *stock* that would turn over to the evaluated technologies by 2026, under the two participation scenarios described above.

Selected highlights:

- Technical issues and lack of physical space as they pertain to wall insulation upgrades may act as a barrier to building envelope measure participation.
- Conversely, the relative technical simplicity of upgrading roof insulation may facilitate uptake.
- Predictable savings levels may lead to a relatively low perceived risk and increased uptake.
- Co-benefits, such as increased occupant comfort, may facilitate uptake.
- Workshop participants noted that there is an ongoing roof insulation improvement program in Newfoundland and Labrador schools, that there have been few insulation retrofits in Labrador to date, and that in addition to insulation, air infiltration issues must be considered, especially with respect to preventing moisture damage.

The preceding results were used as a reference point for estimating participation rates related to other building envelope opportunities in the Commercial sector. Specifically, participation rates for the measure “Roof insulation” were taken into account when estimating participation rates for the measure “Air curtains.”

### 6.4.6 C5 - Building Recommissioning & Advanced BAS

Workshop participants concluded that, under the conditions represented by the Upper Achievable scenario, participation rates up to 85% could be achieved in Office buildings in the Island and Isolated service region by 2026 for the measure “Building Recommissioning.” Workshop participants agreed that a “flattened” Adoption Curve B (essentially a hybrid between curves A and B) represented the best fit with the pace of participation in the intervening years from 2007 to 2026 under this Upper Achievable scenario. Advanced BAS were also considered as part of this discussion. Upper Achievable participation rates were estimated at 65%, following adoption curve A. A weighted average participation rate for these two measures is reported in Exhibit 6.8 below.

Under the more modest market conditions represented by the Lower Achievable scenario, participation rates up to 40% could be achieved in Office buildings in the Island and Isolated service region by 2026 for the measure “Building Recommissioning.” Workshop participants agreed that Adoption Curve B represented the best fit with the pace of participation in the intervening years from 2007 to 2026 under this Lower Achievable scenario. For Advanced BAS, Upper Achievable participation rates were estimated at 25%, following adoption curve B. A weighted average participation rate for these two measures is reported in Exhibit 6.9 below.

Based on the workshop discussions, it was assumed that participation rates would be directionally higher in institutional sub sectors (Health, Schools and University/College) and directionally lower in the primarily private sub sectors (Non-food Retail, Food Retail, Accommodations and Warehouse/Wholesale) when compared to the above values.

Participation rates in the Labrador Interconnected service region were assumed to be similar those for the Island and Isolated service region.

Selected highlights:

- Workshop participants felt that this was a particularly large opportunity in buildings of all ages, especially buildings older than 15 years
- Participants stressed the importance of maintaining savings over time by training building managers and through service contracts
- Possible roles identified for the Utilities included assistance with training programs for building owners and operators, producing and providing technical information or specific case studies and financial incentives for pre-audits or to lower cost the cost of building “tuning.”

The preceding participation rates were also applied to the HVAC measure “adjustable speed drives,” which was not discussed during the workshop.

### 6.4.7 C6 – Ground Source Heat Pumps

This opportunity considered achievable participation rates for the measure “Ground Source Heat Pumps.” This measure was evaluated at incremental cost and applied at the rate of natural stock turnover.

Workshop participants concluded that, under the conditions represented by the Upper Achievable scenario, participation rates of up to 20% could be achieved in Office buildings in the Island and Isolated service region in the year 2026. Workshop participants agreed that Adoption Curve B represented the best fit in the intervening years from 2007 to 2026 under this Upper Achievable scenario.

Under the more modest market conditions represented by the Lower Achievable scenario, participation rates up to 2% could be achieved in Office buildings in the Island and Isolated service region in the year 2026. Workshop participants agreed that Adoption Curve B represented the best fit with the pace of participation in the intervening years from 2007 to 2026 under this Lower Achievable scenario.

Based on the workshop discussions, it was assumed that participation rates would be directionally higher in institutional sub sectors (Health, Schools and University/College) and directionally lower in the primarily private sub sectors (Non-food Retail, Food Retail, Accommodations and Warehouse/Wholesale) when compared to the above values. Participation rates in the Labrador Interconnected service region were assumed to be similar those for the Island and Isolated service region.

Since measures contained within this opportunity are applicable only at the time of stock turnover, lower participation rates in early milestone periods represent a lost savings opportunity that persists for the duration of the replaced equipment’s service life. C6 participation rates shown in Exhibits 6.8 and 6.9 represent the percentage of the *total stock* that would turn over to the evaluated technologies by 2026, under the two participation scenarios described above.

Selected highlights:

- This measure was seen to be much more attractive for new construction than for retrofits
- In addition to the limited opportunity for uptake of ground source heat pumps, participants felt that there may be some additional opportunity for installation of air source heat pumps and low-temperature heat pumps
- Public and institutional buildings were expected to have slightly higher participation rates
- A commitment by the provincial government to build efficient new public buildings, which could include heat pump systems, may facilitate uptake in retrofit applications.

### 6.4.6 C7 – Advanced New Building Construction

This opportunity considered achievable participation rates for the measures “New buildings – 40% more efficient” and “New buildings – 25% more efficient.” These measures were evaluated at incremental cost and applied at the time of construction.

Workshop participants drew a distinction between likely participation rates within the private and public/institutional sectors. Consequently, participation rates were discussed separately for these two sector groups, and combined in a weighted average in Exhibits 6.8 and 6.9.

Workshop participants concluded that, under the conditions represented by the Upper Achievable scenario, participation rates of up to 100% for public Office buildings and 25% in private buildings for the measure “New buildings – 40% more efficient” could be achieved in Office buildings in the Island and Isolated service region in the year 2026. In addition, participation rates of up to 50% in private buildings for the measure “New buildings – 25% more efficient” could be achieved in Office buildings in 2026. No curve shape was applied to the estimated participation rates. Instead, participation rates were discussed for earlier milestone years. It was estimated that private offices would achieve participation rates of 30%, and publicly owned offices would achieve participation rates of 100% for the measure “New buildings – 25% more efficient” in 2011. It was assumed that no new buildings would be built to a 40% more efficient standard by the 2011 milestone year.

Lower Achievable participation rates were not discussed for this opportunity during the workshop. Discussion during the workshop, data from other jurisdictions and the prior experience of the consulting team were used to estimate the Lower Achievable participation rates presented in Exhibit 6.9.

Based on the workshop discussions, it was assumed that participation rates would be similar to the rates discussed for publicly-owned Office buildings in institutional sub sectors (Health, Schools and University/College) and similar to those discussed for private Office buildings in the primarily private sub sectors (Non-food Retail, Food Retail, Accommodations and Warehouse/Wholesale) when compared to the above values. Participation rates in the Labrador Interconnected service region were assumed to be similar those for the Island and Isolated service region.

Selected highlights:

- Participants noted that as part of its recent Energy Plan, the Government of Newfoundland and Labrador will implement a policy requiring construction of all buildings receiving provincial funding to exceed the Model National Energy Code by 25%
- Participants estimated that new office construction will be split 50-50 between the public and private sectors.

Since measures contained within this opportunity are applicable only at the time of stock turnover, lower participation rates in early milestone periods represent a lost savings opportunity that persists for the duration of the replaced equipment's service life. C4 participation rates shown in Exhibits 6.8 and 6.9 represent the percentage of the *total stock* that would turn over to the evaluated technologies by 2026, under the two participation scenarios described above.

### 6.4.7 C8 – ENERGY STAR Computer Equipment

This opportunity considered achievable participation rates for three computer equipment measures: ENERGY STAR computers, ENERGY STAR office equipment and high-efficiency servers. All of the measures discussed within this opportunity were evaluated at incremental cost and applied at the rate of natural stock turnover.

Due to time constraints and the fact that this opportunity was outside of the expertise of most workshop participants, this measure was not discussed during the workshop. Estimates made for participation rates for the residential measure "ENERGY STAR computer" (residential workshop opportunity R8) were used to estimate participation rates for this opportunity.

### 6.4.8 Extrapolated Participation Rates – Remaining Energy-efficiency Opportunities

As noted previously, the workshop results and follow-up email responses were used as a reference point, combined with consultant experience, to estimate participation rates for the remaining energy-efficiency opportunities that are contained in the Economic Potential Forecast.

Exhibits 6.8 and 6.9 provide, respectively, a summary of the estimated Upper and Lower participation rates for the remaining energy-efficiency opportunities. As illustrated, each exhibit shows:

- Workshop reference number, which refers to the package of Opportunity Profiles that were provided to workshop participants
- The affected technology
- The participation rates by 2026 (or in 2026, in the case of measures implemented at time of existing stock turnover).

- Notes that illustrate sources and rationale used by the consultant when estimating the participation rates shown.

## Exhibit 6.8: Participation Rates – Upper Achievable Potential

| Workshop Reference # | Upgrade Technology/Measures | Participation Rate 2026 | Adoption Curve Shape | Notes |
|---|---|---|---|---|
| C1 | T12 baseline: Redesign with high-performance T8s | 74% | A | Workshop measure C1 |
| C2 | T8 baseline: Redesign with high-performance T8s | 90% | C | Workshop measure C2 |
| C2 | Occupancy sensors | 98% | C | Workshop measure C2 |
| C3 | Compact fluorescent lamps | 98% | D | Curve D in 2016, Workshop measure C3 |
| | Pulse-start metal halide | 85% | C | Based on Measures C1 & C2 |
| | High-intensity fluorescent | 85% | C | Based on Measures C1 & C2 |
| C6 | Ground source heat pump | 9% | B | Workshop measure C6 |
| | High-efficiency chillers | 38% | A | Based on workshop results, consultant experience |
| | Adjustable speed drives | 73% | B/A | Flattened curve B, based on measure C5 |
| | Premium efficiency motors | 78% | C | Based on workshop results, consultant experience, Industrial workshop measure I6 |
| C5 | Advanced BAS/Building recommissioning | 73% | B/A | Flattened curve B. Workshop measure C5 |
| | ENERGY STAR Refrigerators and Freezers | 47% | B | Based on consultant experience |
| | High-efficiency supermarket refrigeration | 63% | B | Based on consultant experience |
| | Low-flow aerators & shower heads | 90% | C | Based on workshop results, consultant experience |
| | ENERGY STAR computers | 80% | B | Based on residential workshop measure R8 |
| | ENERGY STAR office equipment | 80% | B | Based on residential workshop measure R8 |
| | High-efficiency servers | 80% | B | Based on residential workshop measure R8 |
| C4 | High-performance glazings | 13% | A | Workshop measure C4 |
| C4 | Wall insulation | 13% | A | Workshop measure C4 |
| C4 | Roof insulation | 21% | A | Workshop measure C4 |
| | Air curtains | 33% | A | Based on workshop measure C4 |
| C7 | New buildings - 40% more efficient | 60% | * | Based on input from workshop measure C7 |
| | Dimming controls | 20% | A | Based on consultant experience, barriers to significant uptake |

* An adoption curve was not assigned to the measure "New buildings - 40% more efficient". Participation rates and trends were discussed for multiple milestone periods, as well as for public and private buildings. The participation rates approximate a flattened curve B.

## Exhibit 6.9: Participation Rates – Lower Achievable Potential

| Workshop Reference # | Upgrade Technology/Measures | Participation Rate 2026 | Adoption Curve Shape | Notes |
|---|---|---|---|---|
| C1 | T12 baseline: Redesign with high-performance T8s | 64% | A | Workshop measure C1 |
| C2 | T8 baseline: Redesign with high-performance T8s | 73% | C | Workshop measure C2 |
| C2 | Occupancy sensors | 80% | C | Workshop measure C2 |
| C3 | Compact fluorescent lamps | 90% | D | Curve D in 2016, Workshop measure C3 |
| | Pulse-start metal halide | 75% | C | Based on Measures C1 & C2 |
| | High-intensity fluorescent | 75% | C | Based on Measures C1 & C2 |
| C6 | Ground source heat pump | 1% | B | Workshop measure C6 |
| | High-efficiency chillers | 28% | A | Based on workshop results, consultant experience |
| | Adjustable speed drives | 31% | B | Based on measure C5 |
| | Premium efficiency motors | 68% | C | Based on workshop results, consultant experience, Industrial workshop measure I6 |
| C5 | Advanced BAS/Building recommissioning | 31% | B | Workshop measure C5 |
| | ENERGY STAR Refrigerators and Freezers | 35% | B | Based on consultant experience |
| | High-efficiency supermarket refrigeration | 47% | B | Based on consultant experience |
| | Low-flow aerators & shower heads | 75% | C | Based on workshop results, consultant experience |
| | ENERGY STAR computers | 15% | B | Based on residential workshop measure R8 |
| | ENERGY STAR office equipment | 15% | B | Based on residential workshop measure R8 |
| | High-efficiency servers | 15% | B | Based on residential workshop measure R8 |
| C4 | High-performance glazings | 4% | A | Workshop measure C4 |
| C4 | Wall insulation | 4% | A | Workshop measure C4 |
| C4 | Roof insulation | 13% | A | Workshop measure C4 |
| | Air curtains | 27% | A | Based on workshop measure C4 |
| C7 | New buildings - 40% more efficient | 40% | * | Based on input from workshop measure C7 |
| | Dimming controls | 10% | A | Based on consultant experience, barriers to significant uptake |

* An adoption curve was not assigned to the measure "New buildings - 40% more efficient". Participation rates and trends were discussed for multiple milestone periods, as well as for public and private buildings. The participation rates approximate a flattened curve B.

## 6.5 SUMMARY OF ACHIEVABLE ELECTRICITY SAVINGS

Exhibits 6.10 and 6.11 provide a summary of the achievable electricity savings under both the Lower and Upper scenarios for the Island and Isolated and Labrador Interconnected service regions respectively.

Under the Reference Case for the Island and Isolated service region, commercial electricity use would grow from the Base Year level of 1,881GWh/yr. to approximately 2,233 GWh/yr. by 2026. This contrasts with the Upper Achievable scenario in which electricity use would increase to approximately 1,846 GWh/yr. for the same period, a difference of approximately 387 GWh/yr., or about 17%. Under the Lower Achievable scenario, electricity use would increase to approximately 1,972 GWh/yr. for the same period, a difference of approximately 261 GWh/yr., or about 12%.

Under the Reference Case for the Labrador Interconnected service region, commercial electricity use would grow from the Base Year level of 201GWh/yr. to approximately 240 GWh/yr. by 2026. This contrasts with the Upper Achievable scenario in which electricity use would increase to approximately 212 GWh/yr. for the same period, a difference of approximately 28 GWh/yr., or about 12%. Under the Lower Achievable scenario, electricity use would increase to approximately 221 GWh/yr. for the same period, a difference of approximately 19 GWh/yr., or about 8%.

**Exhibit 6.10: Reference Case versus Upper and Lower Achievable Potential Electricity Consumption in Commercial Sector for the Island and Isolated Service Region (GWh/yr.)**

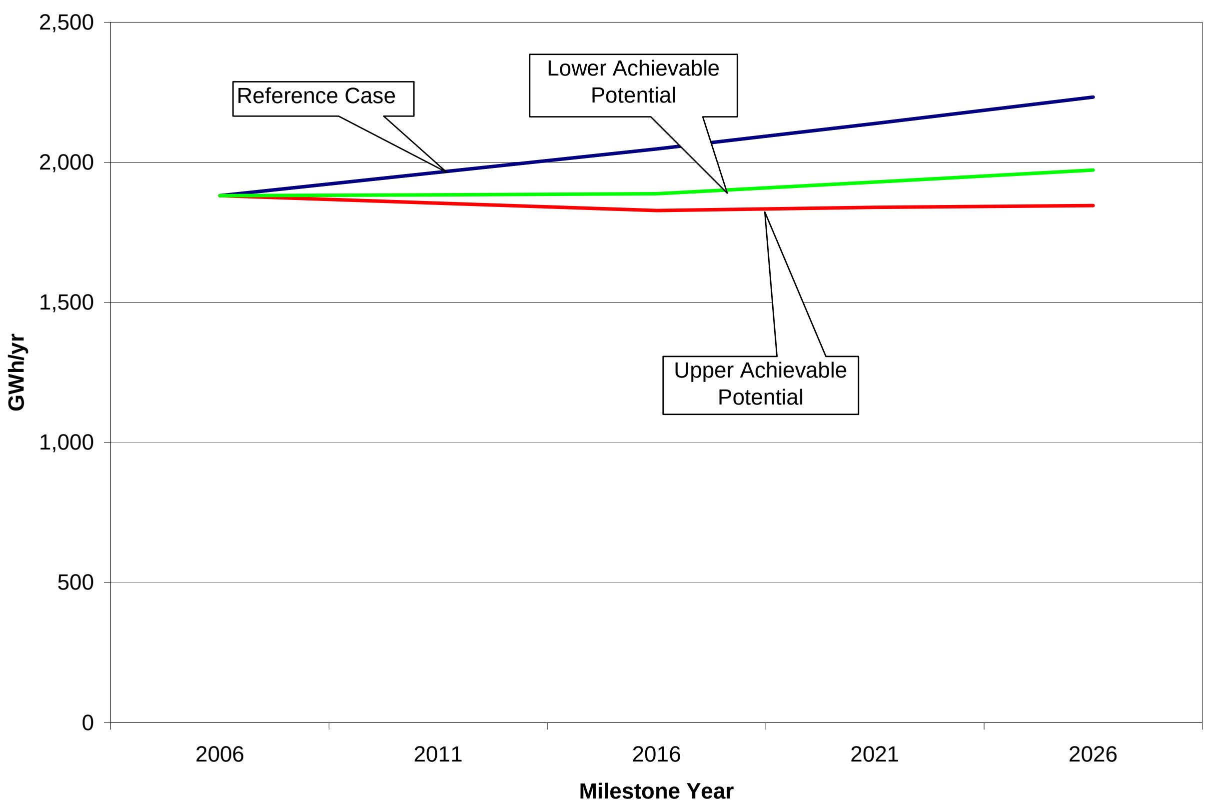
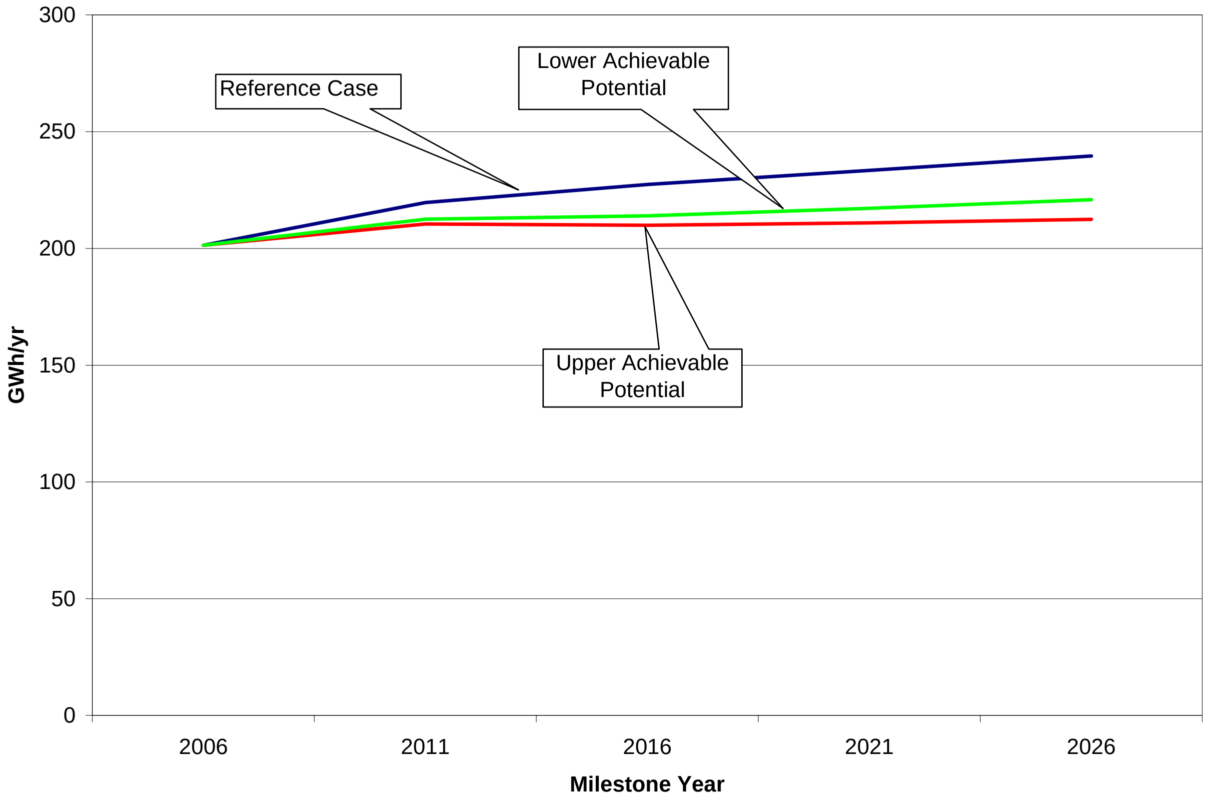


**Exhibit 6.11: Reference Case versus Upper and Lower Achievable Potential Electricity Consumption in Commercial Sector for the Island and Isolated Service Region (GWh/yr.)**




Further detail on the total potential electricity savings provided by the Achievable Potential Forecasts is provided in the following exhibits:

- Exhibits 6.12 and 6.13 present, respectively, the Upper and Lower Achievable results by end use, sub sector and milestone year for the Island and Isolated service region.
- Exhibits 6.14 and 6.15 present, respectively, the Upper and Lower Achievable results by end use, sub sector and milestone year for the Labrador Interconnected service region.
- Exhibits 6.16 and 6.17 present, respectively, Upper and Lower Achievable savings in 2026 by major end use and sub sector for the Island and Isolated service region.
- Exhibits 6.18 and 6.19, respectively, present Upper and Lower Achievable savings in 2026 by major end use and sub sector for the Labrador Interconnected service region.
- Exhibit 6.20 presents Upper and Lower Achievable savings by scenario, milestone year and service region.

**Exhibit 6.12: Summary of Annual Electricity Savings for the Island and Isolated Service Region by End Use and Sub Sector, Upper Achievable Potential (GWh/yr.)**

| Building Type | Milestone Year | Total | General Lighting | Secondary Lighting | Outdoor Lighting | Computer Equipment | Other Plug Loads | Food Service Equipment | Refrigeration | Elevators | Miscellaneous | Space Heating | Space Cooling | HVAC Fans and Pumps | Domestic Hot Water | Street Lighting |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Office | 2011 | 22.7 | 10.8 | 5.3 | 0.2 | 1.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.8 | 1.1 | 2.1 | 1.1 | |
| | 2016 | 48.4 | 19.7 | 10.5 | 0.6 | 4.7 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 1.8 | 2.4 | 6.7 | 1.9 | |
| | 2021 | 72.1 | 26.8 | 10.5 | 0.8 | 11.1 | 0.0 | 0.0 | 0.1 | 0.0 | 0.1 | 3.3 | 3.5 | 13.3 | 2.5 | |
| | 2026 | 103.7 | 33.1 | 10.6 | 1.1 | 20.5 | 0.0 | 0.0 | 0.2 | 0.0 | 0.2 | 8.6 | 4.9 | 21.6 | 2.8 | |
| Non-food Retail | 2011 | 14.4 | 11.4 | 1.1 | 0.2 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.7 | 0.5 | 0.2 | |
| | 2016 | 27.9 | 21.0 | 2.2 | 0.4 | 0.4 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.2 | 1.6 | 1.6 | 0.4 | |
| | 2021 | 32.1 | 21.9 | 2.2 | 0.6 | 0.9 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.4 | 2.1 | 3.3 | 0.6 | |
| | 2026 | 36.7 | 22.3 | 2.2 | 0.7 | 1.7 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.8 | 2.8 | 5.4 | 0.6 | |
| Food Retail | 2011 | 5.4 | 3.2 | 0.3 | 0.1 | 0.1 | 0.0 | 0.0 | 1.2 | 0.0 | 0.0 | -0.1 | 0.2 | 0.2 | 0.3 | |
| | 2016 | 12.3 | 5.4 | 0.6 | 0.2 | 0.2 | 0.0 | 0.0 | 4.3 | 0.0 | 0.0 | 0.1 | 0.3 | 0.7 | 0.5 | |
| | 2021 | 17.6 | 6.8 | 0.7 | 0.3 | 0.5 | 0.0 | 0.0 | 6.7 | 0.0 | 0.0 | 0.2 | 0.4 | 1.3 | 0.7 | |
| | 2026 | 22.4 | 7.3 | 0.8 | 0.4 | 0.9 | 0.0 | 0.1 | 9.2 | 0.0 | 0.0 | 0.3 | 0.5 | 2.2 | 0.7 | |
| Healthcare | 2011 | 7.3 | 1.0 | 4.1 | 0.2 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.4 | 0.2 | 0.6 | 0.6 | |
| | 2016 | 14.5 | 1.7 | 7.0 | 0.5 | 0.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.4 | 0.3 | 1.9 | 1.2 | |
| | 2021 | 20.5 | 1.9 | 7.9 | 0.6 | 1.3 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 3.0 | 0.5 | 3.7 | 1.5 | |
| | 2026 | 27.2 | 1.9 | 8.2 | 0.7 | 2.3 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 5.3 | 0.7 | 6.1 | 1.8 | |
| Schools | 2011 | 6.0 | 3.3 | 0.6 | 0.2 | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.8 | 0.0 | 0.2 | 0.6 | |
| | 2016 | 13.6 | 5.8 | 1.8 | 0.5 | 1.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 2.7 | 0.0 | 0.7 | 1.1 | |
| | 2021 | 22.7 | 7.7 | 3.1 | 0.7 | 2.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 5.8 | 0.0 | 1.4 | 1.5 | |
| | 2026 | 33.2 | 9.2 | 4.3 | 0.9 | 4.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 10.4 | 0.0 | 2.4 | 1.7 | |
| Accomodations | 2011 | 10.4 | 3.2 | 4.2 | 0.1 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | -0.6 | 0.2 | 0.2 | 3.0 | |
| | 2016 | 21.1 | 6.3 | 7.5 | 0.2 | 0.3 | 0.0 | 0.0 | 0.2 | 0.0 | 0.0 | 0.3 | 0.5 | 0.6 | 5.2 | |
| | 2021 | 24.4 | 6.3 | 7.8 | 0.3 | 0.6 | 0.0 | 0.0 | 0.3 | 0.0 | 0.0 | 0.5 | 0.6 | 1.2 | 6.8 | |
| | 2026 | 27.2 | 6.2 | 7.9 | 0.3 | 1.1 | 0.0 | 0.0 | 0.4 | 0.0 | 0.0 | 0.8 | 0.7 | 2.0 | 7.7 | |
| University/College | 2011 | 7.8 | 4.6 | 1.3 | 0.1 | 0.3 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.1 | 0.9 | 0.4 | |
| | 2016 | 15.8 | 7.6 | 2.4 | 0.3 | 1.4 | 0.0 | 0.0 | 0.2 | 0.0 | 0.0 | 0.1 | 0.2 | 3.0 | 0.7 | |
| | 2021 | 23.1 | 9.2 | 2.5 | 0.4 | 3.3 | 0.0 | 0.0 | 0.3 | 0.0 | 0.0 | 0.2 | 0.3 | 6.1 | 0.8 | |
| | 2026 | 30.8 | 9.4 | 2.5 | 0.6 | 6.0 | 0.0 | 0.0 | 0.4 | 0.0 | 0.0 | 0.3 | 0.4 | 10.1 | 0.9 | |
| Warehouse/Wholesale | 2011 | 3.3 | 2.8 | 0.4 | 0.1 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | -0.3 | 0.0 | 0.1 | 0.2 | |
| | 2016 | 6.8 | 4.6 | 0.6 | 0.2 | 0.2 | 0.0 | 0.0 | 0.3 | 0.0 | 0.0 | 0.1 | 0.0 | 0.3 | 0.3 | |
| | 2021 | 9.1 | 5.8 | 0.7 | 0.3 | 0.5 | 0.0 | 0.0 | 0.5 | 0.0 | 0.0 | 0.3 | 0.0 | 0.6 | 0.4 | |
| | 2026 | 10.9 | 6.2 | 0.8 | 0.4 | 0.9 | 0.0 | 0.0 | 0.7 | 0.0 | 0.0 | 0.4 | 0.1 | 1.1 | 0.5 | |
| Small Commercial | 2011 | 26.7 | | | | | | | | | | | | | | |
| | 2016 | 48.9 | | | | | | | | | | | | | | |
| | 2021 | 62.8 | | | | | | | | | | | | | | |
| | 2026 | 77.8 | | | | | | | | | | | | | | |
| Other Buildings | 2011 | 4.8 | | | | | | | | | | | | | | |
| | 2016 | 8.6 | | | | | | | | | | | | | | |
| | 2021 | 10.8 | | | | | | | | | | | | | | |
| | 2026 | 13.3 | | | | | | | | | | | | | | |
| Non Buildings | 2011 | 0.0 | | | | | | | | | | | | | | |
| | 2016 | 0.0 | | | | | | | | | | | | | | |
| | 2021 | 0.0 | | | | | | | | | | | | | | |
| | 2026 | 0.0 | | | | | | | | | | | | | | |
| Isolated Buildings | 2011 | 0.5 | | | | | | | | | | | | | | |
| | 2016 | 1.0 | | | | | | | | | | | | | | |
| | 2021 | 1.4 | | | | | | | | | | | | | | |
| | 2026 | 1.8 | | | | | | | | | | | | | | |
| Streetlighting | 2011 | 0.6 | | | | | | | | | | | | | | 0.6 |
| | 2016 | 1.2 | | | | | | | | | | | | | | 1.2 |
| | 2021 | 1.8 | | | | | | | | | | | | | | 1.8 |
| | 2026 | 2.4 | | | | | | | | | | | | | | 2.4 |
| Total | 2011 | 110.0 | 40.3 | 17.3 | 1.2 | 2.1 | 0.0 | 0.0 | 1.4 | 0.0 | 0.0 | 1.2 | 2.4 | 4.9 | 6.4 | 0.6 |
| | 2016 | 220.1 | 72.1 | 32.4 | 2.9 | 8.7 | 0.0 | 0.1 | 5.1 | 0.0 | 0.1 | 6.7 | 5.3 | 15.5 | 11.3 | 1.2 |
| | 2021 | 298.4 | 86.2 | 35.4 | 4.0 | 20.4 | 0.0 | 0.2 | 8.0 | 0.0 | 0.2 | 13.8 | 7.5 | 31.0 | 14.8 | 1.8 |
| | 2026 | 387.4 | 95.6 | 37.4 | 5.2 | 37.7 | 0.0 | 0.3 | 11.0 | 0.0 | 0.3 | 27.0 | 10.1 | 50.7 | 16.8 | 2.4 |

*Notes: 1) Results are measured at the customer's point-of-use and do not include line losses. 2) Any differences in totals are due to rounding. 3) In the above Exhibit, a value displays as 0 if it is between 0 and 0.5. Totals are calculated using the actual numerical value. 4) Negative values in the space heating end use are a result of the reduction in internal heat gains due to lighting and appliance measures being greater than any savings from space heating measures.*

# Exhibit 6.13: Summary of Annual Electricity Savings for the Island and Isolated Service Region by End Use and Sub Sector, Lower Achievable Potential (GWh/yr.)

| Building Type | Milestone Year | Total | General Lighting | Secondary Lighting | Outdoor Lighting | Computer Equipment | Other Plug Loads | Food Service Equipment | Refrigeration | Elevators | Miscellaneaous | Space Heating | Space Cooling | HVAC Fans and Pumps | Domestic Hot Water | Street Lighting |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Office | 2011 | 14.6 | 6.3 | 4.9 | 0.2 | 0.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.5 | 0.7 | 0.8 | 0.9 | |
| | 2016 | 31.3 | 13.0 | 9.5 | 0.5 | 1.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.2 | 1.6 | 2.7 | 1.5 | |
| | 2021 | 45.4 | 19.7 | 9.5 | 0.8 | 2.9 | 0.0 | 0.0 | 0.1 | 0.0 | 0.1 | 2.2 | 2.4 | 5.7 | 2.0 | |
| | 2026 | 62.8 | 27.4 | 9.5 | 1.0 | 5.4 | 0.0 | 0.0 | 0.1 | 0.0 | 0.1 | 3.5 | 3.4 | 10.0 | 2.3 | |
| Non-food Retail | 2011 | 12.0 | 9.8 | 1.0 | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.5 | 0.2 | 0.2 | |
| | 2016 | 23.4 | 18.4 | 1.9 | 0.4 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.2 | 1.2 | 0.7 | 0.4 | |
| | 2021 | 26.1 | 19.4 | 2.0 | 0.5 | 0.3 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.4 | 1.5 | 1.4 | 0.5 | |
| | 2026 | 29.2 | 20.3 | 2.0 | 0.7 | 0.5 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.7 | 1.9 | 2.5 | 0.5 | |
| Food Retail | 2011 | 4.5 | 2.6 | 0.2 | 0.1 | 0.0 | 0.0 | 0.0 | 1.2 | 0.0 | 0.0 | -0.1 | 0.1 | 0.1 | 0.2 | |
| | 2016 | 10.5 | 4.5 | 0.4 | 0.2 | 0.1 | 0.0 | 0.0 | 4.3 | 0.0 | 0.0 | 0.1 | 0.2 | 0.3 | 0.4 | |
| | 2021 | 15.1 | 5.7 | 0.6 | 0.3 | 0.1 | 0.0 | 0.0 | 6.7 | 0.0 | 0.0 | 0.2 | 0.3 | 0.6 | 0.6 | |
| | 2026 | 19.5 | 6.4 | 0.7 | 0.4 | 0.2 | 0.0 | 0.1 | 9.2 | 0.0 | 0.0 | 0.3 | 0.4 | 1.0 | 0.6 | |
| Healthcare | 2011 | 5.2 | 0.8 | 3.2 | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.1 | 0.2 | 0.5 | |
| | 2016 | 10.2 | 1.4 | 5.8 | 0.5 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.4 | 0.2 | 0.7 | 0.9 | |
| | 2021 | 13.5 | 1.6 | 6.7 | 0.6 | 0.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.1 | 0.4 | 1.6 | 1.2 | |
| | 2026 | 17.1 | 1.7 | 7.4 | 0.7 | 0.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 2.1 | 0.5 | 2.7 | 1.4 | |
| Schools | 2011 | 3.7 | 2.0 | 0.5 | 0.2 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.3 | 0.0 | 0.1 | 0.5 | |
| | 2016 | 8.0 | 3.9 | 1.4 | 0.5 | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.8 | 0.0 | 0.3 | 0.9 | |
| | 2021 | 13.2 | 5.5 | 2.6 | 0.7 | 0.6 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 2.0 | 0.0 | 0.6 | 1.2 | |
| | 2026 | 19.1 | 7.1 | 3.6 | 0.9 | 1.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 3.9 | 0.0 | 1.1 | 1.3 | |
| Accomodations | 2011 | 9.0 | 3.0 | 3.7 | 0.1 | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | -0.6 | 0.2 | 0.1 | 2.5 | |
| | 2016 | 18.4 | 5.8 | 6.8 | 0.2 | 0.1 | 0.0 | 0.0 | 0.2 | 0.0 | 0.0 | 0.3 | 0.4 | 0.3 | 4.4 | |
| | 2021 | 20.7 | 5.8 | 7.0 | 0.2 | 0.2 | 0.0 | 0.0 | 0.3 | 0.0 | 0.0 | 0.5 | 0.5 | 0.5 | 5.7 | |
| | 2026 | 22.7 | 5.7 | 7.2 | 0.3 | 0.3 | 0.0 | 0.0 | 0.4 | 0.0 | 0.0 | 0.7 | 0.6 | 0.9 | 6.5 | |
| University/College | 2011 | 4.8 | 2.8 | 1.1 | 0.1 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.3 | 0.3 | |
| | 2016 | 9.8 | 5.1 | 2.2 | 0.3 | 0.3 | 0.0 | 0.0 | 0.2 | 0.0 | 0.0 | 0.1 | 0.1 | 1.1 | 0.5 | |
| | 2021 | 13.9 | 6.8 | 2.3 | 0.4 | 0.6 | 0.0 | 0.0 | 0.3 | 0.0 | 0.0 | 0.1 | 0.2 | 2.5 | 0.7 | |
| | 2026 | 18.2 | 8.1 | 2.4 | 0.5 | 1.2 | 0.0 | 0.0 | 0.4 | 0.0 | 0.0 | 0.2 | 0.3 | 4.4 | 0.8 | |
| Warehouse/Wholesale | 2011 | 2.7 | 2.3 | 0.3 | 0.1 | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | -0.3 | 0.0 | 0.0 | 0.2 | |
| | 2016 | 5.5 | 3.9 | 0.5 | 0.2 | 0.1 | 0.0 | 0.0 | 0.3 | 0.0 | 0.0 | 0.1 | 0.0 | 0.1 | 0.3 | |
| | 2021 | 7.4 | 5.0 | 0.6 | 0.2 | 0.1 | 0.0 | 0.0 | 0.5 | 0.0 | 0.0 | 0.3 | 0.0 | 0.3 | 0.4 | |
| | 2026 | 8.7 | 5.5 | 0.7 | 0.3 | 0.2 | 0.0 | 0.0 | 0.7 | 0.0 | 0.0 | 0.4 | 0.1 | 0.5 | 0.4 | |
| Small Commercial | 2011 | 19.5 | | | | | | | | | | | | | | |
| | 2016 | 35.7 | | | | | | | | | | | | | | |
| | 2021 | 44.0 | | | | | | | | | | | | | | |
| | 2026 | 52.4 | | | | | | | | | | | | | | |
| Other Buildings | 2011 | 3.5 | | | | | | | | | | | | | | |
| | 2016 | 6.2 | | | | | | | | | | | | | | |
| | 2021 | 7.6 | | | | | | | | | | | | | | |
| | 2026 | 9.0 | | | | | | | | | | | | | | |
| Non Buildings | 2011 | 0.0 | | | | | | | | | | | | | | |
| | 2016 | 0.0 | | | | | | | | | | | | | | |
| | 2021 | 0.0 | | | | | | | | | | | | | | |
| | 2026 | 0.0 | | | | | | | | | | | | | | |
| Isolated Buildings | 2011 | 0.3 | | | | | | | | | | | | | | |
| | 2016 | 0.7 | | | | | | | | | | | | | | |
| | 2021 | 1.0 | | | | | | | | | | | | | | |
| | 2026 | 1.3 | | | | | | | | | | | | | | |
| Streetlighting | 2011 | 0.3 | | | | | | | | | | | | | | 0.3 |
| | 2016 | 0.6 | | | | | | | | | | | | | | 0.6 |
| | 2021 | 0.9 | | | | | | | | | | | | | | 0.9 |
| | 2026 | 1.2 | | | | | | | | | | | | | | 1.2 |
| Total | 2011 | 80.1 | 29.6 | 14.9 | 1.1 | 0.5 | 0.0 | 0.0 | 1.4 | 0.0 | 0.0 | 0.1 | 1.7 | 1.8 | 5.3 | 0.3 |
| | 2016 | 160.4 | 55.9 | 28.6 | 2.7 | 2.1 | 0.0 | 0.1 | 5.1 | 0.0 | 0.1 | 3.2 | 3.8 | 6.1 | 9.4 | 0.6 |
| | 2021 | 208.7 | 69.6 | 31.3 | 3.7 | 5.1 | 0.0 | 0.1 | 7.9 | 0.0 | 0.1 | 6.8 | 5.3 | 13.3 | 12.2 | 0.9 |
| | 2026 | 261.2 | 82.3 | 33.5 | 4.8 | 9.4 | 0.0 | 0.2 | 10.9 | 0.0 | 0.2 | 11.9 | 7.2 | 23.1 | 13.8 | 1.2 |

*Notes: 1) Results are measured at the customer's point-of-use and do not include line losses. 2) Any differences in totals are due to rounding. 3) In the above Exhibit, a value displays as 0 if it is between 0 and 0.5. Totals are calculated using the actual numerical value. 4) Negative values in the space heating end use are a result of the reduction in internal heat gains due to lighting and appliance measures being greater than any savings from space heating measures.*

## Exhibit 6.14: Summary of Annual Electricity Savings for the Labrador Interconnected Service Region by End Use and Sub Sector, Upper Achievable Potential (GWh/yr.)

| Building Type | Milestone Year | Total | General Lighting | Secondary Lighting | Outdoor Lighting | Computer Equipment | Other Plug Loads | Food Service Equipment | Refrigeration | Elevators | Miscellaneous | Space Heating | Space Cooling | HVAC Fans and Pumps | Domestic Hot Water | Street Lighting |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Office | 2011 | 0.2 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | |
| | 2016 | 0.6 | 0.2 | 0.0 | 0.0 | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 | 0.1 | 0.1 | |
| | 2021 | 1.1 | 0.3 | 0.0 | 0.0 | 0.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | 0.0 | 0.1 | 0.1 | |
| | 2026 | 1.6 | 0.4 | 0.0 | 0.0 | 0.6 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | 0.0 | 0.2 | 0.1 | |
| Non-food Retail | 2011 | 2.0 | 1.8 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | -0.1 | 0.1 | 0.1 | 0.1 | |
| | 2016 | 4.3 | 3.5 | 0.0 | 0.1 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | 0.1 | 0.2 | 0.1 | |
| | 2021 | 5.0 | 3.8 | 0.0 | 0.1 | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | 0.2 | 0.3 | 0.1 | |
| | 2026 | 5.8 | 4.0 | 0.1 | 0.1 | 0.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.3 | 0.3 | 0.5 | 0.1 | |
| Food Retail | 2011 | 0.3 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | |
| | 2016 | 0.6 | 0.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | |
| | 2021 | 0.9 | 0.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 0.1 | 0.1 | |
| | 2026 | 1.2 | 0.5 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.2 | 0.0 | 0.0 | 0.2 | 0.0 | 0.1 | 0.1 | |
| Healthcare | 2011 | 1.6 | 0.1 | 0.5 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.3 | 0.0 | 0.1 | 0.4 | |
| | 2016 | 2.6 | 0.2 | 0.8 | 0.1 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.4 | 0.0 | 0.2 | 0.7 | |
| | 2021 | 3.5 | 0.2 | 1.0 | 0.1 | 0.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.7 | 0.0 | 0.4 | 0.8 | |
| | 2026 | 4.2 | 0.2 | 1.1 | 0.1 | 0.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.8 | 0.1 | 0.5 | 0.9 | |
| Schools | 2011 | 0.4 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | |
| | 2016 | 0.8 | 0.2 | 0.1 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | 0.0 | 0.1 | 0.1 | |
| | 2021 | 1.2 | 0.4 | 0.1 | 0.0 | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.3 | 0.0 | 0.1 | 0.1 | |
| | 2026 | 1.6 | 0.5 | 0.1 | 0.0 | 0.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.3 | 0.0 | 0.2 | 0.1 | |
| Accomodations | 2011 | 0.3 | 0.1 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | -0.1 | 0.0 | 0.0 | 0.1 | |
| | 2016 | 0.7 | 0.2 | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | |
| | 2021 | 0.8 | 0.2 | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.3 | |
| | 2026 | 0.9 | 0.2 | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 | 0.1 | 0.3 | |
| University/College | 2011 | 0.2 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | |
| | 2016 | 0.5 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 | 0.1 | 0.0 | |
| | 2021 | 0.7 | 0.2 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 | 0.2 | 0.1 | |
| | 2026 | 1.0 | 0.3 | 0.0 | 0.0 | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 | 0.3 | 0.1 | |
| Warehouse/Wholesale | 2011 | 0.2 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | |
| | 2016 | 0.4 | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | -0.1 | 0.0 | 0.0 | 0.0 | |
| | 2021 | 0.7 | 0.5 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | -0.1 | 0.0 | 0.1 | 0.1 | |
| | 2026 | 1.1 | 0.7 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.1 | |
| Small Commercial | 2011 | 1.7 | | | | | | | | | | | | | | |
| | 2016 | 2.9 | | | | | | | | | | | | | | |
| | 2021 | 3.5 | | | | | | | | | | | | | | |
| | 2026 | 4.0 | | | | | | | | | | | | | | |
| Other Buildings | 2011 | 0.7 | | | | | | | | | | | | | | |
| | 2016 | 1.1 | | | | | | | | | | | | | | |
| | 2021 | 1.3 | | | | | | | | | | | | | | |
| | 2026 | 1.5 | | | | | | | | | | | | | | |
| Non Buildings | 2011 | 0.0 | | | | | | | | | | | | | | |
| | 2016 | 0.0 | | | | | | | | | | | | | | |
| | 2021 | 0.0 | | | | | | | | | | | | | | |
| | 2026 | 0.0 | | | | | | | | | | | | | | |
| Other Institutional | 2011 | 1.8 | | | | | | | | | | | | | | |
| | 2016 | 3.0 | | | | | | | | | | | | | | |
| | 2021 | 3.7 | | | | | | | | | | | | | | |
| | 2026 | 4.2 | | | | | | | | | | | | | | |
| Streetlighting | 2011 | 0.0 | | | | | | | | | | | | | | 0.0 |
| | 2016 | 0.0 | | | | | | | | | | | | | | 0.0 |
| | 2021 | 0.0 | | | | | | | | | | | | | | 0.0 |
| | 2026 | 0.0 | | | | | | | | | | | | | | 0.0 |
| Total | 2011 | 9.3 | 2.5 | 0.6 | 0.1 | 0.2 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.4 | 0.1 | 0.3 | 0.8 | 0.0 |
| | 2016 | 17.5 | 4.9 | 1.2 | 0.2 | 0.6 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.9 | 0.2 | 0.8 | 1.3 | 0.0 |
| | 2021 | 22.4 | 5.9 | 1.5 | 0.3 | 1.2 | 0.0 | 0.0 | 0.2 | 0.0 | 0.0 | 1.5 | 0.3 | 1.3 | 1.6 | 0.0 |
| | 2026 | 27.2 | 6.7 | 1.7 | 0.3 | 2.2 | 0.0 | 0.1 | 0.2 | 0.0 | 0.0 | 2.1 | 0.4 | 2.0 | 1.7 | 0.0 |

*Notes: 1) Results are measured at the customer's point-of-use and do not include line losses. 2) Any differences in totals are due to rounding. 3) In the above Exhibit, a value displays as 0 if it is between 0 and 0.5. Totals are calculated using the actual numerical value. 4) Negative values in the space heating end use are a result of the reduction in internal heat gains due to lighting and appliance measures being greater than any savings from space heating measures.*

## Exhibit 6.15: Summary of Annual Electricity Savings for the Labrador Interconnected Service Region by End Use and Sub Sector, Lower Achievable Potential (GWh/yr.)

| Building Type | Milestone Year | Total | General Lighting | Secondary Lighting | Outdoor Lighting | Computer Equipment | Other Plug Loads | Food Service Equipment | Refrigeration | Elevators | Miscellaneous | Space Heating | Space Cooling | HVAC Fans and Pumps | Domestic Hot Water | Street Lighting |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Office | 2011 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | |
| | 2016 | 0.3 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | |
| | 2021 | 0.6 | 0.2 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 | 0.1 | 0.1 | |
| | 2026 | 0.8 | 0.3 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | 0.0 | 0.1 | 0.1 | |
| Non-food Retail | 2011 | 1.7 | 1.6 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | -0.1 | 0.0 | 0.0 | 0.0 | |
| | 2016 | 3.6 | 3.1 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.1 | 0.1 | 0.1 | |
| | 2021 | 4.0 | 3.3 | 0.0 | 0.1 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | 0.1 | 0.2 | 0.1 | |
| | 2026 | 4.5 | 3.5 | 0.0 | 0.1 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | 0.2 | 0.3 | 0.1 | |
| Food Retail | 2011 | 0.2 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | |
| | 2016 | 0.4 | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | |
| | 2021 | 0.6 | 0.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | |
| | 2026 | 0.8 | 0.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | |
| Healthcare | 2011 | 1.2 | 0.1 | 0.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | 0.0 | 0.1 | 0.3 | |
| | 2016 | 2.0 | 0.2 | 0.7 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.3 | 0.0 | 0.1 | 0.5 | |
| | 2021 | 2.5 | 0.2 | 0.8 | 0.1 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.4 | 0.0 | 0.2 | 0.7 | |
| | 2026 | 3.0 | 0.2 | 1.0 | 0.1 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.5 | 0.0 | 0.3 | 0.7 | |
| Schools | 2011 | 0.3 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | |
| | 2016 | 0.5 | 0.1 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | 0.0 | 0.0 | 0.1 | |
| | 2021 | 0.8 | 0.2 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | 0.0 | 0.1 | 0.1 | |
| | 2026 | 1.0 | 0.3 | 0.1 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | 0.0 | 0.1 | 0.1 | |
| Accomodations | 2011 | 0.3 | 0.1 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | -0.1 | 0.0 | 0.0 | 0.1 | |
| | 2016 | 0.6 | 0.2 | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | |
| | 2021 | 0.7 | 0.2 | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | |
| | 2026 | 0.7 | 0.2 | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | |
| University/College | 2011 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | |
| | 2016 | 0.3 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 | 0.1 | 0.0 | |
| | 2021 | 0.4 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 | 0.1 | 0.0 | |
| | 2026 | 0.5 | 0.2 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 | 0.1 | 0.0 | |
| Warehouse/Wholesale | 2011 | 0.1 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | |
| | 2016 | 0.3 | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | |
| | 2021 | 0.5 | 0.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | -0.1 | 0.0 | 0.0 | 0.1 | |
| | 2026 | 0.7 | 0.6 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.1 | |
| Small Commercial | 2011 | 1.3 | | | | | | | | | | | | | | |
| | 2016 | 2.3 | | | | | | | | | | | | | | |
| | 2021 | 2.5 | | | | | | | | | | | | | | |
| | 2026 | 2.7 | | | | | | | | | | | | | | |
| Other Buildings | 2011 | 0.5 | | | | | | | | | | | | | | |
| | 2016 | 0.9 | | | | | | | | | | | | | | |
| | 2021 | 1.0 | | | | | | | | | | | | | | |
| | 2026 | 1.0 | | | | | | | | | | | | | | |
| Non Buildings | 2011 | 0.0 | | | | | | | | | | | | | | |
| | 2016 | 0.0 | | | | | | | | | | | | | | |
| | 2021 | 0.0 | | | | | | | | | | | | | | |
| | 2026 | 0.0 | | | | | | | | | | | | | | |
| Other Institutional | 2011 | 1.4 | | | | | | | | | | | | | | |
| | 2016 | 2.4 | | | | | | | | | | | | | | |
| | 2021 | 2.7 | | | | | | | | | | | | | | |
| | 2026 | 2.9 | | | | | | | | | | | | | | |
| Streetlighting | 2011 | 0.0 | | | | | | | | | | | | | | 0.0 |
| | 2016 | 0.0 | | | | | | | | | | | | | | 0.0 |
| | 2021 | 0.0 | | | | | | | | | | | | | | 0.0 |
| | 2026 | 0.0 | | | | | | | | | | | | | | 0.0 |
| Total | 2011 | 7.2 | 2.1 | 0.5 | 0.1 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.2 | 0.1 | 0.2 | 0.6 | 0.0 |
| | 2016 | 13.4 | 4.2 | 1.0 | 0.2 | 0.2 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.6 | 0.2 | 0.4 | 1.0 | 0.0 |
| | 2021 | 16.2 | 5.0 | 1.2 | 0.2 | 0.3 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.9 | 0.2 | 0.7 | 1.3 | 0.0 |
| | 2026 | 18.8 | 5.6 | 1.4 | 0.2 | 0.5 | 0.0 | 0.0 | 0.2 | 0.0 | 0.0 | 1.3 | 0.3 | 1.0 | 1.4 | 0.0 |

*Notes: 1) Results are measured at the customer's point-of-use and do not include line losses. 2) Any differences in totals are due to rounding. 3) In the above Exhibit, a value displays as 0 if it is between 0 and 0.5. Totals are calculated using the actual numerical value. 4) Negative values in the space heating end use are a result of the reduction in internal heat gains due to lighting and appliance measures being greater than any savings from space heating measures.*

**Exhibit 6.16: Savings by Major End Use, Upper Achievable – Island and Isolated Service Region 2026 (%)**

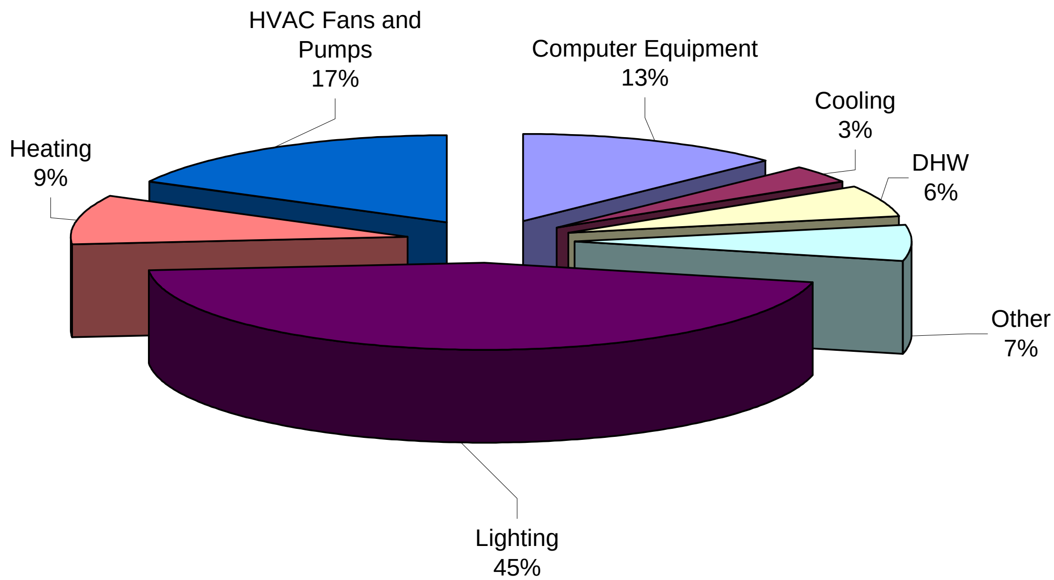



**Exhibit 6.17: Savings by Major End Use, Lower Achievable – Island and Isolated Service Region 2026 (%)**

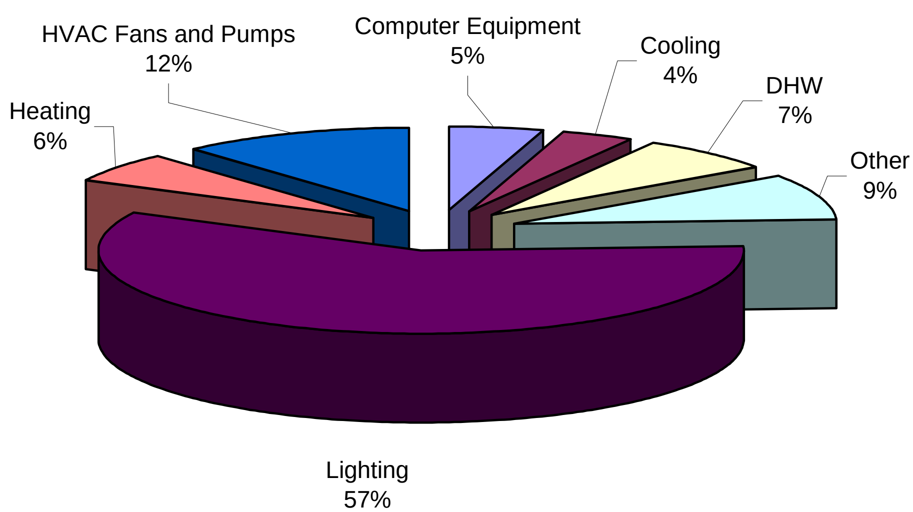


**Exhibit 6.18: Savings by Major End Use, Upper Achievable – Labrador Interconnected Service Region 2026 (%)**

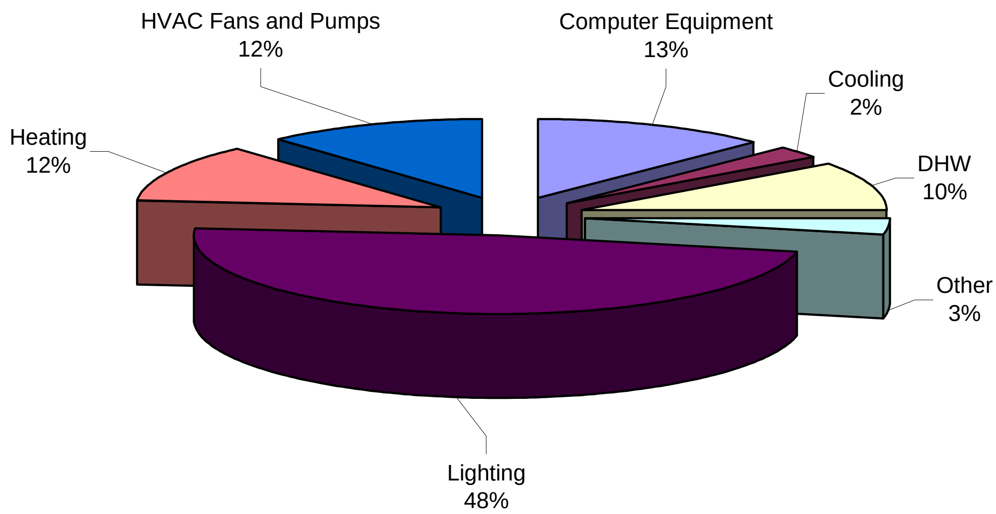



**Exhibit 6.19: Savings by Major End Use, Lower Achievable – Labrador Interconnected Service Region 2026 (%)**

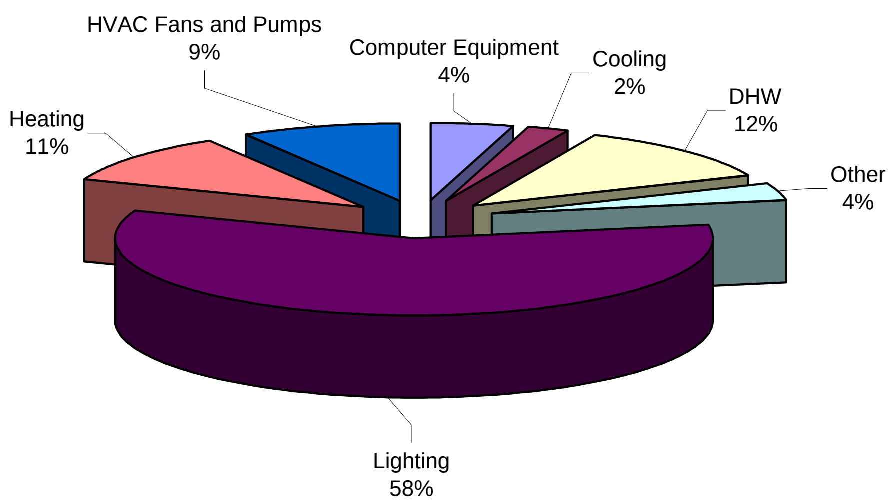
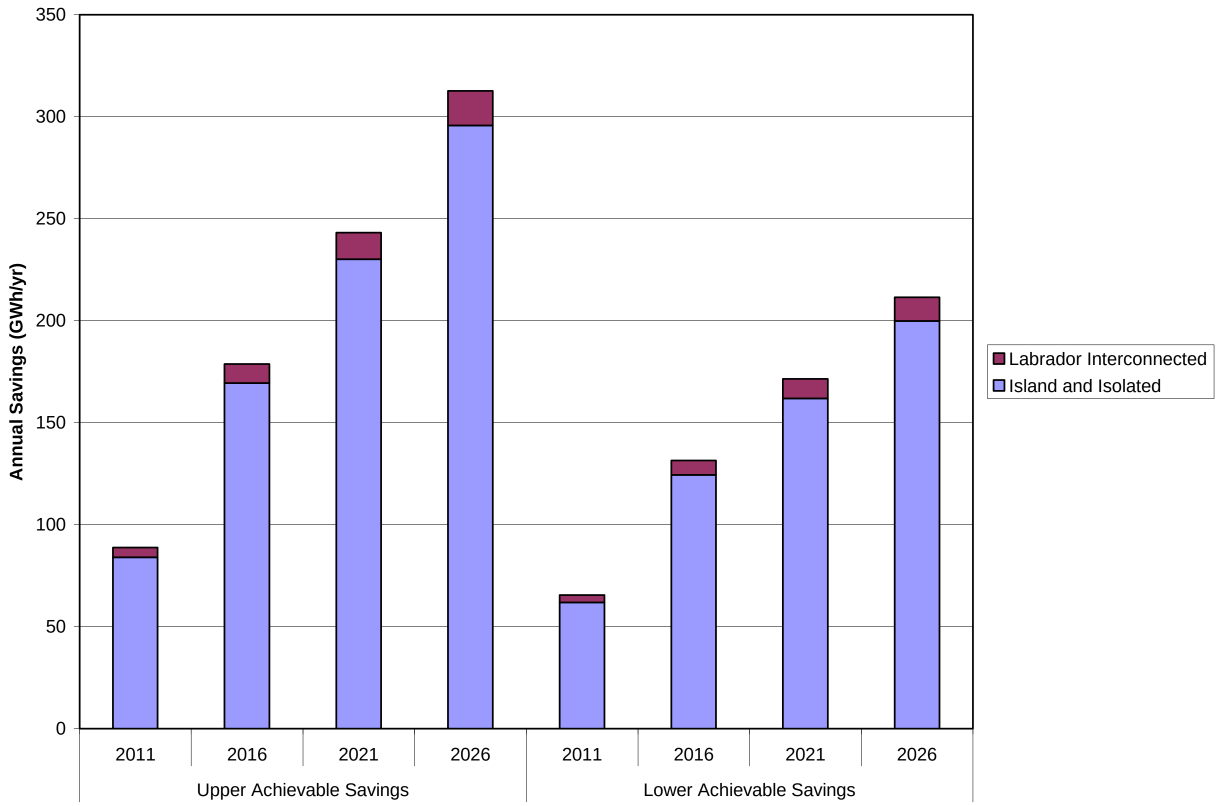


**Exhibit 6.20: Savings by Scenario, Milestone Year and Service Region**




## 6.6 PEAK LOAD IMPACTS

The electricity (electric energy) savings (GWh) contained in the preceding scenarios also result in a reduction in electric demand (MW).[55]

The conversion of electricity savings to hourly demand requires the following steps:

- Annual electricity savings for each combination of sub sector and end use are disaggregated *by month*
- Monthly electricity savings are then further disaggregated *by day type* (weekday, weekend day and peak day)
- Finally, each day type is disaggregated *by hour*.

The above steps that convert electricity to electric demand require the development and application of the following four factors (sets of ratios).

[55] Peak load savings were modelled using Applied Energy Group's Cross-Sector Load Shape Library Model (LOADLIB).

- **Monthly Usage Factor**

This factor represents the percentage of annual electricity use that occurs in each month of the year. This set of monthly fractions (percentages) reflects the seasonality of the load shape, whether a facility, process or end use, and is dictated by weather or other seasonal factors. This allocation factor can be obtained from either (in decreasing order of priority): (a) monthly consumption statistics from end-use load studies; (b) monthly seasonal sales (preferably weather normalized) obtained by subtracting a “base” month from winter and summer heating and cooling months; or (c) heating or cooling degree days on an appropriate base.

- **Weekend to Weekday Factor**

This factor is a ratio that describes the distribution of electricity use between weekends and weekdays

- **Peak Day Factor**

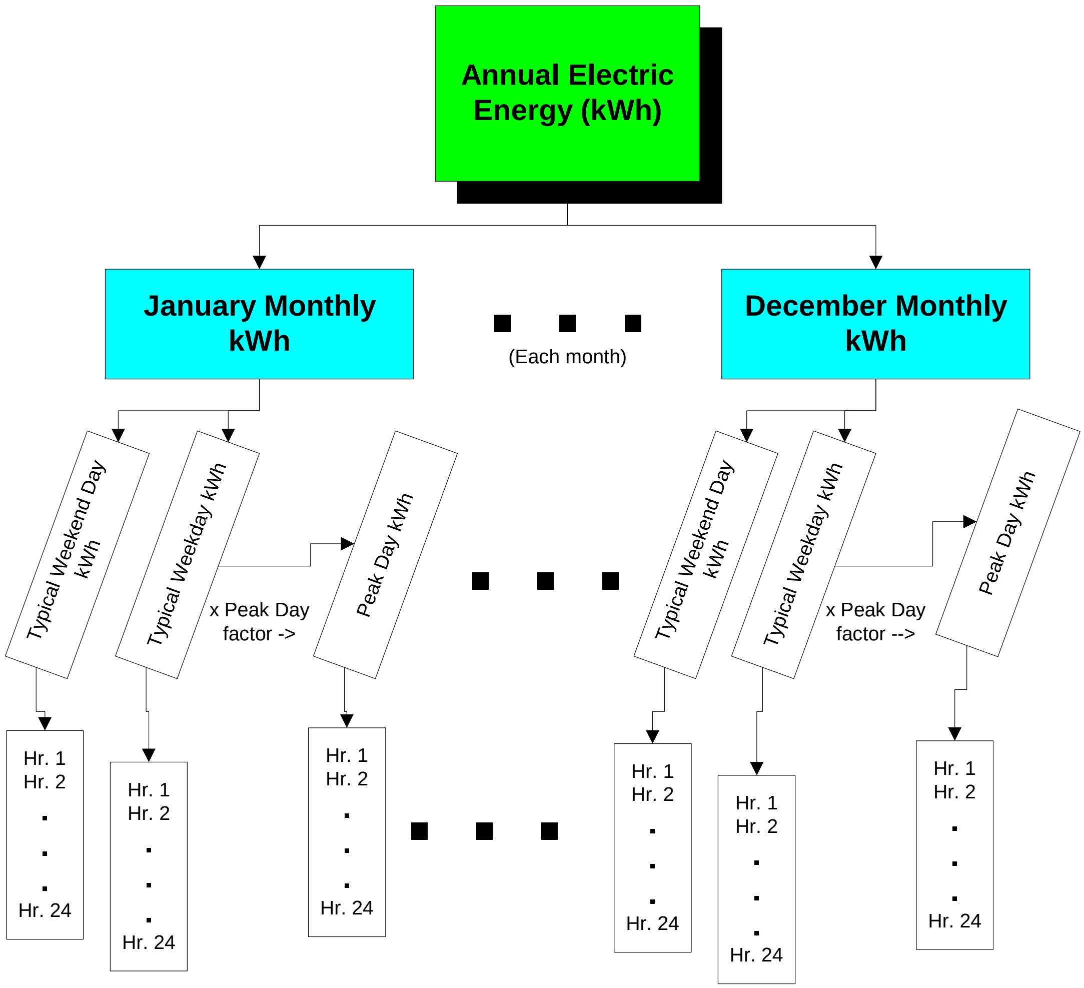
This factor defines the degree of daily weather sensitivity associated with the load shape, particularly heating or cooling; it compares a peak (e.g., hottest or coldest) day to a typical weekday in that month.

- **Hourly Factor**

This factor describes the typical distribution of daily electricity use for each day type (weekday, weekend day, peak day) and for each month. It reflects the operating hours of the electric equipment or end use by sub sector. For example, for lighting, this would be affected by time of day and season (affected by daylight).

Exhibit 6.21 provides an illustration of the sequential application of the above factors to convert annual electricity to hourly demand. Further description is provided in Appendix E.

**Exhibit 6.21: Illustration of Electricity to Peak load Calculation**




For the purposes of this study, the peak load period was defined as

> *The morning period from 7 am to noon and the evening period from 4 pm to 8 pm on the four coldest days in the December to March period; this is a total of 36 hours per year.*

Exhibit 6.22 presents a summary of the peak load reductions that would occur during the peak period noted above as a result of the electricity savings contained in Upper and Lower Achievable scenarios. In each case, the reductions are an average value over the peak period and are defined relative to the Reference Case.

**Exhibit 6.22: Peak load Reductions (MW) Relative to Reference Case by Milestone Year, Service Region and Achievable Scenario**

| Service Region | Milestone Year | Peak Load Reduction (MW) | |
|---|---|---|---|
| | | Upper Achievable | Lower Achievable |
| Island and Isolated | 2011 | 16 | 11 |
| | 2016 | 31 | 23 |
| | 2021 | 41 | 29 |
| | 2026 | 53 | 34 |
| Labrador Interconnected | 2011 | 0.8 | 0.7 |
| | 2016 | 2.0 | 1.6 |
| | 2021 | 2.6 | 1.9 |
| | 2026 | 3.2 | 2.2 |

# 7. CONCLUSIONS AND NEXT STEPS

This study has confirmed the existence of significant cost-effective CDM potential within Newfoundland and Labrador's commercial sector. The study results provide:

- Specific estimates of the potential CDM savings opportunities, defined by sector, sub sector, end use and, in several cases, specific technology(s)
- A baseline set of energy technology penetrations and energy use practices that can assist in the design of specific programs.

The next step[56] in this process involves the selection of a cost-effective portfolio of CDM programs and the setting of specific CDM targets and spending levels. To provide a preliminary reference point for this next step in the program development process, the study team conducted a brief literature search in an attempt to identify typical CDM spending levels in other jurisdictions. The literature search identified two (relatively) recent studies that had addressed similar issues on behalf of other Canadian utilities. The two studies are:

- *Demand-Side Management: Determining Appropriate Spending Levels and Cost-Effectiveness Testing,* which was prepared by Summit Blue Consulting and the Regulatory Assistance Project for the Canadian Association of Members of Public Utility Tribunals (CAMPUT). The study was completed January 30, 2006.
- *Planning and Budgeting for Energy Efficiency/Demand-Side Management Programs,* which was prepared by Navigant Consulting for Union Gas (Ontario) Limited. The study was completed in July 2005.

The CAMPUT study, which included a review of U.S. and Canadian jurisdictions, concluded that an annual CDM expenditure equal to about 1.5% of annual electricity revenues might be appropriate for a utility (or jurisdiction) that is in the early stages of CDM[57] programming. This level of funding recognizes that it takes time to properly introduce programs into the market place.

The same study found that once program delivery experience is gained, a ramping up to a level of about 3% of annual electricity revenues is appropriate. The study also notes that higher percentages may be warranted if rapid growth in electricity demand is expected or if there is an increasing gap between demand and supply due to such things as plant retirements or siting limitations. The current emphasis on climate change mitigation measures would presumably also fall into a similar category of potential CDM drivers.

The CAMPUT study also notes that even those states with 3% of annual revenues as their CDM target have found that there are more cost-effective CDM opportunities than could be met by the 3% funding. The finding is consistent with the situation in British Columbia. In the case of BC Hydro, CDM expenditures over the past few years have been about 3.3% of electricity

[56] Full treatment of these next steps is beyond the scope of the current project.
[57] The term DSM (demand-side management) and CDM are used interchangeably in this section.

revenues.[58] However, the results of BC Hydro's recently completed study (Conservation Potential Review (CPR) 2007) identified over 20,000 GWh of remaining cost-effective CDM opportunities by 2026. The magnitude of remaining cost-effective CDM opportunities combined with the aggressive targets set out in British Columbia's provincial Energy Plan suggest that BC Hydro's future CDM expenditures are likely to increase significantly if the new targets are to be met.

- **Additional notes:**

- Neither of the studies noted above found any one single, simple model for setting CDM spending levels and targets. Rather, the more general conclusion is that utilities use a number of different approaches that are reasonable for their context. In fact, the CAMPUT report identified seven approaches to setting CDM spending levels.

  - Based on cost-effective CDM potential estimates
  - Based on percentages of utility revenues
  - Based on Mills/kWh of utility electric sales
  - Levels set through resource planning process
  - Levels set through the restructuring process
  - Tied to projected load growth
  - Case-by-case approach.

- The CAMPUT study also notes that, although not always explicit, a key issue in most jurisdictions is resolving the trade off between wanting to procure all cost-effective energy-efficiency measures and concerns about the resulting short-term effect on rates. The study concludes that CDM budgets based on findings from an Integrated Resource Plan or a benefit-cost assessment tend to accept whatever rate effects are necessary to secure the overall resource plan, inclusive of the cost-effective energy-efficiency measures.

[58] CAMPUT, 2006. p. 14.

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# 9. TERMS USED IN BUILDING PROFILES

| Profile Term | Explanation |
|---|---|
| **Building Envelope** | Defines the thermal characteristics of a building's exterior components |
| U-value | The rate of heat loss, in Btu per hour per square foot per degree Fahrenheit (BTU/hr. $f^2.^oF$) through walls, roofs and windows. The U-value is the reciprocal of the R-value |
| Shading coefficient (SC) | Is a measure of the total amount of heat passing through the glazing compared with that through a single clear glass |
| Window-to-wall ratio | Defines the ratio of window to insulated exterior wall area |
| **General Lighting** | Defines the lighting types that are used within the main areas of a building, e.g., for a school, the area is classrooms and the lighting type is fluorescent; for a Food Retail store, the main area is the retail floor and the lighting types are fluorescent and metal halide. |
| LPD | Lighting power density expressed in terms of $W/ft^2$ |
| Lux | The amount of visible light per square meter incident on a surface ($lumen/m^2$) |
| Inc | Incandescent lamps |
| CFL | Compact fluorescent lamps |
| T12 | T12 fluorescent lamps with magnetic ballasts |
| T8 | T8 fluorescent lamps with electronic ballasts |
| MH | Metal halide lamps |
| HPS | High-pressure sodium lamps |
| HID | High-intensity discharge lighting includes both MH and HPS |
| **Secondary Lighting** | Defines the lighting types that are used within the secondary areas of a building, e.g., for a school, the secondary areas are corridors, lobbies, foyers, etc., and the lighting type is fluorescent. |
| **Tertiary Lighting** | Defines the lighting types that are used within special purpose areas of a building, e.g., for a school, the tertiary area is a gymnasium and the lighting type is metal halide. |
| **Outdoor Lighting** | Defines the outdoor lighting including parking lot and façade |
| **Overall LPD** | The total floor weighted LPD that includes general, secondary, tertiary, and outdoor. |
| **Fans** | Defines mix of air handling systems |
| CAV | Constant air volume |
| VAV | Variable air volume |
| **Space Heating** | Defines the mix of heating equipment types found within the stock of buildings |
| ASHP | Air source heat pump |
| WSHP | Water source heat pump |
| Resistance | Electric resistance heating equipment including boilers and baseboard heaters |
| Natural Gas | Natural gas heating equipment including packaged rooftop units and boilers |
| **Space Cooling** | Defines the mix of cooling equipment types found within the stock of buildings |
| Centrifugal | Standard centrifugal chillers with a full load performance of 0.75 kW/ton |
| Centri HE | High-efficiency centrifugal chillers assumed to have a performance of <0.65 kW/ton |
| Recip Open | Semi-hermetic reciprocating chillers |
| DX | Direct expansion cooling equipment that use small tonnage hermetic R-22 compressors |

# CONSERVATION AND DEMAND MANAGEMENT (CDM) POTENTIAL

# NEWFOUNDLAND and LABRADOR

# Industrial Sector

***–Final Report–***

*Prepared for:*

**Newfoundland & Labrador Hydro and**
**Newfoundland Power**

*Prepared by:*

**Marbek Resource Consultants Ltd.**

*In association with:*
**CBCL Ltd.**

*January 18, 2008*

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# EXECUTIVE SUMMARY

## ❑ Background and Objectives

Newfoundland and Labrador Hydro and Newfoundland Power (collectively the Utilities) have partnered to produce this study, recognizing the role that each has in energy conservation and least cost electric utility planning within the province. Increasing electricity costs and the expectations of a growing number of their customers and stakeholders have contributed to the increased focus on conservation and demand management (CDM) and resulted in a number of recent initiatives and projects targeting energy savings in the province. This study is the next step in the Utilities efforts to develop a comprehensive plan for CDM in Newfoundland and Labrador. The Utilities envision electricity conservation and demand management (CDM) to be a valuable component in meeting the province's future electricity requirements.

This study will also be a significant component in the further implementation of the Province's recently released Energy Plan. The Energy Plan establishes a long-term vision for how the province's energy resources will be developed and utilized to benefit the people of the province today as well as for future generations. Electricity conservation and demand management (CDM) are an important component of the provincial Energy Plan as are the conservation and demand management components for the other energy resources of the province.

This report meets, in part, the requirements of the Public Utilities Board Order PU 8 2007 requiring NLH to file this study and a five-year plan for implementation of CDM programs in 2008.

The objective of this study is to identify the potential contribution of specific CDM technologies and measures in the Residential, Commercial and Industrial sectors and to assess their economic costs and benefits. The Newfoundland and Labrador economy is expected to grow over the next 20 years, with an associated increase in energy consumption. The benefits of increased penetration of energy efficiency technologies include reduced energy costs for individuals and businesses, as well as environmental benefits through reduced pollution and greenhouse gas emissions.

The outputs from this study will assist the Utilities CDM planners and others to develop specific CDM programs for implementation and to optimize the contribution of CDM technologies and measures to the province's overall energy future.

## ❑ Scope and Organization

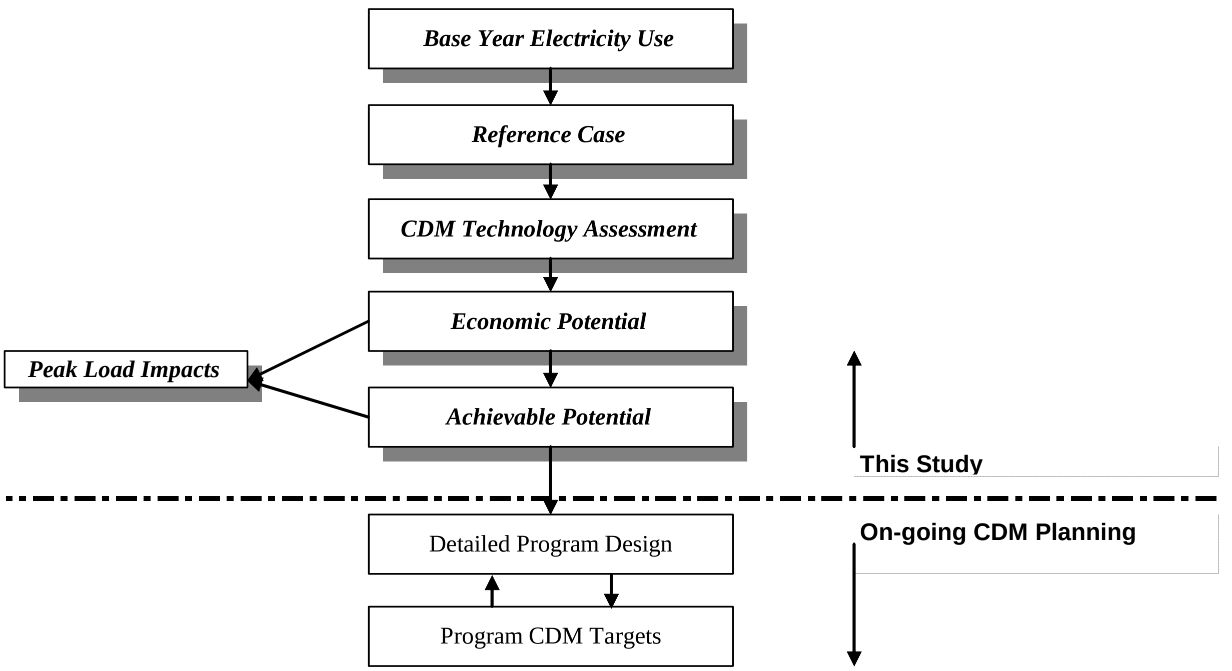
This study covers a 20-year study period from 2006 to 2026 and addresses the Residential, Commercial and Industrial sectors as well as street lighting. The study addresses the customers from both utilities. Due to differences in cost and rate structures, the Utilities' customers are organized into two service regions, which in this report are referred to as the Island and Isolated, and the Labrador Interconnected. For the purposes of this study, the isolated diesel system customers have been combined with those in the Island service region due to their relatively small size and electricity usage. The study reviews all commercially viable electrical efficiency technologies or measures.

## ❑ Approach

It was agreed that the Industrial sector, including the large transmission level customers, would be treated at a much higher level than the Residential and Commercial sectors, The detailed end-use analysis of electrical efficiency opportunities in the Industrial sector employed Marbek's customized spreadsheet model. The model is organized by major industrial sub sector and major end use. The sub sectors and end uses are described in detail in Section 2.

The major steps involved in the analysis are shown in Exhibit ES1 and are discussed in greater detail in Section 1. As illustrated in Exhibit ES1, the results of this study, and in particular the estimation of Achievable Potential,[1] support the on-going work of the Utilities; however, it should be emphasized that the estimation of Achievable Potential is not synonymous with either the setting of specific targets or with program design.

**Exhibit ES1: Study Approach - Major Analytical Steps**




## ❑ Overall Study Findings

As in any study of this type, the results presented in this report are based on a large number of important assumptions. Assumptions such as those related to the current penetration of energy-efficient technologies and the rate of future growth in the stock of industrial buildings are particularly influential. Wherever possible, the assumptions used in this study are consistent with those used by the Utilities and are based on best available information, which in many cases includes the professional judgement of the consultant team, Utilities' personnel and local experts.

[1] The proportion of savings identified that could realistically be achieved within the study period without consideration of budgetary constraints.

The reader should, therefore, use the results presented in this report as best available estimates; major assumptions, information sources and caveats are noted throughout the report.

The study findings confirm the existence of significant potential cost-effective opportunities for CDM in Newfoundland and Labrador's Industrial sector. Electricity savings from efficiency improvements within the Island and Isolated service region would provide between 125 and 59 GWh/yr. of electricity savings by 2026 in, respectively, the Upper and Lower Achievable scenarios. The most significant Achievable Savings opportunities were in the actions that addressed motors and compressed air, and refrigeration/freezing and cooling for the Small and Medium Sector, and process specific equipment in the Large Industrial Sector.

- **Summary of Electricity Savings**

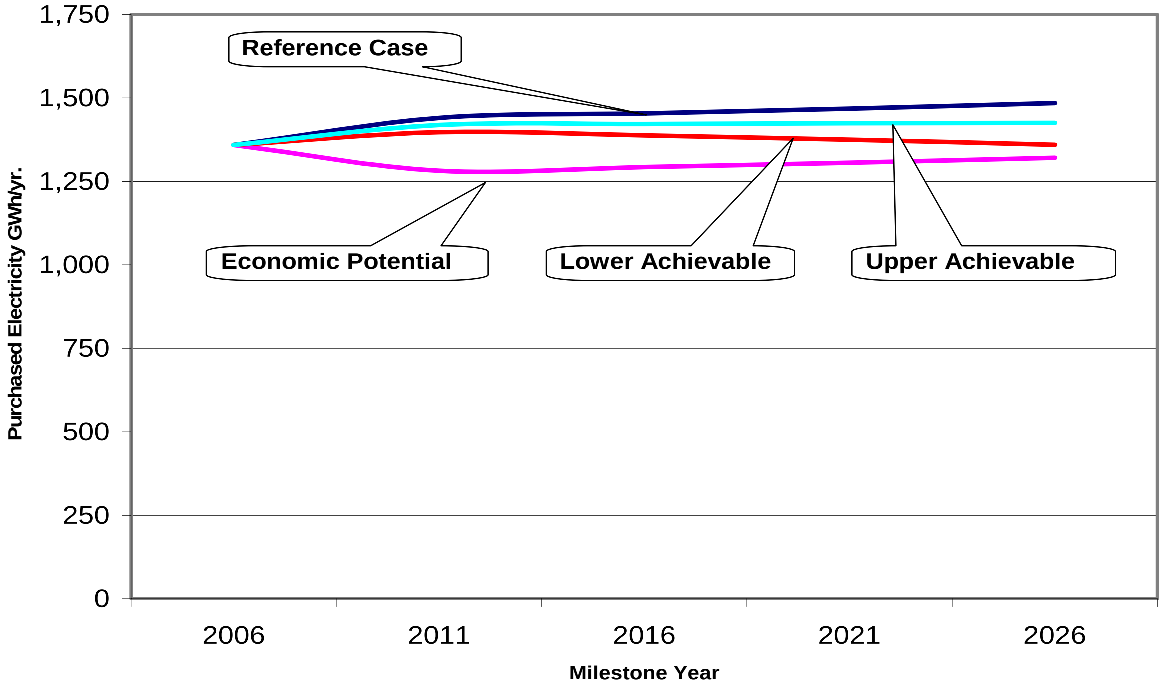
A summary of the levels of annual electricity consumption contained in each of the forecasts addressed by the study is presented in Exhibits ES2 and ES3, by milestone year, and discussed briefly in the paragraphs below.

**Exhibit ES2: Summary of Forecast Results for the Island and Isolated Service Region – Annual Purchased Electricity Consumption,* Industrial Sector (GWh/yr.)**

| Annual Consumption (GWh/yr.) | | | | | | Potential Annual Savings | | |
|---|---|---|---|---|---|---|---|---|
| Milestone Year | Base Year | Reference Case | Economic | Achievable | | Economic | Achievable | |
| | | | | Upper | Lower | | Upper | Lower |
| 2006 | 1,359 | 1,359 | | | | | | |
| 2011 | | 1,440 | 1,282 | 1,397 | 1,419 | 158 | 43 | 21 |
| 2016 | | 1,454 | 1,293 | 1,388 | 1,422 | 161 | 66 | 32 |
| 2021 | | 1,468 | 1,306 | 1,375 | 1,424 | 162 | 93 | 44 |
| 2026 | | 1,484 | 1,321 | 1,360 | 1,425 | 164 | 125 | 59 |

**Results are measured at the customer's point-of-use and do not include line losses and exclude self-generation of about 3,200 GWh/yr.*

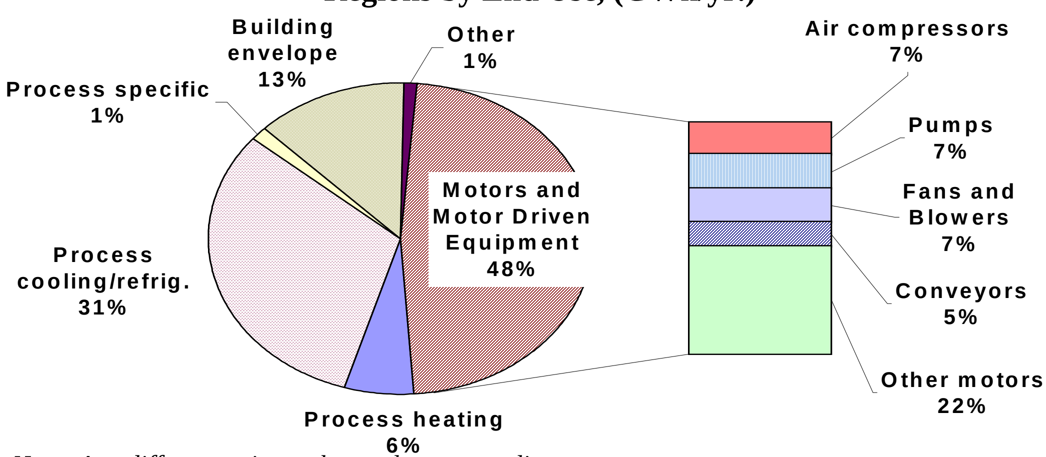
**Exhibit ES3: Reference Case versus Upper and Lower Achievable Potential Electricity Consumption in the Industrial Sector (GWh/yr.)**




## Base Year Electricity Use

In the Base Year of 2006, the Island and Isolated and Labrador Interconnected service regions consumed about 4,558 GWh, of which 1,359 GWh was purchased electricity. The Large Industrial sub sector consumed 79% of the total purchased electricity. Exhibit ES4 shows the purchase electricity use by end use for the Small and Medium Industrial sector. Most of the electricity is used by motor and motor drive equipment (48%) and process cooling and refrigeration/freezing (31%).

**Exhibit ES4: Small and Medium Industry Base Year Modelled Annual Purchased Electricity Consumption for the Island and Isolated and Labrador Interconnected Service Regions by End Use, (GWh/yr.)**




*Note: Any differences in totals are due to rounding.*

### *Reference Case*

In the absence of new Utilities CDM initiatives, the study estimates that purchased electricity consumption in the Industrial sector will grow from 1,359 GWh/yr. in 2006 to about 1,484 GWh/yr. by 2026 in the Island and Isolated and Labrador Interconnected service regions. This represents an overall growth of about 9% in the period and compares very closely with NLH's load forecast, which also included consideration of the impacts of "natural conservation" for the Small and Medium Industrial sectors.

### *Economic Potential Forecast*

Under the conditions of the Economic Potential Forecast,[2] the study estimated that electricity consumption in the Industrial sector would decline to about 1,321 GWh/yr. by 2026 in the Island and Isolated and Labrador Interconnected service regions. Annual savings relative to the Reference Case are 164 GWh/yr. or about 11%.

### *Achievable Potential*

The Achievable Potential is the proportion of the economic electricity savings (as noted above) that could realistically be achieved within the study period. In the Industrial sector within the Island and Isolated and Labrador Interconnected service regions, the Achievable Potential for electricity savings was estimated to be 125 GWh/yr. and 59 GWh/yr. by 2026 in, respectively, the Upper and Lower scenarios.

The most significant Achievable savings opportunities were in the actions that addressed motors and compressed air, refrigeration/freezing and cooling for the Small and Medium Industrial Sectors, and process specific equipment in the Large Industrial sector.

[2] The level of electricity consumption that would occur if all equipment were upgraded to the level that is cost effective against future avoided electricity costs.

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**APPENDICES**

Appendix A: Industry Electricity Survey
Appendix B: Opportunity Profiles
Appendix C: Opportunity Profile Worksheets

## List of Exhibits

# 1. INTRODUCTION

## 1.1 BACKGROUND AND OBJECTIVES

Newfoundland and Labrador Hydro and Newfoundland Power (collectively the Utilities) have partnered to produce this study, recognizing the role that each has in energy conservation and least cost electric utility planning within the province. Increasing electricity costs and the expectations of a growing number of their customers and stakeholders have contributed to the increased focus on conservation and demand management (CDM) and resulted in a number of recent initiatives and projects targeting energy savings in the province. This study is the next step in the Utilities efforts to develop a comprehensive plan for CDM in Newfoundland and Labrador. The Utilities envision electricity conservation and demand management (CDM) to be a valuable component in meeting the province's s future electricity requirements.

This study will also be a significant component in the further implementation of the Province's recently released Energy Plan. The Energy Plan establishes a long-term vision for how the province's energy resources will be developed and utilized to benefit the people of the province today as well as for future generations. Electricity conservation and demand management (CDM) are an important component of the provincial Energy Plan as are the conservation and demand management components for the other energy resources of the province.

This report is prepared to meet, in part, the requirements of the Public Utilities Board Order PU 8 2007 requiring NLH to file this study and a five year plan for implementation of CDM programs in 2008.

The objective of this study is to identify the potential contribution of specific CDM technologies and measures in the Residential, Commercial and Industrial sectors and to assess their economic costs and benefits. The Newfoundland and Labrador economy is expected to grow over the next 20 years, with an associated increase in energy consumption. The benefits of increased penetration of energy efficiency technologies include reduced energy costs for individuals and businesses, as well as environmental benefits through reduced pollution and greenhouse gas emissions.

The outputs from this study will assist the Utilities CDM planners and others to develop specific CDM programs for implementation and to optimize the contribution of CDM technologies and measures to the province's overall energy future.

## 1.2 STUDY SCOPE

The scope of this study is summarized below.

- **Sector Coverage:** This study addresses the Residential, Commercial and Industrial sectors as well as street lighting. It was agreed that the Industrial sector, including the large transmission level customers, would be treated at a much higher level than the Residential and Commercial sectors.

- **Geographical Coverage**: The study addresses the customers from both utilities. Due to differences in cost and rate structures, the Utilities' customers are organized into two service regions, which in this report are referred to as the Island and Isolated and the Labrador Interconnected. For the purposes of this study, the isolated diesel system customers have been combined with those in the Island service region due to their relatively small size and electricity usage..

- **Study Period**: This study covers a 20-year period. The Base Year is the calendar year 2006, with milestone periods at five-year increments: 2011, 2016, 2021 and 2026. The Base Year of 2006 was selected as this was the most recent calendar year for which complete customer data were available.

- **Technologies:** The study addresses conservation and demand management (CDM) measures. CDM refers to a broad range of potential measures (see Section 1.3, Definitions); however, for the purposes of this study, it was agreed that the primary focus is on energy-efficiency measures. This includes measures that reduce electricity use, and for the Residential and Commercial sectors the associated capacity impact on a winter peak period was included.

### 1.2.1 Data Caveat

As in any study of this type, the results presented in this report are based on a large number of important assumptions. Assumptions such as those related to the current penetration of energy-efficient technologies, the rate of future growth in the province's industrial electricity load and customer willingness to implement new CDM measures are particularly influential.

Wherever possible, the assumptions used in this study are consistent with those used by the Utilities and are based on best available information, which in many cases includes the professional judgement of the consultant team, client personnel and/or local experts. The reader should use the results presented in this report as best available estimates; major assumptions, information sources and caveats are noted throughout the report.

## 1.3 DEFINITIONS

This study uses numerous terms that are unique to analyses and consequently it is important to ensure that readers have a clear understanding of what each term means when applied to this study. A brief description of some of the most important terms and their application within this study is included below.

| | |
|---|---|
| ***Base Year Electricity Use*** | The Base Year is the starting point for the analysis. It provides a description of "where" and "how" electrical energy is currently used in the existing Industrial sector facilities. The results are calibrated to actual utility customer billing data for the Base Year. As noted previously, the Base Year for this study is the calendar year 2006. |

***Reference Case Electricity Use*** The Reference Case Electricity Use estimates the expected level of electrical energy consumption that would occur over the study period in the absence of new (post-2006) utility-based CDM initiatives. It provides the point of comparison for the subsequent calculation of "economic" and "achievable" electricity savings potentials. The Reference Case aligns well with the NLH Long Term Planning (PLF) Review Forecast, Summer/Fall 2006.

***Conservation and Demand Management (CDM) Measures*** CDM refers to a broad range of potential measures that can include: energy efficiency (use more efficiently), energy conservation (use less), demand management (use less during peak periods), fuel switching (use a different fuel to provide the energy service) and self-generation/co-generation (displace load off of grid).

As noted in Section 1.2, it was agreed that the primary focus is on energy-efficiency measures and this includes measures that reduce electricity use.

***The Cost of Conserved Energy (CCE)*** The CCE is calculated for each energy-efficiency measure. The CCE is the annualized incremental capital and operating and maintenance (O&M) cost of the upgrade measure divided by the annual energy savings achieved, excluding any administrative or program costs. The CCE represents the cost of conserving one kWh of electricity; it can be compared directly to the cost of supplying one new kWh of electricity.

***Economic Potential Electricity Forecast*** The Economic Potential Electricity Forecast is the level of electricity consumption that would occur if all equipment and facilities were upgraded to the level that is cost effective against the future avoided cost of electricity in the Newfoundland and Labrador Hydro service area (for this study, the value was set at $0.0980/kWh for the Island and Isolated service area and $0.0432/kWh for the Labrador Interconnected service area).[3]). All the energy-efficiency upgrades included in the technology assessment that had a CCE equal to, or less than, the preceding avoided cost of new electricity supply were incorporated into the Economic Potential Forecast.

***Achievable Potential*** The Achievable Potential is the proportion of the savings identified in the Economic Potential Forecast that could realistically be achieved within the study period. Achievable Potential recognizes that it is difficult to induce customers to

[3] Sensitivity analysis was also conducted using avoided cost values expected to prevail if the Lower Churchill/DC Link project is completed.

purchase and install all the electrical efficiency technologies that meet the criteria defined by the Economic Potential Forecast. The results are presented as a range, defined as "upper" and "lower."

## 1.4 APPROACH

To meet the objectives outlined above, the study was conducted within an iterative process that involved a number of well-defined steps. At the completion of each step, the client reviewed the results and, as applicable, revisions were identified and incorporated into the interim results. The study then progressed to the next step. A summary of the steps is presented below.

***Step 1:*** **Develop Base Year Electricity Use Profile**

- Compile available data on the Utilities' industrial customers.
- Conduct "high-level" facility energy use survey of transmission level customers.
- Develop "high-level" technical profile of electricity use within the major industrial facilities, based on survey results, existing facility data, experience in other jurisdictions and study team experience.
- Create sector model inputs and generate results.
- Calibrate sector model results using actual utility billing data.

***Step 2:*** **Develop Reference Case Electricity Use Profile**

- Develop computer spreadsheet simulations of electricity use in each industrial sub sector and electricity end use.
- Compile data on forecast levels of growth in Industrial sub sectors, "natural" changes in equipment efficiency levels and/or practices.
- Define sector model inputs and create forecasts of electricity use for each of the milestone years.

***Step 3:*** **Identify and Assess Energy-efficiency Measures**

- Develop list of energy-efficiency measures.
- Compile cost and performance data for each measure.
- Identify the baseline technologies employed in the Reference Case, develop energy-efficiency upgrade options and associated electricity savings for each option and determine the CCE for each upgrade option.

***Step 4:*** **Estimate Economic Electricity Savings Potential**

- Compile utility economic data on the forecast cost of new electricity generation; costs of $0.0980/kWh and $0.0432/kWh were selected as the economic screens for, respectively, the Island and Isolated and Labrador Interconnected service regions.
- Screen the identified energy-efficiency upgrade options from Step 3 against the utility economic data.
- Identify the energy-efficiency upgrade measures and industry sub sectors where the cost of saving one kilowatt of electricity is equal to, or less than, the cost of new electricity generation.

- Apply the economically attractive electrical efficiency measures from Step 3 within the energy use simulation model developed previously for the Reference Case.
- Determine annual electricity consumption in each industrial sub sector and end use when the economic efficiency measures are employed.
- Compare the electricity consumption levels when all economic efficiency measures are used with the Reference Case consumption levels and calculate the electricity savings.

***Step 5:*** **Estimate Achievable Potential Electricity Savings**

- "Bundle" the electricity reduction opportunities identified in the Economic Potential Forecasts into a set of opportunities.
- For each of the identified opportunities, create an Opportunity Profile that provides a "high-level" implementation framework, including measure description, cost and savings profile, target sub sectors, potential delivery allies, barriers and possible synergies.
- Review historical achievable program results and prepare preliminary Assessment Worksheets.
- Conduct workshop with industry, suppliers and engineering consulting representatives to define achievable potential.
- Determine achievable potential for each end use and sub sector.

## 1.5 ANALYTICAL MODEL

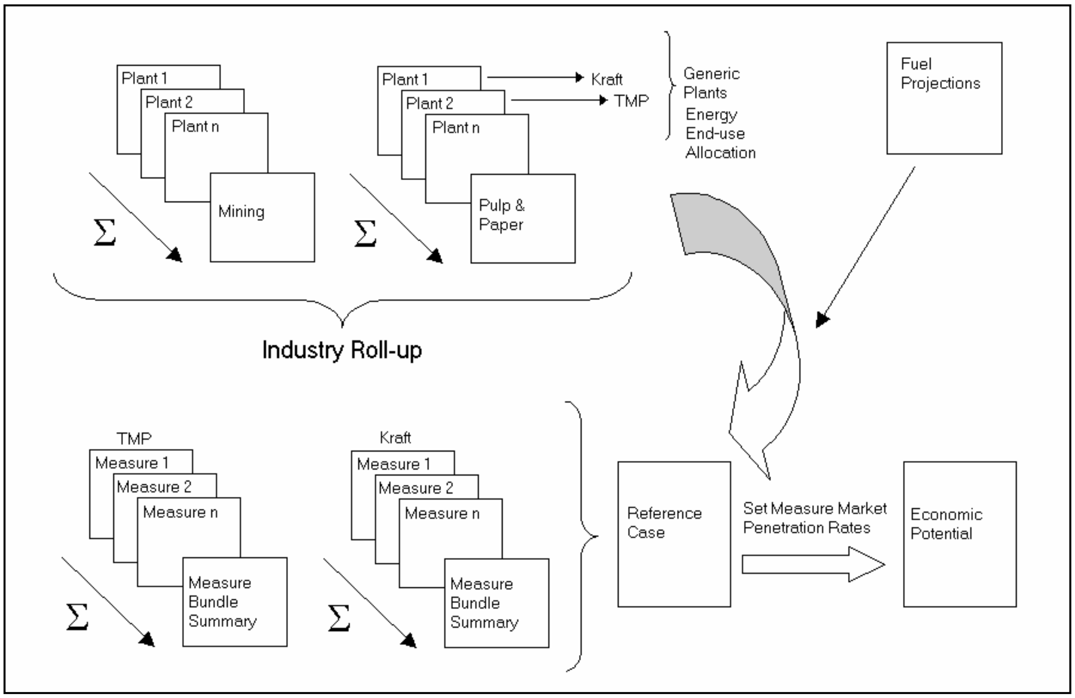
The analysis of the Industrial sector employed Marbek's customized spreadsheet model. The model is organized by major industrial sub sector and major end use. The sub sectors and end uses are described in detail in Section 2.

The model addresses each sub sector by defining a "generic" plant for the sub sector as a whole. Exhibit 1.1 illustrates how the model combines sub sector, end use, efficiency measures and fuel share data to generate the energy use forecasts used in the study.

The generic plant construct within the model is used to define an energy consumption profile representative of a "typical" or archetype plant within a given industry sub sector (or a specific type of plant within a given sub sector if there are substantial process differences). In Exhibit 1.1, the Pulp and Paper sub sector is used as an example with two archetype plants: TMP (thermomechanical pulping mill) and Kraft (kraft pulping mill). The generic plant is a composite of energy use patterns, energy intensities and consumption levels within the particular target sub sector. The candidate energy management measures are applied to the generic plant to model energy savings potential.

Marbek's existing stock of generic industrial plants was used as a starting point for the analysis. The model was customized to the specific Newfoundland and Labrador facilities based on a survey of Large industry and input from Newfoundland and Labrador study team experts familiar with the provincial industrial facilities.

**Exhibit 1.1: Industry Model Diagram**




Note:

- TMP :Thermomechanical pulping mill (Archetype plant in pulp and paper sector)
- Kraft: Kraft pulping mill (Archetype plant in pulp and paper sector)

## 1.6 STUDY ORGANIZATION AND REPORTS

The study was organized and conducted by sector using a common methodology, as outlined above. The results for each sector are presented in individual reports as well as in a summary report. They are entitled:

- *Conservation and Demand Management Potential (2006 to 2026), Newfoundland and Labrador, Residential Sector*
- *Conservation and Demand Management Potential (2006 to 2026), Newfoundland and Labrador, Commercial Sector*
- *Conservation and Demand Management Potential (2006 to 2026), Newfoundland and Labrador, Industrial Sector*
- *Conservation and Demand Management Potential (2006 to 2026), Newfoundland and Labrador, Residential, Commercial and Industrial Sectors, Summary Report*

The study also prepared a brief CDM program evaluation report, which is entitled:

- *Conservation and Demand Management Potential (2006 to 2026), Newfoundland and Labrador, Program Evaluation Guidelines*.

This report presents the Industrial sector results; it is organized as follows:

- Section 2 presents a profile of Industrial sector Base Year electricity use in Newfoundland and Labrador, including a discussion of the major steps involved and the data sources employed.
- Section 3 presents a profile of Industrial sector Reference Case electricity use in Newfoundland and Labrador for the study period 2006 to 2026, including a discussion of the major steps involved.
- Section 4 identifies and assesses the economic attractiveness of the selected energy-efficiency technology measures for the Industrial sector.
- Section 5 presents the Industrial sector Economic Potential Electricity Forecast for the study period 2006 to 2026.
- Section 6 presents the estimated Upper and Lower Achievable Potential for electricity savings for the study period 2006 to 2026.
- Section 7 presents conclusions and next steps.
- Section 8 presents a listing of major references.

# 2. BASE YEAR (F2006) ELECTRICITY USE

## 2.1 INTRODUCTION

This section provides a profile of Base Year (2006) electricity use in Newfoundland and Labrador's Industrial sector. The discussion is organized into the following subsections:

- Segmentation of Industrial Sector
- Definition of End Uses
- Development of Electricity Use Profiles
- Summary of Results.

## 2.2 SEGMENTATION OF INDUSTRIAL SECTOR

The first major task in developing the Base Year calibration involved the segmentation of the industrial customers into specific sub sectors. The choice of sub sectors was determined by the combination of four factors:

- Data availability
- The need to maintain customer confidentiality
- The need to facilitate subsequent analysis of potential electrical efficiency improvements, which means that there must be similarity in terms of major design and operating considerations, such as manufacturing process, hours of operation and product type
- The resources required to assess industrial facilities, especially with large industrial facilities being significantly different from each other. As noted in Section 1, it was agreed that the Industrial sector would be treated at a "high level."

A summary of the Industrial sub sectors that are used in this study is provided in Exhibit 2.1

**Exhibit 2.1: Industrial Sub Sectors**

- **Large Industrial** (includes: Pulp and Paper, Large Mining and Oil Refining)
- **Small and Medium Industrial**:
  - Fishing and Fish Processing
  - Manufacturing
  - Other

A brief description of the industrial customers included in each of the sub sectors shown in Exhibit 2.1 is provided below.

- **Large Industrial**. This classification is based on the amount of electricity used and not on production volumes or number of employees. Facilities included in this category use more than 50 GWh electricity annually. This sub sector consists of six transmission level customers from the following sub sectors: Mining, Pulp and Paper and Oil Refining.

- **Small and Medium Industrial.** Similar to the Large Industrial category, this category is based on the amount of electricity and includes facilities that use less than 50 GWh/yr. The following sub sectors are included:

  - **Fishing and Fish Processing**. This sub sector consists of approximately 175 facilities. This sub sector's monthly electricity consumption is seasonal (monthly consumption peaking in July and August; minimum usage from January to March). The monthly peak consumption is almost 3.5 times more than the minimum monthly consumption.

  - **Manufacturing.** This sub sector consists of approximately 135 facilities; monthly electricity consumption is relatively stable throughout the year.

  - **Other.** This sub sector includes all the industrial facilities using less than 50 GWh/yr. and which are not included under the Fishing or Manufacturing sub sectors. The sub sectors included are: Small and Medium Mining, Municipal Water and Sewer Facilities and Commercial and Utility Water Systems. Approximately 95 facilities are included in this sub sector and the monthly electricity consumption is relatively consistent throughout the year.

The modeling of energy use was executed at the sub sector level, with archetypes for each of the three Large, and Small and Medium Industrial sub sectors. For the Large Industrial sector, the data and results are presented at the aggregated Large Industrial sub sector level to ensure that confidentiality of facility information is maintained.

## 2.3 DEFINITION OF END USES

Electricity use within each of the sub sectors noted above is further defined on the basis of specific end uses. In this study, an end use is defined as, "the final application or final use to which energy is applied. End uses are the services of economic value to the users of energy."

A summary of the major Industrial sector end uses used in this study is provided in Exhibit 2.2 together with a brief description of each.

**Exhibit 2.2: Industrial Sector End Uses**

| Electricity End Use | | Description |
|---|---|---|
| Process heating | | Process heating, including hot water and steam production and distribution |
| Process cooling / refrigeration / freezing | | Process related cooling, refrigeration and freezing |
| Motors and motor driven equipment | Compressed air | Compressed air utilities, including compressors and compressed air distribution system |
| | Pumps | Process pumps |
| | Fans and blowers | Fans and blowers |
| | Conveyors | Conveyors and material handling |
| | Other motors | Motors not included in other categories, for example, motors in grinding, stamping, pressing equipment |
| Process specific | | Processes and equipment not included in the other process categories and are specific to a sub sector |
| Building envelope and comfort | Lighting | Lighting systems |
| | Comfort heating, cooling, ventilation and air conditioning (HVAC) | HVAC for comfort and work space climate control |
| Other | | End uses not included in the other categories. These end-uses include system-wide end uses, such as plant-wide control systems and other supporting end uses, such as electric doors, electric charging for electric forklifts. |

## 2.4 DEVELOPMENT OF INDUSTRIAL ELECTRICITY USE PROFILES

Electricity end-use profiles were developed for the six sub sectors described above. The profiles map proportionally how much electricity is used by each of the end uses for each sub sector. These profiles represent the sub sector archetypes and are used in the model to calculate the electricity used by each end use for each sub sector.

Three archetype profiles were developed for Large industry based on the results of a survey of the facilities included in these sub sectors.[4] In each case, site personnel provided data, which addressed both the allocation of electricity use by end use and general best practices implemented at the sites. A copy of the survey instrument is contained in Appendix A.

Experience from previous industry studies in other Canadian jurisdictions provided the necessary archetype end-use profiles for the three Small and Medium Industrial sub sectors. These profiles were reviewed by industry experts familiar with industry in Newfoundland and Labrador (NL) and were revised to be representative of the NL industrial sub sectors.

[4] The results were also compared with those from detailed studies of similar industries undertaken by Marbek and were found to compare well.

## 2.5 SUMMARY OF MODEL RESULTS

The summary of Base Year model results are measured at the customer's point-of-use.[5]

Exhibit 2.3 presents the model results for the Island and Isolated and Labrador Interconnected service regions with the results broken out by Industrial sub sector and end use. It is assumed that self-generated electricity is mixed with purchased electricity and does not apply selectively to end uses. Purchased electricity is the main focus to determine savings potential and self-generated electricity is presented separately.[6]

Highlights of the results are as follows:

### 2.5.1 Base Year Electricity Use by Sub Sector

Exhibits 2.3 and 2.4 indicate that:

- Almost 70% of all electricity use by industry is self-generated, while the remaining 30% (1,359 GWh/yr.) is supplied by NLH and NP. All the self-generated electricity is produced by the Large Industrial sub sector.
- Large industrial facilities use approximately 94% of all the electricity used by industry in Newfoundland and Labrador but consume about 1,067 GWh/yr. (79%) if only purchased electricity is considered.
- Of the Small and Medium Industrial sub sector, the Fishing and Fish Processing sub sector accounts for about 53% of electricity use.

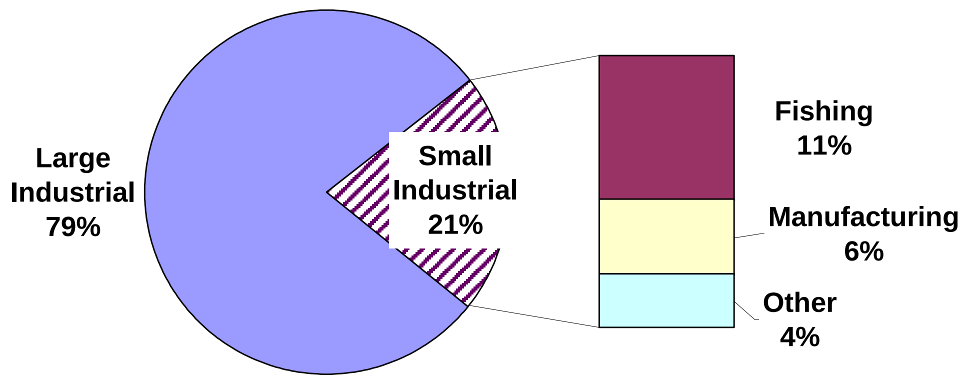
**Exhibit 2.3: Base Year Modelled Annual Electricity Consumption for the Island and Isolated and Labrador Interconnected Service Regions by Sub Sector, (GWh/yr.)**

| Sectors | | Purchased Electricity (GWh/yr.) | Self-generated Electricity (GWh/ yr.) | Total Electricity Use (GWh/yr.) | Percentage of Total (%) |
|---|---|---|---|---|---|
| Large Industrial | | 1,067 | 3,229 | 4,296 | 94% |
| Small and Medium Industrial | *Fishing* | *156* | | *156* | *3%* |
| | *Manufacturing* | *81* | | *81* | *2%* |
| | *Other* | *56* | | *56* | *1%* |
| | Sub-total | 292 | 0 | 292 | 6% |
| ***Total*** | | ***1,359*** | ***3,229*** | ***4,588*** | ***100%*** |
| ***Percentage of Total*** | | ***29.6%*** | ***70.4%*** | ***100.0%*** | |

*Note: Any differences in totals are due to rounding.*

[5] Self-generated electricity includes line losses of transmission facilities not owned by NLH.
[6] Self-generation sites are owned and operated by individual customers, not the Utilities. As detailed, site-specific analysis of individual industrial facilities was outside the scope of this study, these facilities and related CDM opportunities were not included in the results presented.

**Exhibit 2.4: Base Year Modelled Annual Purchased Electricity Consumption for the Island and Isolated and Labrador Interconnected Service Region by Sub Sector, (GWh/yr.)**




*Note: Any differences in totals are due to rounding.*

### 2.5.2 Base Year Electricity Use by End Use

The electricity use by industrial end uses is summarized and illustrated in Exhibits 2.5 to 2.7. The results indicate that:

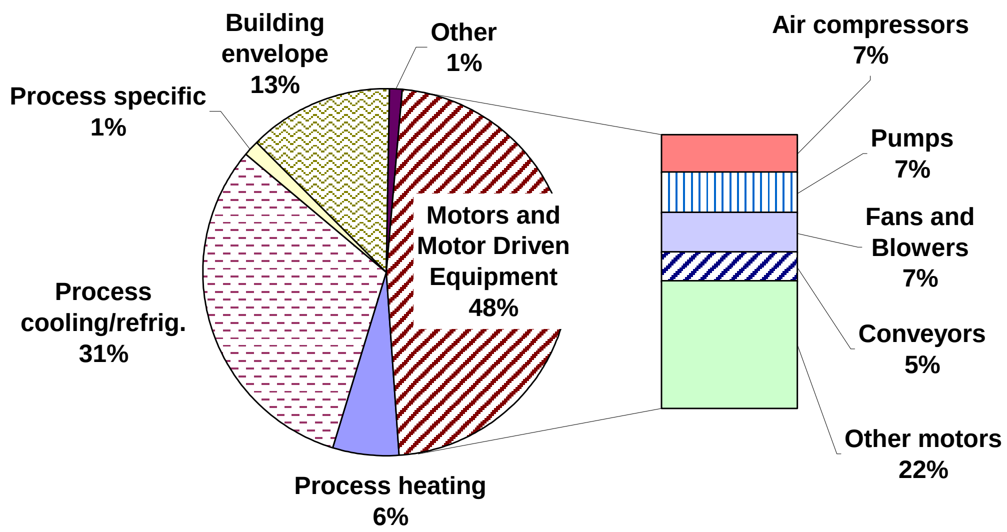
- Motors and motor driven equipment, including compressed air systems, use close to 63% of all the electricity in industry. Within this end use "other motors" account for almost 55% of end-use electricity; pumps account for 17%.
- The second largest electricity end-use consumption is associated with the process-specific end use, namely 18% of total industrial electricity use.
- When only purchased electricity is assessed and self-generation is excluded, the motor and motor driven equipment portion of electricity use decreases slightly to 60% (as illustrated in Exhibit 2.6). Within this end use, the portion of electricity used by "other motors" decreases to 45%, while the portion allocated to pumps increases to 22% and compressed air increases from 10% to 16%. This change is mainly due to the difference in end-use profiles of Large industry, which is responsible for all self-generated electricity.

## Exhibit 2.5: Base Year Modelled Annual Total Electricity Consumption for the Island and Isolated and Labrador Interconnected Service Region by Sub Sector and End Use, (GWh/yr.)

| **Electricity End Use** | | **Large Industry – Electricity Use** | | **Small and Medium Industry – Electricity Use** | | | | | **Total** | **Percentage of Total (%)** |
|---|---|---|---|---|---|---|---|---|---|---|
| | | **Sub Total (GWH/yr.)** | **Percentage of Total (%)** | **Fishing (GWH/yr.)** | **Manufact. (GWH/yr.)** | **Other (GWH/yr.)** | **Sub Total (GWH/yr.)** | **Percentage of Total (%)** | | |
| Process heating (incl. water heaters, steam production) | | 260 | 6% | *12* | *2* | *2* | 17 | 5.7% | **277** | 6.0% |
| Process cooling / refrigeration / freezing | | 26 | < 1% | *90* | *< 1* | *1* | 92 | 31.4% | **118** | 2.6% |
| Motors and motor driven equipment | Air compressors | 189 | 4% | *5* | *14* | *1* | 20 | 6.7% | **209** | 4.5% |
| | Pumps | 474 | 11% | *9* | *4* | *7* | 20 | 7.0% | **494** | 10.8% |
| | Fans and blowers | 273 | 6% | *2* | *11* | *8* | 20 | 6.9% | **293** | 6.4% |
| | Conveyors | 292 | 7% | *6* | *3* | *5* | 12 | 4.0% | **304** | 6.6% |
| | Other motors | 1,542 | 36% | *6* | *33* | *25* | 64 | 22.1% | **1,606** | 35.0% |
| Process specific | | 817 | 19% | *3* | *< 1* | *1* | 4 | 1.5% | **822** | 17.9% |
| Building envelope and comfort | Lighting | 220 | 5% | *12* | *11* | *3* | 29 | 10.1% | **250** | 5.5% |
| | Comfort heating, cooling, ventilation and air conditioning (HVAC) | 140 | 3% | *8* | *2* | *2* | 11 | 3.8% | **151** | 3.3% |
| Other | | 62 | 2% | *2* | *< 1* | *1* | 2 | 0.8% | **65** | 1.4% |
| ***TOTAL*** | | ***4,296*** | 100% | *156* | *81* | *56* | ***292*** | 100.0% | ***4,588*** | ***100.0%*** |
| Percentage of Total | | 94% | | *3.4%* | *1.8%* | *1.2%* | 6.4% | | 100.0% | |

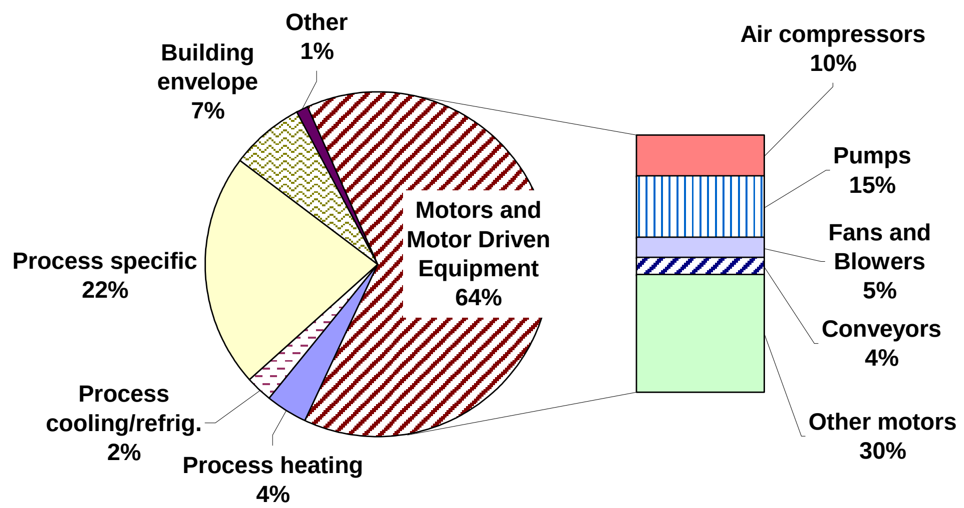
*Note: Any differences in totals are due to rounding.*

**Exhibit 2.6: Small and Medium Industry Base Year Modelled Annual Purchased Electricity Consumption for the Island and Isolated and Labrador Interconnected Service Regions by End Use, (GWh/yr.)**




*Note: Any differences in totals are due to rounding.*

**Exhibit 2.7: Large Industry Base Year Modelled Annual Purchased Electricity Consumption for the Island and Isolated and Labrador Interconnected Service Regions by End Use, (GWh/yr.)**




*Note: Any differences in totals are due to rounding.*

# 3. REFERENCE CASE ELECTRICITY USE

## 3.1 INTRODUCTION

This section presents the Industrial sector Reference Case for the study period (2006 to 2026). The Reference Case estimates the expected level of electricity consumption that would occur over the study period in the absence of new Utilities-based CDM initiatives.

The Reference Case, therefore, provides the point of comparison for the calculation of electricity savings opportunities associated with each of the subsequent scenarios that are assessed within this study.

The discussion is presented within the following subsections:

- Forecast Electricity Consumption
- “Natural” Changes Affecting Electricity Use
- Summary of Model Results.

## 3.2 FORECAST ELECTRICITY CONSUMPTION

Exhibit 3.1 provides the electricity consumption forecast for the milestone years 2011, 2016, 2021 and 2026. The forecast is based on projected growth forecasts for Small and Medium industry provided by NLH, which includes anticipated closing of existing facilities and opening of new facilities. Potential new large industrial loads on the system are not included due to the uncertain and unknown make-up of process end use energy requirements. The self-generated electricity consumption is frozen for the 20-year forecast.

**Exhibit 3.1: Forecast Annual Electricity Consumption for the Island and Isolated and Labrador Interconnected Service Regions by Sub Sector and Milestone Year, (GWh/yr.)**

| Sub Sector | | Electricity Use by Milestone Year (GWH/y) | | | | |
|---|---|---|---|---|---|---|
| | | **2006** | **2011** | **2016** | **2021** | **2026** |
| Large Industrial | Purchased electricity | 1,067 | 1,132 | 1,132 | 1,132 | 1,132 |
| | Self-generation | 3,229 | 3,229 | 3,229 | 3,229 | 3,229 |
| | *Sub-total* | *4,296* | *4,361* | *4,361* | *4,361* | *4,361* |
| Small and Medium Industrial (Purchased) | Fishing | 156 | 161 | 168 | 174 | 181 |
| | Manufacturing | 81 | 85 | 89 | 94 | 99 |
| | Other | 56 | 62 | 65 | 68 | 71 |
| | *Sub-total* | *292* | *308* | *322* | *336* | *352* |
| Total purchased electricity | | 1,359 | 1,440 | 1,454 | 1,468 | 1,484 |
| Total self-generated electricity | | 3,229 | 3,229 | 3,229 | 3,229 | 3,229 |
| ***TOTAL*** | | ***4,588*** | ***4,669*** | ***4,683*** | ***4,697*** | ***4,713*** |

## 3.3 "NATURAL" CHANGES AFFECTING ELECTRICITY USE

The Reference Case is calibrated to the Utilities' forecasts, which assumes "natural" conservation through efficiency improvements in Small and Medium industry over the 20-year forecast period.

## 3.4 SUMMARY OF MODEL RESULTS

Exhibits 3.2 to 3.5 summarize the model results for each of the milestone years in the study period. Consistent with the scope of analysis for this sector, the results shown assume that the generic plant end-use profiles are frozen for the study period. As a result, the distribution of electricity use in each of the forecast milestone years is very similar to the Base Year results. For example:

- The Large Industrial sub sector continues to dominate electricity use, accounting for approximately 76% of total purchased industrial electricity use in 2026.
- Motors and motor driven equipment (61%) continue to account for the largest share of total (large, and Small and Medium combined) industrial electricity use in 2026.
- In the Small and Medium Industrial sub sector, process refrigeration accounts for about 30% of the electricity use.
- The building envelope and comfort end use continues to account for less than 5% of total electricity use in both the Large, and Small and Medium Industrial sub sectors over the study period.

## Exhibit 3.2: Forecast Year 2011 Modelled Annual Purchased Electricity Consumption for the Island and Isolated and Labrador Interconnected Service Regions by Sub Sector and End Use, (GWh/yr.)

| Electricity End Use | | Large Industry - Electricity Use | | Small Industry - Electricity Use | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | **Sub-Total (GWH/y)** | **Percentage of Total (%)** | **Fishing (GWH/y)** | **Manufact. (GWH/y)** | **Other (GWH/y)** | **Sub-Total (GWH/y)** | **Percentage of Total (%)** | **Total** | **Percentage of Total (%)** |
| Process heating (incl. water heaters, steam production) | | 48 | 4% | *13* | *2* | *3* | 18 | 6% | 66 | 5% |
| Process cooling / refrigeration / freezing | | 26 | 2% | *94* | *0.1* | *2* | 95 | 31% | 122 | 8% |
| Motors and motor driven equipment | Air compressors | 111 | 10% | *5* | *14* | *1* | 21 | 7% | 132 | 9% |
| | Pumps | 169 | 15% | *10* | *4* | *7* | 22 | 7% | 191 | 13% |
| | Fans and Blowers | 59 | 5% | *2* | *12* | *8* | 21 | 7% | 80 | 6% |
| | Conveyors | 54 | 5% | *6* | *3* | *6* | 16 | 5% | 70 | 5% |
| | Other motors | 335 | 30% | *6* | *35* | *27* | 69 | 22% | 404 | 28% |
| Process specific | | 238 | 21% | *3* | *0.3* | *1* | 4 | 1% | 242 | 17% |
| Building envelope and comfort | Lighting | 52 | 5% | *13* | *12* | *3* | 28 | 9% | 79 | 5% |
| | Comfort heating, cooling, ventilation and air conditioning (HVAC) | 28 | 2% | *8* | *2* | *2* | 12 | 4% | 40 | 3% |
| Other | | 12 | 1% | *2* | *0.4* | *1* | 3 | 1% | 15 | 1% |
| ***TOTAL*** | | ***1,132*** | 100% | *161* | *85* | *62* | ***308*** | 100% | ***1,440*** | ***100%*** |
| Percentage of Total | | 79% | | *11%* | *6%* | *4%* | 21% | | 100% | |

*Note: Any differences in totals are due to rounding.*

## Exhibit 3.3: Forecast Year 2016 Modelled Annual Purchased Electricity Consumption for the Island and Isolated and Labrador Interconnected Service Regions by Sub Sector and End Use, (GWh/yr.)

| Electricity End Use | | Large Industry - Electricity Use Sub-Total (GWH/y) | Large Industry - Electricity Use Percentage of Total (%) | Small Industry - Electricity Use Fishing (GWH/y) | Manufact. (GWH/y) | Other (GWH/y) | Sub-Total (GWH/y) | Percentage of Total (%) | Total | Percentage of Total (%) |
|---|---|---|---|---|---|---|---|---|---|---|
| Process heating (incl. water heaters, steam production) | | 48 | 4% | *13* | *2* | *3* | 19 | 6% | 67 | 5% |
| Process cooling / refrigeration / freezing | | 26 | 2% | *97* | *0.1* | *2* | 99 | 31% | 125 | 9% |
| Motors and motor driven equipment | Air compressors | 111 | 10% | *5* | *15* | *1* | 22 | 7% | 133 | 9% |
| | Pumps | 169 | 15% | *10* | *5* | *8* | 23 | 7% | 192 | 13% |
| | Fans and Blowers | 59 | 5% | *2* | *12* | *9* | 23 | 7% | 82 | 6% |
| | Conveyors | 54 | 5% | *7* | *4* | *6* | 17 | 5% | 70 | 5% |
| | Other motors | 335 | 30% | *7* | *36* | *29* | 72 | 22% | 407 | 28% |
| Process specific | | 238 | 21% | *3* | *0.3* | *1* | 5 | 1% | 243 | 17% |
| Building envelope and comfort | Lighting | 52 | 5% | *13* | *12* | *3* | 29 | 9% | 80 | 6% |
| | Comfort heating, cooling, ventilation and air conditioning (HVAC) | 28 | 2% | *8* | *2* | *2* | 12 | 4% | 40 | 3% |
| Other | | 12 | 1% | *2* | *0.4* | *1* | 3 | 1% | 15 | 1% |
| ***TOTAL*** | | ***1,132*** | 100% | *168* | *89* | *65* | ***322*** | 100% | ***1,454*** | ***100%*** |
| Percentage of Total | | 78% | | *12%* | *6%* | *4%* | 22% | | 100% | |

*Note: Any differences in totals are due to rounding.*

## Exhibit 3.4: Forecast Year 2021 Modelled Annual Purchased Electricity Consumption for the Island and Isolated and Labrador Interconnected Service Regions by Sub Sector and End Use, (GWh/yr.)

| Electricity End Use | | Large Industry - Electricity Use | | Small Industry - Electricity Use | | | | | Total | Percentage of Total (%) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Sub-Total (GWH/y) | Percentage of Total (%) | Fishing (GWH/y) | Manufact. (GWH/y) | Other (GWH/y) | Sub-Total (GWH/y) | Percentage of Total (%) | | |
| Process heating (incl. water heaters, steam | | 48 | 4% | *14* | *2* | *3* | 19 | 6% | 67 | 5% |
| Process cooling / refrigeration / freezing | | 26 | 2% | *101* | *0.1* | *2* | 103 | 31% | 129 | 9% |
| Motors and motor driven equipment | Air compressors | 111 | 10% | *5* | *16* | *2* | 23 | 7% | 134 | 9% |
| | Pumps | 169 | 15% | *10* | *5* | *8* | 24 | 7% | 193 | 13% |
| | Fans and Blowers | 59 | 5% | *2* | *13* | *9* | 24 | 7% | 83 | 6% |
| | Conveyors | 54 | 5% | *7* | *4* | *7* | 17 | 5% | 71 | 5% |
| | Other motors | 335 | 30% | *7* | *38* | *30* | 76 | 22% | 411 | 28% |
| Process specific | | 238 | 21% | *3* | *0.3* | *1* | 5 | 1% | 243 | 17% |
| Building envelope and comfort | Lighting | 52 | 5% | *14* | *13* | *3* | 30 | 9% | 82 | 6% |
| | Comfort heating, cooling, ventilation and air conditioning (HVAC) | 28 | 2% | *9* | *2* | *2* | 13 | 4% | 41 | 3% |
| Other | | 12 | 1% | *2* | *0.5* | *1* | 3 | 1% | 15 | 1% |
| ***TOTAL*** | | ***1,132*** | 100% | *174* | *94* | *68* | ***336*** | 100% | ***1,468*** | ***100%*** |
| Percentage of Total | | 77% | | *12%* | *6%* | *5%* | 23% | | 100% | |

*Note: Any differences in totals are due to rounding.*

**Exhibit 3.5: Forecast Year 2026 Modelled Annual Total Electricity Consumption for the Island and Isolated and Labrador Interconnected Service Regions by Sub Sector and End Use, (GWh/yr.)**

| Electricity End Use | | Large Industry - Electricity Use | | Small Industry - Electricity Use | | | | | Total | Percentage of Total (%) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Sub-Total (GWH/y) | Percentage of Total (%) | Fishing (GWH/y) | Manufact. (GWH/y) | Other (GWH/y) | Sub-Total (GWH/y) | Percentage of Total (%) | | |
| Process heating (incl. water heaters, steam production) | | 48 | 4% | *15* | *2* | *3* | 20 | 6% | 68 | 5% |
| Process cooling / refrigeration / freezing | | 26 | 2% | *105* | *0.1* | *2* | 107 | 30% | 133 | 9% |
| Motors and motor driven equipment | Air compressors | 111 | 10% | *5* | *17* | *2* | 24 | 7% | 135 | 9% |
| | Pumps | 169 | 15% | *11* | *5* | *9* | 25 | 7% | 194 | 13% |
| | Fans and Blowers | 59 | 5% | *2* | *14* | *10* | 25 | 7% | 84 | 6% |
| | Conveyors | 54 | 5% | *7* | *4* | *7* | 18 | 5% | 72 | 5% |
| | Other motors | 335 | 30% | *7* | *41* | *32* | 80 | 23% | 415 | 28% |
| Process specific | | 238 | 21% | *4* | *0.3* | *1* | 5 | 1% | 243 | 16% |
| Building envelope and comfort | Lighting | 52 | 5% | *15* | *14* | *4* | 32 | 9% | 83 | 6% |
| | Comfort heating, cooling, ventilation and air conditioning (HVAC) | 28 | 2% | *9* | *2* | *2* | 13 | 4% | 42 | 3% |
| Other | | 12 | 1% | *2* | *0.5* | *1* | 3 | 1% | 15 | 1% |
| ***TOTAL*** | | ***1,132*** | 100% | *181* | *99* | *71* | ***352*** | 100% | ***1,484*** | ***100%*** |
| Percentage of Total | | 76% | | *12%* | *7%* | *5%* | 24% | | 100% | |

*Note: Any differences in totals are due to rounding.*

# 4. CONSERVATION & DEMAND MANAGEMENT (CDM) MEASURES

## 4.1 INTRODUCTION

This section identifies and assesses the economic attractiveness of the selected energy-efficiency technology measures for the Industrial sector and is presented as follows:

- Methodology
- Description of Energy-efficiency Technologies
- CCE Summary.

## 4.2 METHODOLOGY FOR ASSESSMENT OF ENERGY-EFFICIENCY MEASURES

The following steps were employed:

- Select candidate energy-efficiency measures
- Establish technical performance for each option within a range of applications
- Establish the capital and installation costs for each option
- Calculate the CCE for each conservation measure.

Consistent with the agreed study scope, the analysis of energy-efficiency measures presented in this section is limited to "generic" opportunities that are broadly applicable across North American industrial facilities. As outlined below, the technology descriptions and typical technology cost data draw heavily from the study team's previous and current work in other Canadian jurisdictions.[7] Energy savings estimates are based on the best available data for Newfoundland and Labrador.

A brief discussion of each step is outlined below.

***Step 1 Select Candidate Measures***

The candidate measures were selected in collaboration with the Utilities and from a literature review and previous study team experience. The selected measures are considered to be technically proven and commercially available, even if only at an early stage of market entry. Technology costs were not a factor in the initial selection of candidate technologies.

***Step 2 Establish Technical Performance***

Information on the performance improvements provided by each measure was compiled from available secondary sources including the experience and on-going research work of study team members.

[7] Marbek Resource Consultants and Willis Energy. *BC Hydro Conservation Potential Review- 2007, Industrial Sector.* Prepared for BC Hydro, 2007.

***Step 3 Establish Capital, Installation and Operating Costs for Each Measure***

Information on the cost of implementing each measure was also compiled from secondary sources including the experience and on-going research work of study team members.

The incremental cost is applicable when a measure is installed in a new facility or at the end of its useful life in an existing facility; in this case, incremental cost is defined as the cost difference for the energy-efficiency measure relative to the "baseline" technology. The full cost is applicable when an operating piece of equipment is replaced with a more efficient model prior to the end of its useful life.

In both cases, the costs and savings are annualized, based on the number of years of equipment life and the discount rate, which in this study has been set at 6%. All costs are expressed in constant (2007) dollars.

***Step 4 Calculate CCE for Each Measure***

One of the important sets of information provided in this section is the CCE associated with each energy-efficiency measure. The CCE for an energy-efficient measure is defined as the annualized incremental cost of the upgrade measure divided by the annual energy savings achieved, excluding any administrative or program costs required to achieve full use of the technology or measure. All cost information presented in this section is expressed in constant (2007) dollars.

The CCE provides a basis for the subsequent selection of measures to be included in the Economic Potential Forecast. The CCE is calculated according to the following formula:

$$\frac{C_A + M}{S}$$

Where:

$C_A$ is the annualized installed cost
$M$ is the incremental annual cost of O&M
$S$ is the annual kWh energy savings.

And $A$ is the annualization factor.

Where: $$A = \frac{i(1+i)^n}{(1+i)^n - 1}$$

$i$ is the discount rate
$n$ is the life of the measure.

The detailed results (see Exhibit 4.2) show both “incremental” and “full” installed costs for the energy-efficiency measures, as applicable. If the measure or technology is installed in a new facility, or at the point of natural replacement in an existing facility, then the “incremental” cost of the efficient measure versus the cost of the baseline technology is used.

If, prior to the end of its life, an operating piece of equipment is replaced with a more efficient model, then the “full” cost of the efficient measure is used. In both cases, the costs of the measures are annualized, based on the number of years of equipment life and the discount rate, and the costs incorporate applicable changes in annual O&M costs.

The annual saving associated with the efficiency measure is the difference in annual electricity consumption with and without the measure.

The CCE calculation is sensitive to the chosen discount rate. In the CCE calculations that accompany this document, three discount rates are shown: 4%, 6% and 8%. The 6% real discount rate was used for the primary CCE calculation. The CCE was also calculated using the 4% and 8% real discount rates to provide sensitivity analysis.

Selection of the appropriate discount rate to be used in this analysis was guided by the intended use of the study results. This study seeks to identify the economic potential for CDM in Newfoundland and Labrador from a provincial perspective. Therefore, the appropriate discount rate is the social opportunity cost of capital, which is the estimated average pre-tax rate of return on public and private investments in the provincial economy.[8]

## 4.3 DESCRIPTION OF ENERGY-EFFICIENCY TECHNOLOGIES

Exhibit 4.1 shows a summary of the energy-efficient measures included in this study.

**Exhibit 4.1: Energy-efficiency Technologies and Measures – Industrial Sector**

| | |
|---|---|
| • Cooling, refrigeration/freezing measures | • Conveyors or material handling measures |
| • Compressed air measures | • Motors measures |
| • Pump measures | • Lighting measures |
| • Fan/blower measures | • Process specific measures |

Energy-efficiency improvement opportunities are presented along with a brief description of the technology, savings relative to the baseline, typical installed costs, applicability and co-benefits. A detailed list of the results of the economic assessment of all measures is provided in Exhibit 4.2. The discussion of measures is organized by end use and sub sector.[9]

The following sources were relied upon for technology descriptions, installed cost data, electricity savings data and useful life data.

[8] This discount rate allows for analytic consistency with the earlier NERA Marginal Cost Study, which used a nominal discount rate of 8.4% (approximately 6% real, i.e. net of inflation). NLH lowered its nominal discount rate in the summer of 2007 to 7.75%; however, this change has no material impact on the results of this study.
[9] Measure inputs not otherwise sourced are based on the consultants’ recent work with BC Hydro and other utility clients.

- Marbek Resource Consultants and Willis Energy. *BC Hydro Conservation Potential Review- 2007, Industrial Sector*. Prepared for BC Hydro, 2007.

- Electricity savings potential studies for Nova Scotia (in progress) and New Brunswick. Both studies were commissioned by the Canadian Manufacturers and Exporters with member of the electric utilities present on the steering committees.

- Electricity savings potential studies for Ontario commissioned by the Ontario Power Authority. The studies addressed Small and Medium industrial facilities and fuel substitution.

- Natural Resources Canada, Office of Energy Efficiency research publications.

### 4.3.1 Cooling and Refrigeration/Freezing

The following efficiency measures for cooling and refrigeration (or freezing) were considered:

- Premium efficiency refrigeration equipment including efficient compressors, optimized floating head pressure and equipment size optimization
- Improved control including adjustable speed drives (ASD)
- Premium efficiency control including computer control and floating head pressure control
- Improved distribution system including increased insulation and piping network optimization.

❑ **Premium Efficiency Refrigeration Equipment**

Improving the efficiency of refrigeration equipment is accomplished through system reconfiguration, such as optimizing the condenser size, and through technology applications such as efficient compressors and condenser fans. Additional energy savings opportunities include high-efficiency refrigeration compressors, which use more efficient electric motors and have lower compressor losses, additional insulation for the refrigeration units and thermo siphon oil coolers for screw compressors.

This measure has attractive energy savings but increased equipment costs. To capitalize on all potential benefits, the feasibility of efficient refrigeration system opportunities are best evaluated during system expansion or as part of a system reliability and safety review.

| **Measure Profile** | |
|---|---|
| Sub Sectors | Small and Medium Industry |
| Typical Measure Size/Specification | 50-HP |
| Typical Measure Costs | $41,000 (full cost)<br>$ 2,000 (incremental cost) |
| Typical Measure Savings | 11 MWh/yr. |
| Useful Measure Life | 25 years |

- **Improved Control**

Improved control is accomplished through the use of ASD on the evaporator fan and condenser fan, compressor speed control and improved defrost control. Currently, most refrigeration systems employ constant speed fan motors on the evaporator and condenser fans. ASD control reduces fan horsepower at part load and reduces the refrigeration load associated with waste heat generated by the fan motors. Improved defrost controls reduce the compressor load by activating the defrost cycle only when excessive ice has accumulated or the temperature has dropped below a preset point.

| **Measure Profile** | |
|---|---|
| Sub Sectors | Small and Medium Industry |
| Typical Measure Size/Specification | 50-HP |
| Typical Measure Costs | $60,000 (full cost)<br>$30,000 (incremental cost) |
| Typical Measure Savings | 13 MWh/yr. |
| Useful Measure Life | 15 years |

- **Premium Efficiency Control**

Premium efficiency refrigeration control is accomplished by using computer controls for the refrigeration equipment, floating head pressure controls to take advantage of low outdoor air temperatures and computerized defrost controls.

Currently, most refrigeration equipment is not designed with computer controls, efficient defrost cycles or floating head pressure controls. Premium refrigeration controls result in improved compressor, evaporator and condenser controls. With floating head pressure controls the system is also able to take advantage of lower outdoor air temperatures. Modern refrigeration controls also include improved defrost cycle algorithms that will reduce the defrost time by as much as 60% compared to conventional defrost controls. Barriers to the implementation of this measure include the high equipment costs and the capacity of the refrigeration plant to incorporate improved refrigeration controls.

| **Measure Profile** | |
|---|---|
| Sub Sectors | Small and Medium Industry |
| Typical Measure Size/Specification | 50-HP |
| Typical Measure Costs | $78,000 (full cost)<br>$48,000 (incremental cost) |
| Typical Measure Savings | 20 MWh/yr. |
| Useful Measure Life | 15 years |

- **Improved Distribution System**

Improving distribution piping requires a thorough analysis of the complex relationship between the flow of refrigerant, oil and pipe insulation. Improved distribution must compromise between maximum capacity at minimum cost and proper oil return to the compressor, while using well-insulated piping.

In industrial screw compressors, oil lubricates the system. Small amounts of oils are always present in the refrigerant. Oil is properly circulated only when the mass velocity of the refrigerant vapour is great enough. Currently, the refrigeration industry uses oil purgers and refrigerant decontamination systems to ensure that the oil does not create problems in the refrigerant system.

Insulation on the refrigerant piping and other parts of the system reduces the absorption of heat by the refrigerant from any environment other than the refrigerated area. An improved distribution system ensures proper refrigerant feed to evaporators without excessive pressure drop, prevents excessive lubricating oil in any part of the system, ensures the compressor is adequately lubricated and optimizes refrigerant distribution.

| **Measure Profile** | |
|---|---|
| Sub Sectors | Small and Medium Industry |
| Typical Measure Size/Specification | 50-HP |
| Typical Measure Costs | $10,000 (full cost)<br>$3,000 (incremental cost) |
| Typical Measure Savings | 7 MWh/yr. |
| Useful Measure Life | 25 years |

### 4.3.2 Compressed Air

Measures that were considered for the compressed air end use include:

- Efficient equipment including efficient compressors, air dryers and equipment size optimization
- Efficient control including ASD, sequencing and dryer dewpoint control
- Efficient distribution system including increased air storage and reduced piping friction losses.

Below is a brief description of the most promising measures as well as summaries of the results of their economic assessment.

- **Premium Efficiency Compressed Air Equipment**

Premium efficiency compressed air equipment includes both the compressor and the air dryer. Each is described briefly below.

Premium efficiency air compressors come with built-in ASD control that allows the compressor output to match the plant air demand. These compressors may save as much as 40% over standard compressors which typically use modulated control.

| Measure Profile | |
|---|---|
| Sub Sectors | All |
| Typical Measure Size/Specification | 200-HP compressor |
| Typical Measure Cost | $62,000 (full cost)<br>$25,000 (incremental cost) |
| Typical Measure Savings | 89 MWh/yr. |
| Useful Measure Life | 25 years |

Premium efficiency air dryers are of the refrigerated type with dewpoint control. These dryers are typically at least 15% more efficient than regenerative desiccant dryers, which are still commonly used in industry.

| Measure Profile | |
|---|---|
| Sub Sectors | All |
| Typical Measure Size/Specification | 2,000 CFM refrigerated air dryer |
| Typical Measure Cost | $37,000 (full cost)<br>$12,000 (incremental cost) |
| Typical Measure Savings | 60 MWh/yr. |
| Useful Measure Life | 20 years |

- **Premium Efficiency Sequencing Control**

As mentioned above, premium efficiency air compressors come with built-in ASD control. The additional measure considered here is sequencing control.

Industrial facilities typically have several air compressors. Sequencing control systems can operate the compressors so that the larger compressor is base loaded (always on), the mid-sized compressors are used as needed to increase supply and an ASD compressor acts as the trim compressor (provides for the variable component of the process air demand). This setup is intended to closely match the demand for compressed air, to maintain consistent pressure and flow and to reduce O&M costs.

This measure applies to a retrofit or to a new facility. In each case, the alternative is to do nothing, i.e., use the factory installed control system. Therefore, the full and the incremental costs are equivalent.

| Measure Profile | |
|---|---|
| Sub Sectors | All |
| Typical Measure Size/Specification | 800-HP compressed air system |
| Typical Measure Cost | $41,000 (full cost) |
| Typical Measure Savings | 119 MWh/yr. |
| Useful Measure Life | 15 years |

- **Improved Distribution System**

This measure involves the addition of air storage to reduce pressure fluctuations, and air piping redesign to reduce friction losses. Not included in this measure are leak fixing and nozzle improvement, which are considered separate O&M measures.

| **Measure Profile** | |
|---|---|
| Sub Sectors | All |
| Typical Measure Size/Specification | 800-HP compressed air system |
| Typical Measure Cost | $10,000 (full cost)<br>$7,000 (incremental cost |
| Typical Measure Savings | 167 MWh/yr. |
| Useful Measure Life | 25 years |

### 4.3.3 Pumps

Measures that were considered for this end use include:

- Efficient and premium efficiency equipment including equipment size optimization
- Efficient control including ASD.

Below is a brief description of these measures as well as summaries of the results of their economic assessment.

- **Premium Efficiency Pump**

In industrial applications pumps are often used for cooling tower sprays, spray cooler, water boosters, liquid transport, liquid recovery and liquid mixing. Energy savings can be gained by replacing older stock pumps with premium efficiency models that are application specific or with premium efficiency impellers and motors. Pumps should be sized and selected based on their performance curve for the required flow. Impeller sizing is also an important consideration; impellers should be sized for a specific application.

| **Measure Profile** | |
|---|---|
| Sub Sectors | All |
| Typical Measure Size/Specification | 50-HP pump |
| Typical Measure Costs | $2,000 (full cost)<br>$600 (incremental cost) |
| Typical Measure Savings | 10 MWh/yr. |
| Useful Measure Life | 20 years |

- **Premium Efficiency Control, Including Adjustable Speed Drives**

Pumps used for variable flow in industrial applications may be candidates for ASD. Currently, most pump installations are single speed and operate continuously independent of the actual load. Installing ASD on smaller pumps will result in significant energy savings in variable load applications where full operation may be required for less than 30% of the operating time. In these applications, 40% energy savings can be achieved. Modulating valves installed on by pass lines will provide sufficient flow at all times, allowing the pump to perform at maximum efficiency on the pump curve. Barriers to implementation include large capital investment equipment; however, energy savings and production improvements will make this an attractive investment.

| **Measure Profile** | |
|---|---|
| Sub Sectors | All |
| Typical Measure Size/Specification | 50-HP pump |
| Typical Measure Costs | $8,100 (full cost)<br>$4,300 (incremental cost) |
| Typical Measure Savings | 15 MWh/yr. |
| Useful Measure Life | 15 years |

### 4.3.4 Fans and Blowers

Measures that were considered for the fans and blowers end use include:

- Efficient and premium efficiency equipment, including equipment size optimization
- Efficient control, including timers and ASD.

❑ **Premium Efficiency Fans and Blowers**

Fans and blowers are often used for ventilation, exhaust, cooling, dust collection and aeration. Energy savings can be gained by replacing older stock fans and blowers with premium efficiency models that are application specific. Fans should be sized and selected for an application based on the performance curve of the fan at the required airflow.

| **Measure Profile** | |
|---|---|
| Sub Sectors | All |
| Typical Measure Size/Specification | 50-HP |
| Typical Measure Cost | $2,000 (full cost)<br>$600 (incremental cost) |
| Typical Measure Savings | 7 MWh/yr. |
| Useful Measure Life | 20 years |

❑ **Premium Efficiency Control, Including Adjustable Speed Drives**

Fans are widely used in industry for conveyance, drying and ventilation purposes. Operations requiring variable air delivery, such as drying, can benefit from premium control with ASD allowing air delivery to match process requirements. ASD save electricity and improve product quality by providing plant operators greater and finer control.

| Measure Profile | |
|---|---|
| Sub Sectors | All |
| Typical Measure Size/Specification | 220-HP fan |
| Typical Measure Cost | $51,500 (full cost)<br>$26,500 (incremental cost) |
| Typical Measure Savings | 66 MWh/yr. |
| Useful Measure Life | 15 years |

### 4.3.5 Conveyors and Material Handling

Measures that were considered for the conveyor (or material handling) end use include:

- Efficient and premium efficiency equipment, including equipment size optimization, low friction systems and drive optimization
- Efficient control, including ASD.

Where variation exists between the economic assessment results for large versus small systems, the measures are grouped by size.

- **Premium Efficiency Conveyors**

Conveyors often use gear boxes to isolate the motor and to provide better torque control. Currently, most gear boxes in most of the Large Industrial sub sectors consist of transmissions with 90%-92% efficiencies. Opportunities include using higher-efficiency drives, couplings and gear/speed reducer alternatives. In older conveyor systems, or where process requirements have changed, it may be possible to resize a conveyor, upgrade the controls or re-engineer the system to improve layout and configuration, all of which will result in energy savings.

| Measure Profile | |
|---|---|
| Sub Sectors | Large Industry |
| Typical Measure Size/Specification | 100-HP system |
| Typical Measure Costs | $40,000 (full cost)<br>$17,5000 (incremental cost) |
| Typical Measure Savings | 12 MWh/yr. |
| Useful Measure Life | 20 years |

- **Premium Efficiency Control for Conveyors**

Incorporating programmable logic controls (PLC) into the conveyor system will result in energy savings. PLC controls can shut down unloaded conveyors and control the conveyor based on load. Barriers to implementation include additional maintenance costs due to increased number of components in the system.

| **Measure Profile** | |
|---|---|
| Sub Sectors | Small and Medium Industry |
| Typical Measure Size/Specification | 50-HP system |
| Typical Measure Costs | $12,000 (full cost)<br>$6,0000 (incremental cost) |
| Typical Measure Savings | 9 MWh/yr. |
| Useful Measure Life | 15 years |

### 4.3.6. Premium Efficiency Motors

The three motor efficiency levels included in this study are standard (93.5% efficient), high efficiency (94.5% efficient) and premium efficiency (95.5% efficient). Premium efficiency motors apply to all sub sectors and end uses.

Electric motors convert approximately 85% of industrial plant electricity use to torque to drive industrial end uses such as fans, pumps, material handling and a large portion of process loads. These motors range in size from 75 Watts to more than 25,000 kW, with corresponding efficiencies of 40%-98%. While inherently efficient in converting electricity to shaft or motive power, on average 5%-8% of this power is lost in motor inefficiencies that occur before the driven equipment losses.

Both synchronous and induction motors are used in industrial facilities. It is estimated that induction motors in the 1-HP to 500-HP range use over 50% of the motor energy use, while induction motors in the 500-HP to 5,000-HP range account for 15% to 20% of the total plant load. Induction motor efficiency can be increased through adherence to proper specification or though the implementation of an efficient motor purchasing program. Synchronous motors are typical of refiner motors in the Pulp and Paper sub sector and of Large Mining grinding operations. These motors are often built up for efficiency in the design process.

Electric motor efficiency improvement has been a major thrust in the North American market for more than 25 years. Throughout the 1980s, standard efficiency induction motors dominated industrial plant installations. Prior to 1990, only 5% of new motor purchases were considered energy efficient. Since the late 1990s, energy-efficient motors comprised the majority of sales.

| **Measure Profile** | |
|---|---|
| Sub Sectors | All |
| Typical Measure Size/Specification | 150-HP motor |
| Typical Measure Costs | $13,000 (full cost)<br>$700 (incremental cost) |
| Typical Measure Savings | 9 MWh/yr. |
| Useful Measure Life | 25 years |

### 4.3.7 Synchronous Belts

Synchronous belts, also called timing, positive drive or high torque drive belts, apply to all sub sectors and end uses.

Often, industrial end uses are driven by pulleys that use V-Belts. By replacing the pulley sheaves with synchronous belt pulleys and installing synchronous belts onto the end use (e.g., fan) an efficiency gain of 3%-5% can be achieved because of reduced slippage and friction between the pulley and belt. Synchronous belts may require motor vibration sensors to prevent damage from continuous operation following a system failure.

Since the alternative to this measure is to do nothing, the full and incremental costs are the same.

| **Measure Profile** | |
|---|---|
| Sub Sectors | All |
| Typical Measure Size/Specification | 150-HP motor |
| Typical Measure Costs | $1,450 (full cost) |
| Typical Measure Savings | 13 MWh/yr. |
| Useful Measure Life | 10 years |

### 4.3.8 Building Envelope and Comfort

This end use includes lighting, comfort heating and cooling, plug loads and elevators. This end use consumed about 8% of electricity in the Industrial sector in the Base Year. Lighting systems account for more than 60% of the electricity consumed by this end use and, therefore, are the focus for this end use.

- **Lighting**

Numerous lighting retrofit measures exist. Summarized here are two of the largest potential lighting measures for industrial facilities: 1) major lighting fixtures and controls retrofit, and 2) replacement of high-intensity discharge lighting with fluorescent high-bay T5 high-output lighting.

Opportunities exist for major lighting retrofits at older facilities, especially larger facilities. The lighting systems in these facilities are often several decades old. In some cases, low-efficiency mercury vapor lighting is still in use and no lighting control measures are in place. Potential electricity savings at such facilities are significant but retrofits are often complicated by a lack of dedicated circuits, and consistency across the facility.

In all cases, these projects are necessarily full cost measures because the retrofit is considered for an existing facility before the end of the useful life of the existing lighting system.

| Measure Profile | |
|---|---|
| Sub Sectors | All |
| Typical Measure Size/Specification | Medium-sized facility |
| Typical Measure Costs | $38,000 (full cost) |
| Typical Measure Savings | 45 MWh/yr. |
| Useful Measure Life | 10 years |

A medium-sized facility is defined as a facility with about 120 lamps, including fluorescent, high-pressure sodium and mercury vapor types. The upgrade measures include retrofitting the lighting fixtures to high-efficiency fixtures and lamps and installing lighting control.

High-intensity discharge (HID) lighting, such as the metal halide lamp, is the most widely used lighting type in industrial facilities. Recent advances in the development of high-bay T5 high-output fluorescent lighting indicate that replacing HID lighting with T5 high-output lighting may be a promising efficiency measure.

HID lighting is used for illuminating high bay areas such as production facilities. HID lighting includes mercury vapor, metal halide and high-pressure sodium lamps. The most widely used type of lamp in industrial facilities is the metal halide. Replacing them with T5 high-output lamps is estimated to reduce electricity use by 20%-40%. Other benefits of T5 high-output lighting over HID lighting are better colour rendering and longer lamp life. Although T5 high-output lighting is commercially available, advances in the technology are fairly recent. To date, the technology has had negligible impact and is not expected to gain market share in the absence of utility or other CDM programs.

| Measure Profile | |
|---|---|
| Sub Sectors | All |
| Typical Measure Size/Specification | 19x4 lamp T5 high-output luminaire plus 24x6 lamp T5 high-output luminaires |
| Typical Measure Costs | $13,000 (full cost)<br>$3,000 (incremental cost) |
| Typical Measure Savings | 4 MWh/yr. |
| Useful Measure Life | 10 years |

### 4.3.9 Process Specific

Electricity consumed in the process-specific end use is about 1% for Small and Medium industry in Newfoundland and Labrador, but is close to 22% of the total electricity use for industry. Large industry in Newfoundland and Labrador consists of six large facilities. Process-specific energy-efficiency measures are very site specific and are best addressed through the use of on-site assessments, which are beyond the scope of this study.

Based on experience in other jurisdictions, potential electricity savings would be expected to be in the range of 10% to 15% for process-specific end uses such as those typically found in the Pulp and Paper, Mining and Oil Refining sub sectors.

#### 4.3.10 Other

This end use includes non-specific miscellaneous loads and consumed only 1% of electricity in the Industrial sector in the Base Year; therefore, a detailed economic analysis was not considered.

### 4.4 CCE SUMMARY

Exhibit 4.2 shows the CCE for each measure.

## Exhibit 4.2: CCE Summary Table – Savings and Costs per Measure

| End Use | Sub Sector | Measure Description | Annual Savings (kWh/year) | Total Cost ($) | Basis: Full or Incremental | Useful Measure Life (y) | 4% Discount Rate: CCE (c/kWh) | 6% Discount Rate: CCE (c/kWh) | 8% Discount Rate: CCE (c/kWh) |
|---|---|---|---|---|---|---|---|---|---|
| Refrigeration / Freezing | Small / Medium | Premium efficiency refrigeration equipment | 11,186 | 41,000 | Full | 25 | 23.5 | 28.7 | 34.3 |
| | | Premium efficiency refrigeration equipment | 11,186 | 2,000 | Incremental | 25 | 1.1 | 1.4 | 1.7 |
| | | Improved control | 13,423 | 60,000 | Full | 15 | 47.7 | 53.5 | 59.7 |
| | | Improved control | 13,423 | 30,000 | Incremental | 15 | 27.6 | 30.5 | 33.6 |
| | | Premium efficiency control | 20,134 | 78,000 | Full | 15 | 40.8 | 45.8 | 51.2 |
| | | Premium efficiency control | 20,134 | 48,000 | Incremental | 15 | 27.4 | 30.5 | 33.8 |
| | | Improved distribution system | 6,711 | 10,000 | Full | 25 | 9.5 | 11.7 | 14.0 |
| | | Improved distribution system | 6,711 | 3,000 | Incremental | 25 | 2.9 | 3.5 | 4.2 |
| Compressed air | All | Premium efficiency ASD compressor | 89,484 | 62,000 | Full | 25 | 6.7 | 7.7 | 8.7 |
| | | Premium efficiency ASD compressor | 89,484 | 25,000 | Incremental | 25 | 4.0 | 4.4 | 4.9 |
| | | Premium efficiency refrigerated air dryer | 59,656 | 37,000 | Full | 20 | 5.4 | 6.2 | 7.2 |
| | | Premium efficiency refrigerated air dryer | 59,656 | 12,000 | Incremental | 20 | 2.3 | 2.6 | 2.9 |
| | | Premium efficiency sequencing control | 119,312 | 41,000 | Full | 15 | 3.8 | 4.2 | 4.7 |
| | | Improved distribution system | 167,037 | 10,000 | Full | 25 | 0.4 | 0.5 | 0.6 |
| | | Improved distribution system | 167,037 | 7,000 | Incremental | 25 | 0.3 | 0.3 | 0.4 |
| Pump | All | Premium efficiency pump | 10,440 | 1,900 | Full | 20 | 3.7 | 4.0 | 4.2 |
| | | Premium efficiency pump | 10,440 | 600 | Incremental | 20 | 2.8 | 2.9 | 3.0 |
| | | Premium efficiency control, incl ASD | 14,914 | 8,100 | Full | 15 | 6.2 | 6.9 | 7.7 |
| | | Premium efficiency control, incl ASD | 14,914 | 4,300 | Incremental | 15 | 3.9 | 4.3 | 4.7 |
| Fans/Blowers | All | Premium efficiency fan / blower | 7,457 | 2,000 | Full | 20 | 5.3 | 5.7 | 6.1 |
| | | Premium efficiency fan / blower | 7,457 | 600 | Incremental | 20 | 3.9 | 4.1 | 4.2 |
| | | Premium efficiency control, including ASD | 65,622 | 51,500 | Full | 15 | 7.7 | 8.8 | 9.9 |
| | | Premium efficiency control, including ASD | 65,622 | 26,500 | Incremental | 15 | 4.3 | 4.8 | 5.4 |
| Conveyors | All | Premium efficiency small conveyors | 5,966 | 4,000 | Full | 20 | 9.1 | 10.0 | 11.0 |
| | | Premium efficiency small conveyors | 5,966 | 2,000 | Incremental | 20 | 6.7 | 7.1 | 7.6 |
| | | Premium efficiency control for small conveyors | 8,948 | 12,000 | Full | 15 | 14.9 | 16.6 | 18.5 |
| | | Premium efficiency control for small conveyors | 8,948 | 6,000 | Incremental | 15 | 8.8 | 9.7 | 10.6 |
| | | Premium efficiency large conveyors | 11,931 | 40,000 | Full | 20 | 27.6 | 32.2 | 37.1 |
| | | Premium efficiency large conveyors | 11,931 | 17,500 | Incremental | 20 | 13.7 | 15.7 | 17.9 |
| | | Premium efficiency control for large conveyors | 17,897 | 43,000 | Full | 15 | 24.4 | 27.5 | 30.9 |
| | | Premium efficiency cotnrol for large conveyors | 17,897 | 20,500 | Incremental | 15 | 13.1 | 14.6 | 16.2 |

# Exhibit 4.2 (Continued)

| End Use | Sub Sector | Measure Description | Annual Savings (kWh/year) | Total Cost ($) | Basis: Full or Incremental | Useful Measure Life (y) | 4% Discount Rate: CCE (c/kWh) | 6% Discount Rate: CCE (c/kWh) | 8% Discount Rate: CCE (c/kWh) |
|---|---|---|---|---|---|---|---|---|---|
| Motors | All | Synchronous belts | 13,423 | 1,450 | Full | 10 | 2.2 | 2.4 | 2.5 |
| | | 30 HP Standard to premium efficiency motor | 1,790 | 6,000 | Full | 25 | 32.6 | 37.4 | 42.6 |
| | | 30 HP High to premium efficiency motor | 1,790 | 1,100 | Incremental | 25 | 12.3 | 13.2 | 14.1 |
| | | 150 HP Standard to premium efficiency motor | 8,948 | 13,000 | Full | 25 | 9.3 | 11.4 | 13.6 |
| | | 150 HP High to premium efficiency motor | 8,948 | 700 | Incremental | 25 | 0.5 | 0.6 | 0.7 |
| | | 1000 HP Standard to premium efficiency motor | 74,570 | 72,000 | Full | 25 | 6.9 | 8.2 | 9.7 |
| | | 1000 HP High to premium efficiency motor | 74,570 | 6,000 | Incremental | 25 | 0.9 | 1.0 | 1.2 |
| Lighting | All | Metal halide to high bay T5 HO | 4,474 | 13,000 | Full | 10 | 47.0 | 50.7 | 54.5 |
| | | Metal halide to high bay T5 HO | 4,474 | 3,000 | Incremental | 10 | 19.4 | 20.3 | 21.2 |
| | | Efficient lighting system, incl design, fixtures, control | 44,742 | 38,000 | Full | 10 | 12.7 | 13.8 | 14.9 |

# 5. ECONOMIC POTENTIAL ELECTRICITY FORECAST

## 5.1 INTRODUCTION

This section presents the Industrial sector Economic Potential Forecast for the study period 2006 to 2026. The Economic Potential Forecast estimates the level of electricity consumption that would occur if all equipment were upgraded to the level that is cost effective against the long-run avoided cost of electricity in the Newfoundland Labrador service area. In this study, "cost effective" means that the technology upgrade cost, referred to as the cost of conserved energy (CCE) in the preceding section, is equal to, or less than, the economic screen.[10]

The discussion in this section is organized and presented in the following subsections:

- Avoided Cost Used for Screening
- Major Modelling Tasks
- Technologies Included in Economic Potential Forecast
- Summary of Results.

## 5.2 AVOIDED COST USED FOR SCREENING

NLH has determined that the primary avoided costs of new electricity supply to be used for this analysis are $0.0980/kWh for the Island and Isolated service region and $0.0432/kWh for the Labrador Interconnected service region. These avoided costs represent a future in which the Lower Churchill project is not built and there is no DC link from Labrador to the Island.[11]

Therefore, the Economic Potential Forecast incorporates all the CDM measures reviewed in Section 4 that have a CCE equal to or less than the avoided costs.

NLH is currently studying the Lower Churchill/DC Link project. However, a decision on whether to proceed is not expected until 2009 and, even if the project proceeds, the earliest completion date would be in late 2014. This means that regardless of the decision, the avoided cost values shown above will be in effect until the approximate mid point of the study period. If the project does proceed, the avoided costs presented above are expected to change. To provide insight into the potential impacts of the Lower Churchill/DC Link project on this study, it was agreed that the consultants would provide a high-level sensitivity analysis.

[10] Costs related to program design and implementation are not yet included.

[11] The avoided costs draw on the results of the earlier study conducted by NERA Economic Consulting, which is entitled: Newfoundland and Labrador Hydro. *Marginal Costs of Generation and Transmission*. May 2006. The avoided costs used in this study include generation, transmission and distribution.

## 5.3 MAJOR MODELLING TASKS

By comparing the results of the Industrial sector Economic Potential Electricity Forecast with the Reference Case, it is possible to determine the aggregate level of potential electricity savings within the Industrial sector, as well as identify which specific end uses provide the most significant opportunities for savings.

To develop the Industrial sector Economic Potential Forecast, the following tasks were completed:

- The CCE for each of the energy-efficient upgrades presented in Exhibit 4.2 were reviewed, using the 6% (real) discount rate. Due to the limited interactive effects between measures in industry, an analysis of interactive effects was excluded from the study.

- Technology upgrades that had a CCE equal to, or less than, the avoided cost threshold were selected for inclusion in the economic potential scenario, either on a “full cost” or “incremental” basis. It is assumed that technical upgrades having a “full cost” CCE that met the cost threshold were implemented in the first forecast year. It is assumed that those upgrades that only met the cost threshold on an “incremental” basis are being introduced more slowly as the existing stock reaches the end of its useful life.

- Electricity use within the Large, and Small and Medium Industrial sectors was modelled with the same energy models used to generate the Reference Case. However, for this forecast, the remaining “baseline” technologies included in the Reference Case forecast were replaced with the most efficient “technology upgrade option” and associated performance efficiency that met the cost threshold of $0.0980/kWh for the Island and Isolated service region and $0.0432/kWh for the Labrador Interconnected service region.

- When more than one upgrade option was applied, the measures were bundled and overall efficiency and market penetration rates were determined.

- A sensitivity analysis was conducted using preliminary avoided cost values that assume development of the Lower Churchill/DC Link.

## 5.4 TECHNOLOGIES INCLUDED IN ECONOMIC POTENTIAL FORECAST

Exhibits 5.1 and 5.2 provide a listing of the technologies selected for inclusion in this forecast for, respectively, the Small and Medium, and Large Industrial sectors. In each case, the exhibits show the following:

- End use affected
- Upgrade measures selected
- Rate at which the upgrade measures were introduced into the stock.

**Exhibit 5.1: Technologies Included in Economic Potential Forecast for Small and Medium Industry and Total Economic Potential Market Penetration Rates**

| End Use | Measures | 2006 | 2011 | 2016 | 2021 | 2026 |
|---|---|---|---|---|---|---|
| Refrigeration / Freezing | Premium efficiency refrigeration equipment | 10% | 36% | 62% | 88% | 100% |
| | Improved distribution system | | | | | |
| Compressed air | Premium efficiency ASD compressor | 15% | 100% | 100% | 100% | 100% |
| | Premium efficiency refrigerated air dryer | | | | | |
| | Premium efficiency sequencing control | | | | | |
| | Improved distribution system | | | | | |
| Pump | Premium efficiency pump | 18% | 100% | 100% | 100% | 100% |
| | Premium efficiency control, incl ASD | | | | | |
| Fans/Blowers | Premium efficiency fan / blower | 18% | 100% | 100% | 100% | 100% |
| | Premium efficiency control, including ASD | | | | | |
| Motors | Synchronous belts | 18% | 100% | 100% | 100% | 100% |
| | 150 HP High to premium efficiency motor | | | | | |
| | 1000 HP High to premium efficiency motor | | | | | |

**Exhibit 5.2: Technologies Included in Economic Potential Forecast for Large Industry and Total Economic Potential Market Penetration Rates**

| End Use | Measures | 2006 | 2011 | 2016 | 2021 | 2026 |
|---|---|---|---|---|---|---|
| Compressed air | Premium efficiency refrigerated air dryer | 18% | 100% | 100% | 100% | 100% |
| | Premium efficiency ASD compressor | | | | | |
| | Premium efficiency sequencing control | | | | | |
| | Improved distribution system | | | | | |
| Pump | Premium efficiency pump | 25% | 100% | 100% | 100% | 100% |
| | Premium efficiency control, incl ASD | | | | | |
| Fans/Blowers | Premium efficiency fan / blower | 25% | 100% | 100% | 100% | 100% |
| | Premium efficiency control, including ASD | | | | | |
| Motors | Synchronous belts | 25% | 100% | 100% | 100% | 100% |
| | 150 HP High to premium efficiency motor | | | | | |
| | 1000 HP High to premium efficiency motor | | | | | |

## 5.5 SUMMARY OF RESULTS

This section compares the Reference Case and Economic Potential Electricity Forecast levels of industry electricity consumption. The results are presented as electricity savings that would occur at the customer's point-of-use. Due to the small sample size of industry in the Labrador Interconnected service region, the results are presented at an aggregated industry level for both Labrador Interconnected and the Island and Isolated service regions. The results are presented in the following exhibits:

- Exhibit 5.3 shows the electricity savings for the Industrial sector over the study period. As illustrated, under the Reference Case industrial electricity use would grow from the Base Year level of 1,359 GWh/yr. to approximately 1,484 GWh/yr. by 2026. This contrasts with the Economic Potential Forecast in which electricity use would decrease to approximately 1,321 GWh/yr. for the same period, a difference of approximately 164 GWh/yr.

- Exhibit 5.4 presents the results by end use, Industrial sector and milestone year.

- Exhibit 5.5 illustrates the 2026 savings by major end use and industrial sector.

**Exhibit 5.3: Reference Case versus Economic Potential Electricity Consumption in Industrial Sector (GWh/yr.)**

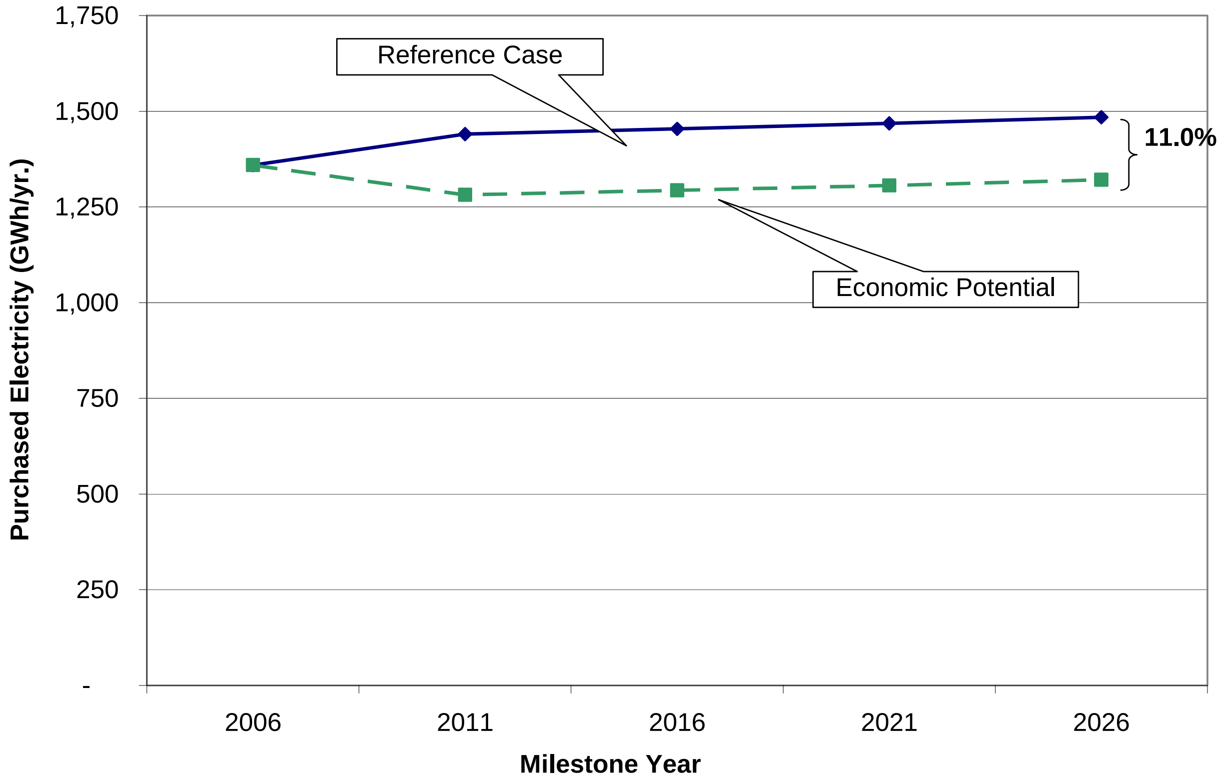
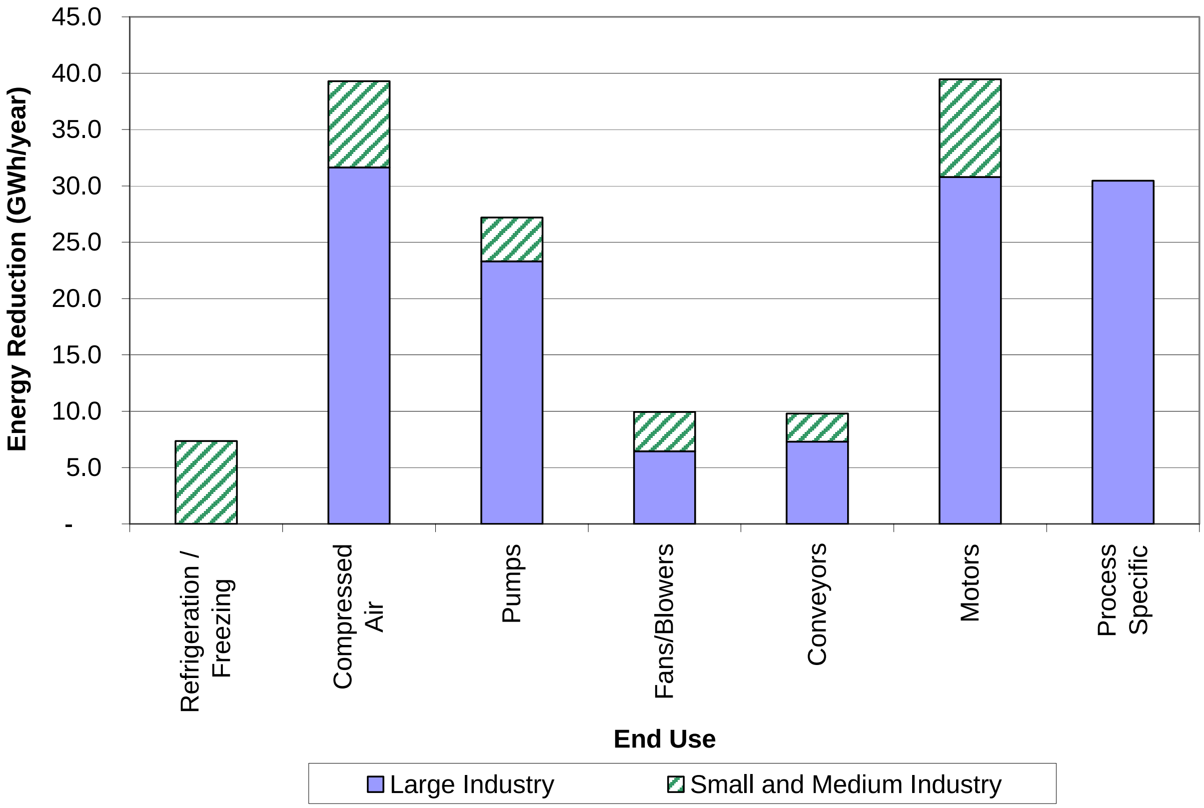


**Exhibit 5.4: Total Potential Electricity Savings by End Use, Industry Sector and Milestone Year (GWh/yr.)**

| End Use | 2006 | 2011 | 2016 | 2021 | 2026 | 2026 Percentage of Total (%) |
|---|---|---|---|---|---|---|
| **Small and Medium Industry** | | | | | | |
| Refrigeration / Freezing | 0.0 | 1.9 | 4.0 | 6.2 | 7.4 | 22% |
| Compressed air | 0.0 | 6.9 | 7.1 | 7.4 | 7.7 | 23% |
| Pumps | 0.0 | 3.5 | 3.6 | 3.7 | 3.9 | 12% |
| Fans/Blowers | 0.0 | 3.1 | 3.2 | 3.3 | 3.5 | 10% |
| Conveyors | 0.0 | 2.2 | 2.3 | 2.4 | 2.5 | 7% |
| Motors | 0.0 | 7.7 | 7.9 | 8.2 | 8.7 | 26% |
| ***Sub-Total*** | ***0.0*** | ***25.2*** | ***28.1*** | ***31.2*** | ***33.6*** | ***100%*** |
| **Large Industry** | | | | | | |
| Compressed air | 0.0 | 32.9 | 32.4 | 32.0 | 31.6 | 24% |
| Pumps | 0.0 | 24.3 | 24.0 | 23.6 | 23.3 | 18% |
| Fans/Blowers | 0.0 | 6.4 | 6.5 | 6.5 | 6.5 | 5% |
| Conveyors | 0.0 | 7.6 | 7.5 | 7.4 | 7.3 | 6% |
| Motors | 0.0 | 32.1 | 31.6 | 31.2 | 30.8 | 24% |
| Process specific | 0.0 | 30.2 | 30.5 | 30.5 | 30.5 | 23% |
| ***Sub-Total*** | ***0.0*** | ***133.5*** | ***132.5*** | ***131.3*** | ***129.9*** | ***100%*** |
| **Total** | | | | | | |
| Refrigeration / Freezing | 0.0 | 1.9 | 4.0 | 6.2 | 7.4 | 5% |
| Compressed air | 0.0 | 39.7 | 39.6 | 39.4 | 39.3 | 24% |
| Pumps | 0.0 | 27.8 | 27.6 | 27.4 | 27.2 | 17% |
| Fans/Blowers | 0.0 | 9.5 | 9.7 | 9.9 | 9.9 | 6% |
| Conveyors | 0.0 | 9.6 | 9.5 | 9.5 | 9.5 | 6% |
| Motors | 0.0 | 40.0 | 39.9 | 39.7 | 39.8 | 24% |
| Process specific | 0.0 | 30.2 | 30.5 | 30.5 | 30.5 | 19% |
| ***TOTAL*** | ***0.0*** | ***158.7*** | ***160.6*** | ***162.5*** | ***163.5*** | ***100%*** |

*Note: The potential electricity savings for the process-specific end use in the Large Industrial sector is based on an assumed savings of 13% (see Section 4.3.9). Any differences in totals are due to rounding.*

**Exhibit 5.5: Savings by Major End Use and Industrial Sector, 2026**




### 5.5.1 Interpretation of Results – Primary Avoided Costs

A systems approach was used to model the energy impacts of the CDM measures presented in the preceding section. In the absence of a systems approach, there would be double counting of savings and an accurate assessment of the total contribution of the energy-efficient upgrades would not be possible.

Highlights of the results presented in the preceding exhibits are summarized below:

- **Electricity Savings by Milestone Year**

The estimated annual economic potential electricity savings in 2011 is about 159 GWh/yr. (11%) compared to the Reference Case. As shown, the savings are relatively flat from 2011 to the end of the study period with estimated savings of about 164 GWh/yr. in 2026. This is because a significant portion of the energy-efficiency measures are applied at full cost and, consequently, were modelled to achieve full market penetration by 2011. The variability to the savings impact between 2011 and 2026 is due to the effect of the measures applied at stock turn-over rates.

- **Electricity Savings by Sector and End Use**

About 80% of the total economic potential savings of 164 GWh/yr. in 2026 is attributed to the Large Industrial sector. The largest potential savings in this sector are associated with motors (29% of total savings) and compressed air and process specific (each contributing between 23% and 24% of total savings).

The end uses with the largest potential savings in the Small and Medium Industrial sector are motors (33%), compressed air (23%) and refrigeration/freezing (22%). Considering small, medium and Large industry, the economic electricity savings potential is the largest for the motors end use (30%) followed by compressed air (24%).

### 5.5.3 Sensitivity Analysis – Alternative Avoided Costs

A sensitivity analysis was conducted using preliminary avoided cost values that assume development of the Lower Churchill/DC Link. The sensitivity analysis reviewed the scope of measures that would pass or fail the economic screen under the changed avoided costs. Based on the preliminary avoided cost values assessed, the analysis concluded that any impacts would be modest.

# 6. ACHIEVABLE POTENTIAL

## 6.1 INTRODUCTION

This section presents the Industrial sector Achievable Potential electricity savings for the study period (2006 to 2026). The Achievable Potential is defined as the proportion of the savings identified in the Economic Potential Forecast that could realistically be achieved within the study period.

Consistent with the study's scope, the Industrial sector are presented at a less detailed level than for the Residential and Commercial sectors.

The remainder of this discussion is organized into the following subsections:

- Description of Achievable Potential
- Approach to Estimation of Achievable Potential
- Workshop Results
- Summary of Achievable Electricity Savings.

## 6.2 DESCRIPTION OF ACHIEVABLE POTENTIAL

Achievable Potential recognizes that it is difficult to induce all customers to purchase and install all the electrical efficiency technologies that meet the criteria defined by the Economic Potential Forecast. For example, customer decisions to implement energy-efficient measures can be constrained by important factors such as:

- Higher first cost of efficient product(s)
- Need to recover investment costs in a short period (payback)
- Lack of product performance information
- Lack of product availability
- Consumer awareness.

The rate at which customers accept and purchase energy-efficient products can be influenced by a variety of factors including, the level of financial incentives, information and other measures put in place by the Utilities, governments and the private sector to remove barriers such as those noted above.

Exhibit 6.1 presents the level of electricity consumption that is estimated in the Achievable Potential scenarios. As illustrated, the Achievable Potential scenarios are "banded" by the two forecasts presented in previous sections, namely, the Economic Potential Forecast and the Reference Case.

Electricity savings under Achievable Potential are typically less than in the Economic Potential Forecast. In the Economic Potential Forecast, efficient new technologies are assumed to fully penetrate the market as soon as it is financially attractive to do so. However, the Achievable Potential recognizes that under "real world" conditions, the rate at which customers are likely to implement new technologies will be influenced by additional practical considerations and will, therefore, occur more slowly than under the assumptions employed in the Economic Potential Forecast. Exhibit 6.1 also shows that future electricity consumption under the Reference Case is greater than in either of the two Achievable Potential forecasts. This is because the Reference Case represents a "worst case" situation in which there are no additional utility market interventions and hence no additional electricity savings beyond those that occur "naturally."

Exhibit 6.1 presents the achievable results as a band of possibilities, rather than a single line. This recognizes that any estimate of Achievable Potential over a 20-year period is necessarily subject to uncertainty and that there are different levels of potential CDM program intervention.

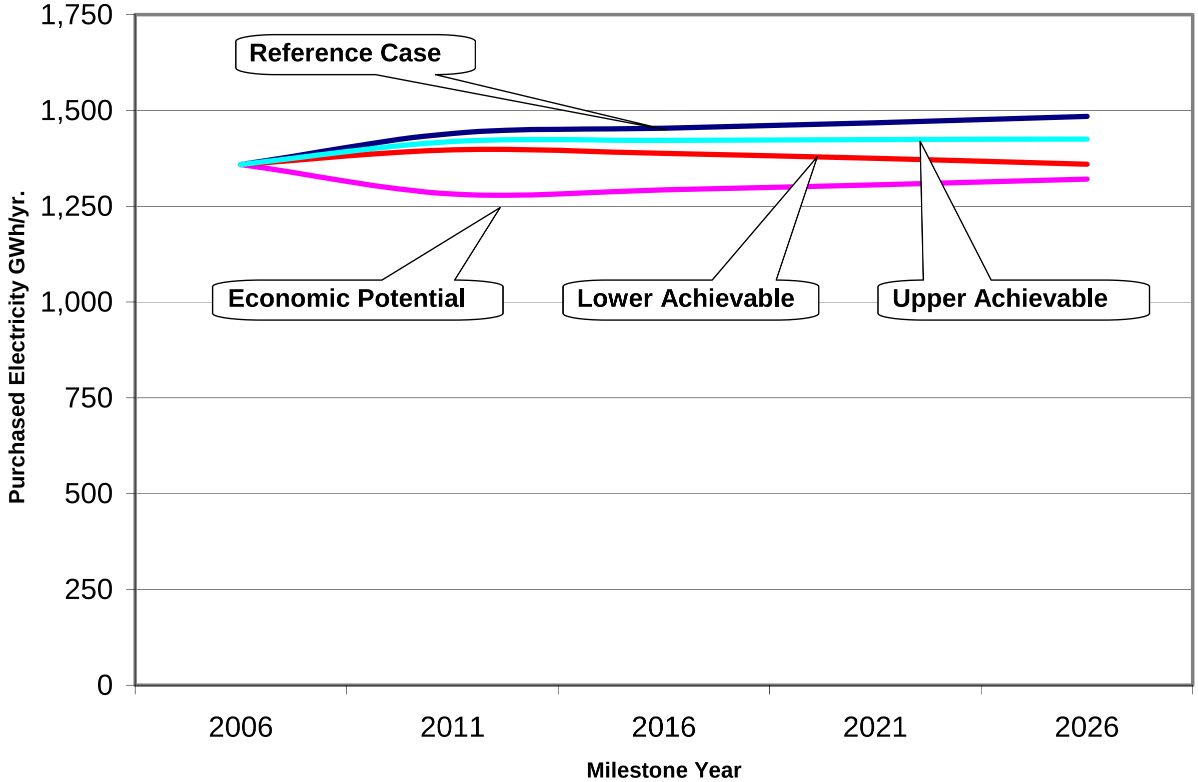
- **The Upper Achievable Potential** assumes both an aggressive program approach and a very supportive context, e.g., healthy economy, very strong public commitment to climate change mitigation, etc.

  However, the Upper Achievable Potential scenario also recognizes that there are limits to the scope of influence of any electric utility. It recognizes that some markets or submarkets may be so price sensitive or constrained by market barriers beyond the influence of CDM programs that they will only fully act if forced to by legal or other legislative means. It also recognizes that there are practical constraints related to the pace that existing inefficient equipment can be replaced by new, more efficient models or that existing building stock can be retrofitted to new energy performance levels

  For the purposes of this study, the Upper Achievable Potential can, informally, be described as: "*Economic Potential less those customers that "can't" or "won't" participate."*

- **The Lower Achievable Potential** assumes that existing CDM programs and the scope of technologies addressed are expanded, but at a more modest level than in the Upper Achievable Potential. Market interest and customer commitment to energy efficiency and sustainable environmental practices remain approximately as current. Similarly, federal, provincial and municipal government energy-efficiency and GHG mitigation efforts remain similar to the present.

**Exhibit 6.1: Annual Electricity Consumption – Example of Achievable Potential Relative to Reference Case and Economic Potential Forecast for the Industrial Sector**



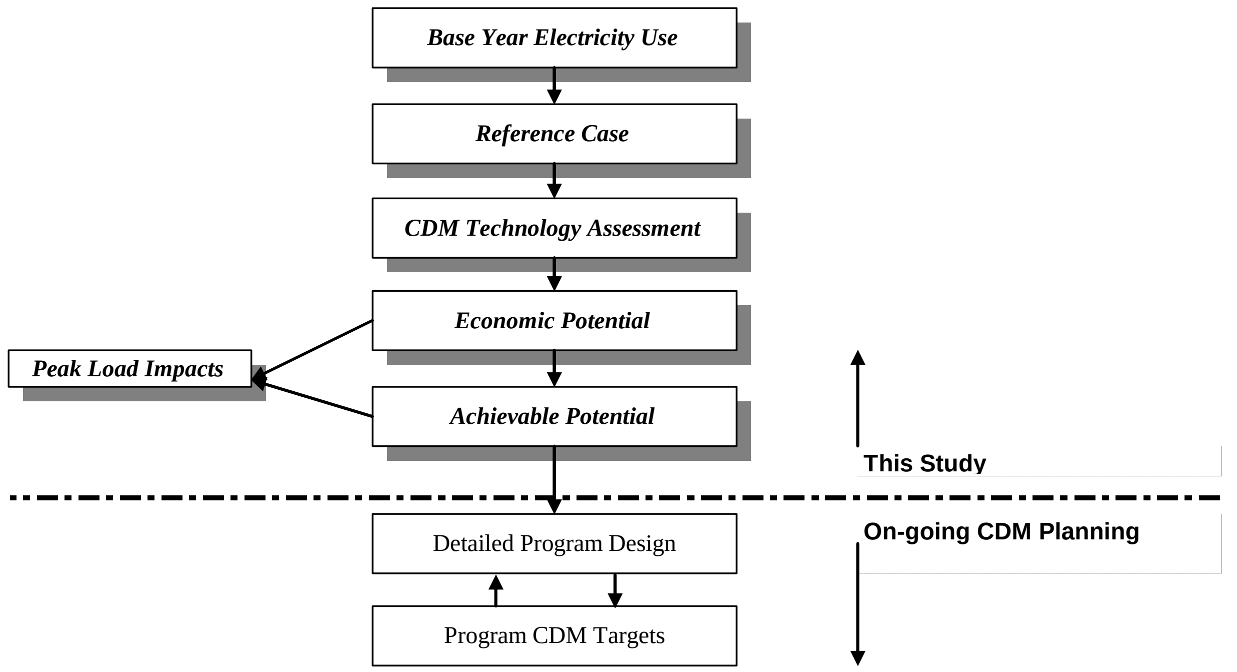

- **Achievable Potential versus Detailed Program Design**

It should also be emphasized that the estimation of Achievable Potential is not synonymous with either the setting of specific program targets or with program design. While both are closely linked to the discussion of Achievable Potential, they involve more detailed analysis that is beyond the scope of this study.[12]

Exhibit 6.2 illustrates the relationship between Achievable Potential and the more detailed program design.

[12] The Achievable Potential savings assume program start-up in 2007. Consequently, electricity savings in the first milestone year of 2011 will need to be adjusted to reflect actual program initiation dates. This step will occur during the detailed program design phase, which will follows this study.

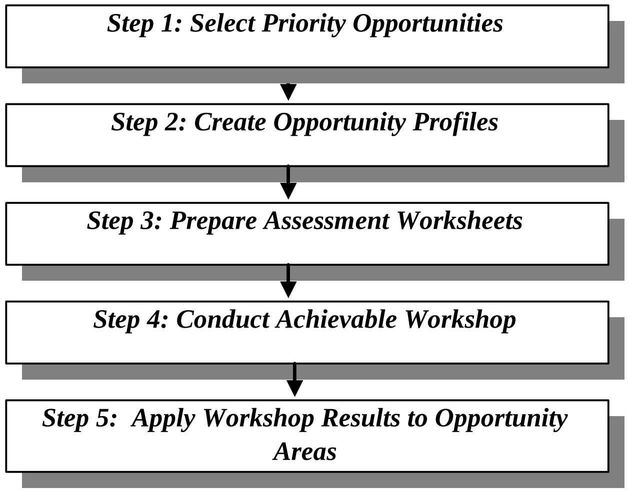
**Exhibit 6.2: Achievable Potential versus Detailed Program Design**




## 6.3 APPROACH TO THE ESTIMATION OF ACHIEVABLE POTENTIAL

Achievable Potential was estimated in a five-step approach. A schematic showing the major steps is shown in Exhibit 6.3 and each step is discussed below.

**Exhibit 6.3: Approach to Estimating Achievable Potential**



## ❑ Step 1: Select Priority Opportunities

The first step in developing the Achievable Potential estimates required that the energy saving opportunities identified in the Economic Potential Forecasts be "bundled" into a set of opportunity areas that would facilitate the subsequent assessment of their potential market penetration. The energy-efficiency opportunity areas were grouped by end use (Exhibit 6.4) for discussion in the Industrial sector workshop held November 1, 2007.

The workshop focused on the Small and Medium Industrial sectors. Exhibit 6.4 summarizes the opportunity areas and shows the approximate percentage that each represents of the total Small and Medium Industrial sectors potential contained in the Economic Potential Forecast. Large industry includes six facilities and the Achievable Potential is deemed to be very site specific. Within the scope of the high-level industry assessment, the Achievable Potential assessment focused on analyzing the Small and Medium Industrial sectors. The results from this assessment were extrapolated to Large industry and, as a "reality check," was compared to the project team's experience in other jurisdictions

**Exhibit 6.4: Industrial Sector Opportunity Areas for Small and Medium Industry – Percentage of Economic Potential for Sector**

| End Use | 2026 Percentage of Total (%) |
|---|---|
| **Small and Medium Industry** | |
| Refrigeration / Freezing | 22% |
| Compressed air | 23% |
| Pumps | 12% |
| Fans/Blowers | 10% |
| Conveyors | 7% |
| Motors | 26% |
| ***Sub-Total*** | ***100%*** |

*Note: Any differences in totals are due to rounding.*

## ❑ Step 2: Create Opportunity Profiles

The next step involved the development of brief profiles for the priority opportunity areas noted above in Exhibit 6.4. A sample profile for Opportunity I1 (cooling and refrigeration/freezing) is presented in Exhibit 6.5; the remaining Opportunity Profiles are provided in Appendix B.

The purpose of the Opportunity Profiles was to provide a "high-level" logic framework that would serve as a guide for participant discussions in the workshop. The intent was to define a broad rationale and direction without getting into the much greater detail required of program design, which, as noted previously, is beyond the scope of this project.

**Exhibit 6.5: Sample Opportunity Profile**

**I1 – Cooling and Refrigeration/Freezing**

***Overview:***
Cooling and refrigeration/freezing apply mainly to the Fishing and Fish Processing sub sector. The opportunity includes improving the efficiency of refrigeration equipment through system reconfiguration, such as optimizing the condenser size, and through technology applications, such as efficient compressors and condenser fans. Improving distribution piping requires a thorough analysis of the complex relationship between the flow of refrigerant, oil and pipe insulation.

***Target Technologies and Measures:***
- Premium efficiency refrigeration equipment including efficient compressors, optimized floating head pressure and equipment size optimization
- Improved distribution system

***Opportunity Costs and Savings Profile***:
- A typical cooling/refrigeration/freezing project has an implementation cost of $2,000 to $50,000
- The total economic potential for these measures is estimated to be 7.4 GWh/yr. by 2026
- Customer payback is in the range of 12 years
- The CCE for these opportunities is estimated to be $0.01 to $0.04/kWh

***Target Audience(s)& Potential Delivery Allies:***
- Fishing and Fish Processing sub sector
- Cooling and refrigeration/freezing equipment manufacturers and suppliers
- Provincial and federal government

***Constraints & Challenges:***
The most significant barriers are:
- Premium efficiency equipment has attractive energy savings but increased equipment costs
- Long payback periods
- Retrofitting main equipment and distribution system require systems to be out of operation and may interfere with production schedules

***Opportunities & Synergies:***
- To capitalize on all potential benefits, the feasibility of efficient refrigeration system opportunities are best evaluated during system expansion or as part of a system reliability and safety review.
- Improved cooling and freezing may improve product quality and ensure compliance with food safety requirements.

***Experience Related to Possible Participation Rates:***

As illustrated in Exhibit 6.5, each Opportunity Profile addresses the following areas:

- ***Overview*** – provides a summary statement of the broad goal and rationale for the opportunity.
- ***Target Technologies and Measures*** **–** highlights the major technologies where the most significant Opportunities have been identified in the Economic Potential Forecast.
- ***Opportunity Costs and Savings Profile*** – provides information on the financial attractiveness of the opportunity from the perspective of both the customer and NLH or NP.

- ***Target Audiences and Potential Delivery Allies*** – identifies key market players that would be expected to be involved in the actual delivery of services. The list of stakeholders shown is intended to be "indicative" and is by no means comprehensive.

- ***Constraints and Challenges –*** identifies key market barriers that are currently constraining the increased penetration of energy-efficient technologies or measures. Interventions for addressing the identified barriers are noted. Again, it is recognized that the interventions are not necessarily comprehensive; rather, their primary purpose was to help guide the workshop discussions.

- ***Opportunities and Synergies –*** identifies information or possible synergies with other Opportunities that may affect workshop participant views on possible customer participation rates.

- ***Experience Related to Possible Participation Rates*** – provides benchmark data on the past performance of Utilities programs, where available.

❑ **Step 3: Prepare Draft Opportunity Assessment Worksheets**

A draft Assessment Worksheet was prepared for each Opportunity Profile in advance of the workshop. The Assessment Worksheets complemented the information contained in the Opportunity Profiles by providing quantitative data on the potential energy savings for each opportunity as well as providing information on the size and composition of the eligible population of potential participants. Energy impacts and population data were taken from the detailed modelling results contained in the Economic Potential Forecast.

A sample Assessment Worksheet for Opportunity I1 (cooling and refrigeration/freezing) is presented in Exhibit 6.6 (worksheets for the remaining opportunity areas are provided in Appendix C). As illustrated in Exhibit 6.6, each Assessment Worksheet addresses the following areas:

- ***Typical Project Costs*** – provides the typical project costs (includes capital and installation costs) for participants to implement the opportunities.

- ***Customer Payback*** – shows the simple payback from the customer's perspective for the package of energy-efficiency measures included in the opportunity area. This information provided an indication of the level of attractiveness that the opportunity measures would present to customers.

- ***Cost of Conserved Energy (CCE)*** – shows the approximate CCE for the measure(s) included within each opportunity area. Where multiple measures are included, a weighted average value is presented. The CCE provides an indication of the relative economic attractiveness of the energy-efficiency measures from the Utilities' perspective. For the purposes of the workshop, this information provided participants with an indication of the scope for using financial incentives to influence customer participation rates. The CCE value combined with the preceding customer payback information provided an important reference point for the workshop participants when considering potential participation rates. The combined information enabled participants to "roughly" estimate the level of financial incentives that could be employed to increase the opportunity's attractiveness to customers without making the measures economically unattractive to NLH or NP.

- ***Total Capacity and Estimated Number of Units*** **–** shows the total population of potential units that could, theoretically, be addressed in the opportunity area. Numbers shown are from the eligible populations used in the Economic Potential Forecasts. The definition of "unit" varies by opportunity area. In the example shown, a unit is defined as a refrigeration unit with a capacity of 50 HP.

- ***Market Penetration Rates*** **–** show the percentage market penetration rates for the Base Year and the economic potential at the milestone years. As noted in the introduction to this section, the approach to the Industrial sector was less detailed than for the Residential and Commercial sectors. In the Industrial sector, market penetration rates were determined by the consultant's interpretation of the workshop discussions. Two scenarios were determined: Lower and Upper.

**Exhibit 6.6: Sample Industrial Sector Opportunity Assessment Worksheet**

**I1: Cooling / Refrigeration / Freezing**

**Opportunities**
Premium efficiency equipment
Improved distribution system

| | |
|---|---|
| Typical project cost | $ 2,000 - $ 50,000 |
| Payback period | 12 years |
| CCE | $ 0.01 - 0.04 / kWh |
| Typical capacity | 50 HP |
| Estimated number of units | 400 - 550 |

| | ***Market Penetration Rate (%)*** | | | |
|---|---|---|---|---|
| ***Milestone Year*** | ***Reference Case*** | ***Achievable Lower*** | ***Achievable Upper*** | ***Economic Potential*** |
| ***2006*** | 10 | 10 | 10 | 10 |
| ***2016*** | 12 | | | 60 |
| ***2026*** | 15 | | | 100 |

- **Step 4: Achievable Potential Workshop**

The most critical step in developing the estimates of Achievable Potential was the half-day workshop held November 1, 2007. Workshop participants consisted of core members of the consultant team, program personnel from the Utilities, industrial facility operators and local trade allies.

The purpose of the workshop was to promote discussion regarding the technical and market conditions confronting the identified energy-efficiency opportunities. Estimates of the Achievable Potential were then developed based on the results of the workshop discussions.

The discussion of each opportunity area was structured around the following questions:

- What is the current age and general condition of the existing stock of equipment? What level of energy-efficiency activity has taken place to date?

- What are the major challenges to implementing energy-efficiency projects involving this type of equipment within the applicable industrial sub sectors?

- What are the minimum conditions that would be required to increase energy-efficiency investments affecting this type of equipment within the applicable industrial sub sectors? How can the Utilities best support additional energy-efficiency investments?

- **Step 5: Apply Workshop Results to Opportunity Areas**

The workshop discussions provided a qualitative understanding of the current Achievable Potential in industry, specifically the Small and Medium Industrial sector. The qualitative potential was converted to quantitative values by considering the profile of the equipment, in terms of age and type of technology, challenges limiting implementation of energy-efficiency opportunities, and experience in other jurisdictions, specifically recent Achievable Potential studies completed by the project team in Nova Scotia, New Brunswick, Ontario and British Columbia. The results for the Small and Medium assessment were extrapolated to the Large Industrial sector and compared with the aforementioned studies. Exhibits 6.7 and 6.8 provide the market penetration rates for the bundled opportunities by end use and milestone year.

**Exhibit 6.7: Market Penetration Rates of Energy-efficiency Opportunities by End Use and Milestone Year – Upper Achievable Potential**

| Small and Medium Industry | | | | | |
|---|---|---|---|---|---|
| **End Use** | **2006** | **2011** | **2016** | **2021** | **2026** |
| Refrigeration / Freezing | 10% | 41% | 64% | 78% | 83% |
| Compressed air | 15% | 43% | 63% | 75% | 80% |
| Pump | 18% | 23% | 35% | 54% | 80% |
| Fans/Blowers | 18% | 23% | 35% | 54% | 80% |
| Conveyors | 18% | 23% | 35% | 54% | 80% |
| Motors | 18% | 23% | 35% | 54% | 80% |
| **Large industry** | | | | | |
| **End Use** | **2006** | **2011** | **2016** | **2021** | **2026** |
| Compressed air | 18% | 45% | 64% | 76% | 81% |
| Pump | 25% | 29% | 40% | 58% | 82% |
| Fans/Blowers | 25% | 29% | 40% | 58% | 82% |
| Conveyors | 25% | 29% | 40% | 58% | 82% |
| Motors | 25% | 29% | 40% | 58% | 82% |

**Exhibit 6.8: Market Penetration Rates of Energy-efficiency Opportunities by End Use and Milestone Year – Lower Achievable Potential**

| Small and Medium Industry | | | | | |
|---|---|---|---|---|---|
| **End Use** | **2006** | **2011** | **2016** | **2021** | **2026** |
| Refrigeration / Freezing | 10% | 26% | 38% | 45% | 48% |
| Compressed air | 15% | 28% | 38% | 45% | 47% |
| Pump | 18% | 21% | 27% | 37% | 49% |
| Fans/Blowers | 18% | 21% | 27% | 37% | 49% |
| Conveyors | 18% | 21% | 27% | 37% | 49% |
| Motors | 18% | 21% | 27% | 37% | 49% |
| **Large industry** | | | | | |
| **End Use** | **2006** | **2011** | **2016** | **2021** | **2026** |
| Compressed air | 18% | 31% | 40% | 47% | 49% |
| Pump | 25% | 28% | 33% | 42% | 54% |
| Fans/Blowers | 25% | 28% | 33% | 42% | 54% |
| Conveyors | 25% | 28% | 33% | 42% | 54% |
| Motors | 25% | 28% | 33% | 42% | 54% |

## 6.4 WORKSHOP RESULTS

The following subsection provides a summary of the key issues identified by participants during the workshop and identifies the major assumptions employed by the consultants for applying the workshop results to achievable estimates.

The results are presented for each of the opportunity areas that were discussed during the workshop, which were:

- Cooling and refrigeration/freezing
- Compressed air
- Motors and driven equipment.[13]

### 6.4.1 I1 – Cooling and Refrigeration/Freezing

Highlights:

- Estimated 95% of the equipment is older than 15 years
- Hurdle rate to implement projects usually less than three years simple payback period
- Awareness of energy efficiency has grown in the past few years
- Short power disruption can have significant negative impact on production, especially in the Fishing and Fish Processing and Manufacturing sub sectors
- Facilities generally do not have expertise in energy efficiency and have a need for engineering resources to assist in developing projects.

Based on the above discussion the market penetration rates were developed as presented in Exhibit 6.7.

### 6.4.2 I2 – Compressed Air

- Estimated 70% of the equipment is older than 10 years
- Hurdle rate to implement projects usually less than two to three years simple payback period
- Compressed air energy-efficiency awareness and knowledge are lacking in industry
- Some suppliers provide free service to detect air leaks in system and to identify energy-efficiency opportunities.

Market penetration rates are presented in Exhibits 6.7 and 6.8.

[13] The discussion of motors (Opportunity Profile I6) was combined with the discussion of driven equipment, such as pumps, fans and blowers, etc.

### 6.4.3 I3-I6 – Motors and Driven Equipment

- Estimated 60% - 70% of the equipment is older than 15 years
- No general standardized frames for existing motors, which limits the direct replacement of motors with new, more efficient motors. More common practice is to repair motors rather than replace them
- Motor driven equipment energy-efficiency awareness and knowledge are lacking in industry. This includes limited use and understanding of energy metering and use profiling
- Limited supply of stock locally available due to wide variety of motors
- Limited take up of variable frequency drives (VFD) due to non-standardized motors, pumps and fans.

Market penetration rates are presented in Exhibits 6.7 and 6.8.

## 6.5 SUMMARY OF ACHIEVABLE ELECTRICITY SAVINGS

Exhibit 6.9 provides an illustration of the achievable electricity savings under both the Lower and Upper scenarios for the combined Island and Isolated and Labrador Interconnected service regions.[14]

As discussed, under the Reference Case industrial purchased electricity use would grow from the Base Year level 1,359 GWh/yr. to approximately 1,484 GWh/yr. by 2026. This contrasts with the Upper Achievable scenario in which electricity use would increase to approximately 1,360 GWh/yr. for the same period, a difference of approximately 125 GWh/yr., or about 8 %. Under the Lower Achievable scenario, electricity use would increase to approximately 59 GWh/yr. for the same period, a difference of approximately 59 GWh/yr., or about 4 %.

Further detail on the total potential electricity savings provided by the Achievable Potential forecasts is provided in Exhibits 6.10 and 6.11. The Exhibits present, respectively, the Upper and Lower Achievable results by end use, sub sector type and milestone year.

[14] The CDM Potential reports for the Residential and Commercial sectors also include an assessment of the peak load reduction impacts associated with the achievable electricity savings. A similar assessment was not included in the Industrial sector study due to the more limited scope applied to this sector and the absence of the required data.

**Exhibit 6.9: Reference Case versus Upper and Lower Achievable Potential Electricity Consumption in the Industrial Sector (GWh/yr.)**

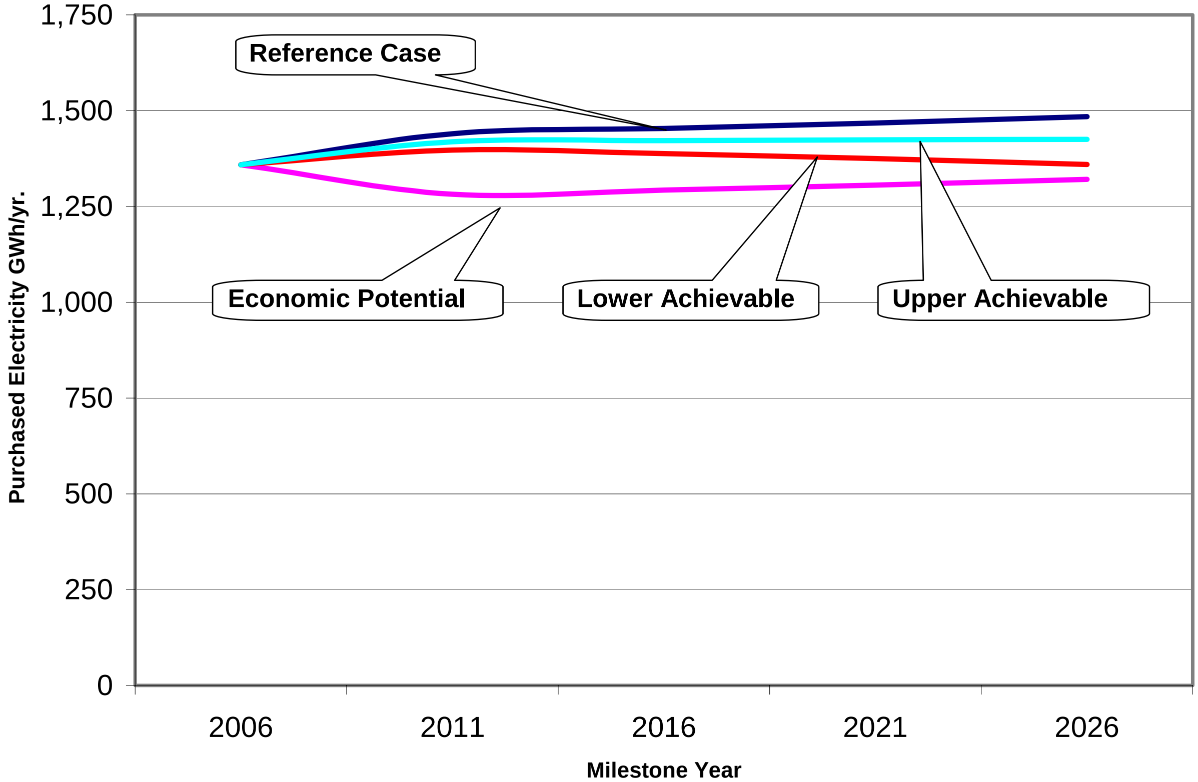


**Exhibit 6.10: Summary of Annual Electricity Savings by End Use and Sub Sector, Upper Achievable Potential (GWh/yr.)**

| End Use | 2006 | 2011 | 2016 | 2021 | 2026 | 2026 Percentage of Total (%) |
|---|---|---|---|---|---|---|
| **Small and Mediun Industry** | | | | | | |
| Refrigeration / Freezing | 0.0 | 2.3 | 4.1 | 5.3 | 5.9 | 23% |
| Compressed air | 0.0 | 2.2 | 3.9 | 5.1 | 5.7 | 22% |
| Pumps | 0.0 | 0.2 | 0.7 | 1.6 | 2.9 | 11% |
| Fans/Blowers | 0.0 | 0.1 | 0.6 | 1.4 | 2.6 | 10% |
| Conveyors | 0.0 | 0.1 | 0.4 | 1.0 | 1.9 | 7% |
| Motors | 0.0 | 0.4 | 1.5 | 3.5 | 6.5 | 25% |
| ***Sub-Total*** | ***0.0*** | ***5.2*** | ***11.1*** | ***17.9*** | ***25.6*** | ***100%*** |
| **Large Industry** | | | | | | |
| Compressed air | 0.0 | 10.4 | 17.8 | 22.2 | 23.7 | 24% |
| Pumps | 0.0 | 1.1 | 4.4 | 9.8 | 17.5 | 18% |
| Fans/Blowers | 0.0 | 0.3 | 1.2 | 2.7 | 4.8 | 5% |
| Conveyors | 0.0 | 0.3 | 1.4 | 3.1 | 5.5 | 6% |
| Motors | 0.0 | 1.4 | 5.8 | 13.0 | 23.1 | 23% |
| Process specific | 0.0 | 24.2 | 24.4 | 24.4 | 24.4 | 25% |
| ***Sub-Total*** | ***0.0*** | ***37.8*** | ***54.9*** | ***75.2*** | ***99.0*** | ***100%*** |
| **Total** | | | | | | |
| Refrigeration / Freezing | 0.0 | 2.3 | 4.1 | 5.3 | 5.9 | 5% |
| Compressed air | 0.0 | 12.6 | 21.7 | 27.4 | 29.5 | 24% |
| Pumps | 0.0 | 1.3 | 5.0 | 11.4 | 20.4 | 16% |
| Fans/Blowers | 0.0 | 0.4 | 1.8 | 4.1 | 7.5 | 6% |
| Conveyors | 0.0 | 0.4 | 1.7 | 4.0 | 7.1 | 6% |
| Motors | 0.0 | 1.8 | 7.3 | 16.6 | 29.8 | 24% |
| Process specific | 0.0 | 24.2 | 24.4 | 24.4 | 24.4 | 20% |
| ***TOTAL*** | ***0.0*** | ***43.0*** | ***66.0*** | ***93.1*** | ***124.5*** | ***100%*** |

*Note: Any differences in totals are due to rounding.*

**Exhibit 6.11: Summary of Annual Electricity Savings by End Use and Sub Sector, Lower Achievable Potential (GWh/yr.)**

| End Use | 2006 | 2011 | 2016 | 2021 | 2026 | 2026 Percentage of Total (%) |
|---|---|---|---|---|---|---|
| **Small and Medium Industry** | | | | | | |
| Refrigeration / Freezing | 0.0 | 1.1 | 2.0 | 2.7 | 2.9 | 24% |
| Compressed air | 0.0 | 1.0 | 1.8 | 2.4 | 2.7 | 22% |
| Pumps | 0.0 | 0.1 | 0.3 | 0.7 | 1.4 | 11% |
| Fans/Blowers | 0.0 | 0.1 | 0.3 | 0.7 | 1.2 | 10% |
| Conveyors | 0.0 | 0.0 | 0.2 | 0.5 | 0.9 | 7% |
| Motors | 0.0 | 0.2 | 0.7 | 1.6 | 3.0 | 25% |
| ***Sub-Total*** | ***0.0*** | ***2.5*** | ***5.3*** | ***8.5*** | ***12.1*** | ***100%*** |
| **Large Industry** | | | | | | |
| Compressed air | 0.0 | 4.8 | 8.3 | 10.4 | 11.1 | 24% |
| Pumps | 0.0 | 0.5 | 2.0 | 4.6 | 8.2 | 17% |
| Fans/Blowers | 0.0 | 0.1 | 0.6 | 1.3 | 2.3 | 5% |
| Conveyors | 0.0 | 0.2 | 0.6 | 1.4 | 2.6 | 5% |
| Motors | 0.0 | 0.7 | 2.7 | 6.1 | 10.8 | 23% |
| Process specific | 0.0 | 12.1 | 12.2 | 12.2 | 12.2 | 26% |
| ***Sub-Total*** | ***0.0*** | ***18.4*** | ***26.4*** | ***35.9*** | ***47.0*** | ***100%*** |
| **Total** | | | | | | |
| Refrigeration / Freezing | 0.0 | 1.1 | 2.0 | 2.7 | 2.9 | 5% |
| Compressed air | 0.0 | 5.9 | 10.1 | 12.8 | 13.8 | 23% |
| Pumps | 0.0 | 0.6 | 2.4 | 5.3 | 9.5 | 16% |
| Fans/Blowers | 0.0 | 0.2 | 0.8 | 1.9 | 3.5 | 6% |
| Conveyors | 0.0 | 0.2 | 0.8 | 1.8 | 3.3 | 6% |
| Motors | 0.0 | 0.8 | 3.4 | 7.7 | 13.9 | 24% |
| Process specific | 0.0 | 12.1 | 12.2 | 12.2 | 12.2 | 21% |
| ***TOTAL*** | ***0.0*** | ***20.9*** | ***31.8*** | ***44.4*** | ***59.1*** | ***100%*** |

*Note: Any differences in totals are due to rounding.*

# 7. CONCLUSIONS AND NEXT STEPS

This study has confirmed the existence of significant cost-effective CDM potential within Newfoundland and Labrador's Industrial sector. The study results provide:

- Specific estimates of the potential CDM savings opportunities, defined by sector, sub sector, end use and, in several cases, specific technology(s)

- A baseline set of energy technology penetrations and energy use practices that can assist in the design of specific programs.

The next step[15] in this process involves the selection of a cost-effective portfolio of CDM programs and the setting of specific CDM targets and spending levels. To provide a preliminary reference point for this next step in the program development process, the study team conducted a brief literature search in an attempt to identify typical CDM spending levels in other jurisdictions. The literature search identified two (relatively) recent studies that had addressed similar issues on behalf of other Canadian utilities. The two studies are:

- *Demand-Side Management: Determining Appropriate Spending Levels and Cost-Effectiveness Testing*, which was prepared by Summit Blue Consulting and the Regulatory Assistance Project for the Canadian Association of Members of Public Utility Tribunals (CAMPUT). The study was completed in January 2006.

- *Planning and Budgeting for Energy Efficiency/Demand-Side Management Programs*, which was prepared by Navigant Consulting for Union Gas (Ontario) Limited. The study was completed in July 2005.

The CAMPUT study, which included a review of U.S. and Canadian jurisdictions, concluded that an annual CDM expenditure equal to about 1.5% of annual electricity revenues might be appropriate for a utility (or jurisdiction) that is in the early stages of CDM[16] programming. This level of funding recognizes that it takes time to properly introduce programs into the market place.

The same study found that once program delivery experience is gained, a ramping up to a level of about 3% of annual electricity revenues is appropriate. The study also notes that higher percentages may be warranted if rapid growth in electricity demand is expected or if there is an increasing gap between demand and supply due to such things as plant retirements or siting limitations. The current emphasis on climate change mitigation measures would presumably also fall into a similar category of potential CDM drivers.

The CAMPUT study also notes that even those states with 3% of annual revenues as their CDM target have found that there are more cost-effective CDM opportunities than could be met by the 3% funding. The finding is consistent with the situation in British Columbia. In the case of BC Hydro, CDM expenditures over the past few years have been about 3.3% of electricity

[15] Full treatment of these next steps is beyond the scope of the current project.
[16] The term DSM (demand-side management) and CDM are used interchangeably in this section.

revenues.[17] However, the results of BC Hydro's recently completed study (Conservation Potential Review (CPR) 2007) identified over 20,000 GWh of remaining cost-effective CDM opportunities by 2026. The magnitude of remaining cost-effective CDM opportunities combined with the aggressive targets set out in British Columbia's provincial Energy Plan suggest that BC Hydro's future CDM expenditures are likely to increase significantly if the new targets are to be met.

- **Additional notes:**

- Neither of the studies noted above found any one single, simple model for setting CDM spending levels and targets. Rather, the more general conclusion is that utilities use a number of different approaches that are reasonable for their context. In fact, the CAMPUT report identified seven approaches to setting CDM spending levels.

  - Based on cost-effective CDM potential estimates
  - Based on percentages of utility revenues
  - Based on Mills/kWh of utility electric sales
  - Levels set through resource planning process
  - Levels set through the restructuring process
  - Tied to projected load growth
  - Case-by-case approach.

- The CAMPUT study also notes that, although not always explicit, a key issue in most jurisdictions is resolving the trade off between wanting to procure all cost-effective energy-efficiency measures and concerns about the resulting short-term effect on rates. The study concludes that CDM budgets based on findings from an Integrated Resource Plan or a benefit-cost assessment tend to accept whatever rate effects are necessary to secure the overall resource plan, inclusive of the cost-effective energy-efficiency measures.

[17] CAMPUT, 2006. p. 14.

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MARBEK
Resource Consultants Ltd.

# APPENDIX A

# Industry Electricity Survey

MARBEK
Resource Consultants Ltd.

# Newfoundland CDM Potential

# Industry Electricity Survey

## INTRODUCTION

This electricity survey focuses on the electricity use and operating practices that will inform the assessment of electricity Conservation and Demand Management (CDM) potential in the province.

Please complete the following questionnaire, and return it within 2 weeks. Should you need immediate assistance call Henri van Rensburg at (416) 364-3772.

## CLIENT INFORMATION

Facility Name: ……………………………………………………………………………..

Facility Address: …………………………………………………………………………..

Your Name: ……………………………………………………………………………...

Title: ……………………………………………………………………………………….

Date: ……………………………………………………………………………………......

Telephone: ………………………………………………………………………………

Fax: ………………………………………………………………………………………..

Email Address: ……………………………………………………………………………….

## A ELECTRICITY USE

Please provide an estimate (in percentages) of how much of the total plant **electricity** is used by each of the end uses:

| Electricity End Use | | Percentage of Total Plant Electricity (%) |
|---|---|---|
| Process heating (incl. water heaters, steam production) | | |
| Process cooling / refrigeration | | |
| Motors and motor driven equipment | Air compressors | |
| | Pumps | |
| | Fans and Blowers | |
| | Conveyors | |
| | Other motors | |
| Process specific | | |
| Building envelope and comfort | Lighting | |
| | Comfort heating, cooling, ventilation and air conditioning (HVAC) | |
| Other | | |
| ***TOTAL*** | | ***100 %*** |

## B GENERAL PRACTICES

Please answer the following questions:

B.1 Does your facility contain any of the following?

| | Yes | No |
|---|---|---|
| Interval metering system | ☐ | ☐ |
| Sub-metering on various plant areas or processes | ☐ | ☐ |
| Electricity demand management control | ☐ | ☐ |
| Power Factor correction equipment | ☐ | ☐ |
| Overall plant control system | ☐ | ☐ |
| Program to replace old motors with high/premium efficiency motors | ☐ | ☐ |
| Program to ensure variable speed/frequency drives (VSD/VFD) are installed on motors/pumps/fans where possible | ☐ | ☐ |

B.2 Does your cooling / refrigeration system contain any of the following systems?

| | Yes | No |
|---|---|---|
| Standalone compressor control system | ☐ | ☐ |
| Integrated compressor control system | ☐ | ☐ |
| VFD controlled compressors | ☐ | ☐ |

B.3 Does your compressed air system contain any of the following systems?

| | Yes | No |
|---|---|---|
| Standalone compressor control system | ☐ | ☐ |
| Integrated compressor control system | ☐ | ☐ |
| VFD controlled compressors | ☐ | ☐ |
| Regular compressed air leak detection survey | ☐ | ☐ |
| Compressed air receiver tanks | ☐ | ☐ |
| Use outside air as make up air (answer only if compressor is air cooled) | ☐ | ☐ |
| Return exhaust air to heat building during winter (answer only if compressor is air cooled) | ☐ | ☐ |

B.4 Does your lighting system contain any of the following systems?

| | Yes | No |
|---|---|---|
| On/off timer settings | ☐ | ☐ |
| Occupancy sensors | ☐ | ☐ |
| Control of lighting system according to zones or separate production areas | ☐ | ☐ |

B.5 Do you operate your HVAC system with the following?

| | Yes | No |
|---|---|---|
| Different temperature setting for summer and winter | ☐ | ☐ |
| Different heating and cooling set points | ☐ | ☐ |
| Set back temperatures when facility is not occupied, for example during weekends | ☐ | ☐ |
| Recover heat from exhaust to heat make up air | ☐ | ☐ |

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# APPENDIX B

# Opportunity Profiles

## Opportunity Profile

### I1 – Cooling and Refrigeration/Freezing

***Overview:***

Cooling and refrigeration/freezing apply mainly to the Fishing and Fish Processing sub sector. The opportunity includes improving the efficiency of refrigeration equipment through system reconfiguration, such as optimizing the condenser size, and through technology applications, such as efficient compressors and condenser fans. Improving distribution piping requires a thorough analysis of the complex relationship between the flow of refrigerant, oil and pipe insulation.

***Target Technologies and Measures:***

- Premium efficiency refrigeration equipment including efficient compressors, optimized floating head pressure and equipment size optimization
- Improved distribution system

***Opportunity Costs and Savings Profile***:

- A typical cooling/refrigeration/freezing project has an implementation cost of $2,000 to $50,000
- The total economic potential for these measures is estimated to be 7.4 GWh/yr. by 2026
- Customer payback is in the range of 12 years
- The CCE for these opportunities is estimated to be $0.01 to $0.04/kWh

***Target Audience(s)& Potential Delivery Allies:***

- Fishing and Fish Processing sub sector
- Cooling and refrigeration/freezing equipment manufacturers and suppliers
- Provincial and federal government

***Constraints & Challenges:***

The most significant barriers are:

- Premium efficiency equipment has attractive energy savings but increased equipment costs
- Long payback periods
- Retrofitting main equipment and distribution system require systems to be out of operation and may interfere with production schedules

***Opportunities & Synergies:***

- To capitalize on all potential benefits, the feasibility of efficient refrigeration system opportunities are best evaluated during system expansion or as part of a system reliability and safety review.
- Improved cooling and freezing may improve product quality and ensure compliance with food safety requirements.

***Experience Related to Possible Participation Rates:***

## Opportunity Profile

### I2 – Compressed Air

***Overview:***
Premium efficiency compressed air equipment includes both the compressor and the air dryer. Premium efficiency air compressors come with built-in ASD control that allows the compressor output to match the plant air demand. These compressors may save as much as 40% over standard compressors which typically use modulated control. Premium efficiency air dryers are of the refrigerated type with dewpoint control. These dryers are typically at least 15% more efficient than regenerative desiccant dryers, which are still commonly used in industry. Industrial facilities typically have several air compressors. Sequencing control systems can operate the compressors so that the larger compressor is base loaded (always on), the mid-sized compressors are used as needed to increase supply and an ASD compressor acts as the trim compressor (provides for the variable component of the process air demand). This setup is intended to closely match the demand for compressed air, to maintain consistent pressure and flow and to reduce O&M costs. Improving the compressed air distribution system involves the addition of air storage to reduce pressure fluctuations, and air piping redesign to reduce friction losses.

***Target Technologies and Measures:***
- Efficient equipment including efficient compressors, air dryers and equipment size optimization
- Efficient control including ASD, sequencing and dryer dewpoint control
- Efficient distribution system including increased air storage and reduced piping friction losses

***Opportunity Costs and Savings Profile***:
- A typical compressed air project has an implementation cost of $5,000 to $65,000
- The total economic potential for these measures is estimated to be 7.7 GWh/yr. by 2026
- Customer payback is in the range of 6-13 years
- The CCE for these opportunities is estimated to be $0.01 to $0.08/kWh

***Target Audience(s)& Potential Delivery Allies:***
- All Industrial sub sectors
- Compressed air equipment manufacturers and suppliers
- Provincial and federal government

***Constraints & Challenges:***
The most significant barriers are:
- Perception by production personnel that existing system should not be changed
- Relatively long payback periods
- Retrofitting main equipment and distribution system require systems to be out of operation and may interfere with production schedules

***Opportunities & Synergies:***
- Heat recovery from air compressors can be used for space heating
- Replacing water cooled air compressors with air cooled compressors eliminates water usage

***Experience Related to Possible Participation Rates:***

## Opportunity Profile

### I3 – Pumps

***Overview:***
Pumps in industrial applications are often used for cooling tower sprays, spray cooler, water boosters, liquid transport, liquid recovery and liquid mixing. Energy savings can be gained by replacing older stock pumps with premium efficiency models that are application specific with premium efficiency impellers and motors. Pumps should be sized and selected based on their performance curve for the required flow. Impeller sizing is also an important consideration. Impellers should be sized specific for an application.

Pumps used for variable flow in industrial applications may be candidates for ASD. Currently, most pump installations are single speed and operate continuously independent of the actual load. Installing ASD on smaller pumps will result in significant energy savings in variable load applications where full operation may be required for less than 30% of the operating time. In these applications, 40% energy savings can be achieved. Modulating valves installed on by-pass lines will provide sufficient flow at all times allowing the pump to perform at maximum efficiency on the pump curve.

***Target Technologies and Measures:***
- Efficient and premium efficiency equipment including equipment size optimization
- Efficient control including ASD

***Opportunity Costs and Savings Profile***:
- A typical pump project has an implementation cost of $500 to $50,000
- The total economic potential for these measures is estimated to be 3.9 GWh/yr. by 2026
- Customer payback is in the range of 2-8 years
- The CCE for these opportunities is estimated to be $0.03 to $0.07/kWh

***Target Audience(s)& Potential Delivery Allies:***
- All Industrial sub sectors
- Pump manufacturers and suppliers
- Provincial and federal government

***Constraints & Challenges:***
The most significant barriers are:
- Relatively large capital investment in equipment for some projects; however, energy savings and production improvements will make this an attractive investment
- Retrofitting main processing pumps will require pumps to be out of operation and may interfere with production schedules

***Opportunities & Synergies:***
- Well accepted and proven technology.
- Improved pumping may result in improved product quality

***Experience Related to Possible Participation Rates:***

## Opportunity Profile

### I4 – Fans and Blowers

***Overview:***

Fans and blowers are often used for ventilation, exhaust, cooling, dust collection and aeration. Energy savings can be gained by replacing older stock fans and blowers with premium efficiency models that are application specific. Fans should be sized and selected for an application based on the performance curve of the fan at the required airflow.

Fans are widely used in industry for conveyance, drying and ventilation purposes. Operations requiring variable air delivery, such as drying, can benefit from premium control with ASD allowing air delivery to match process requirements. ASD save electricity and improve product quality by providing plant operators greater and finer control.

***Target Technologies and Measures:***

- Efficient and premium efficiency equipment, including equipment size optimization
- Efficient control, including timers and ASD

***Opportunity Costs and Savings Profile***:

- A typical fan/blower project has an implementation cost of $500 to $50,000
- The total economic potential for these measures is estimated to be 3.5 GWh/yr. by 2026
- Customer payback is in the range of 2-9 years
- The CCE for these opportunities is estimated to be $0.04 to $0.09/kWh

***Target Audience(s)& Potential Delivery Allies:***

- All Industrial sub sectors
- Fan/blower manufacturers and suppliers
- Provincial and federal government

***Constraints & Challenges:***

The most significant barriers are:

- Lack of understanding by production personnel of energy savings potential

***Opportunities & Synergies:***

- Well accepted and proven technology.
- Improved air quality and indoor climate control

***Experience Related to Possible Participation Rates:***

## Opportunity Profile

### I5 – Conveyors

***Overview:***

Conveyors often use gear boxes to isolate the motor and to provide better torque control. Opportunities include using higher-efficiency drives, couplings and gear/speed reducer alternatives. In older conveyor systems, or where process requirements have changed, it may be possible to resize a conveyor, upgrade the controls or re-engineer the system to improve layout and configuration, all of which will result in energy savings. Incorporating programmable logic controls (PLC) into the conveyor system will result in energy savings. PLC controls can shut down unloaded conveyors and control the conveyor based on load.

***Target Technologies and Measures:***

- Efficient and premium efficiency equipment, including equipment size optimization, low friction systems, and drive optimization
- Efficient control, including ASD

***Opportunity Costs and Savings Profile***:

- A typical conveyor project has an implementation cost of $4,000 to $20,000
- The total economic potential for these measures is estimated to be 2.5 GWh/yr. by 2026
- Customer payback is in the range of 4-7 years
- The CCE for these opportunities is estimated to be $0.07 to $0.10/kWh

***Target Audience(s)& Potential Delivery Allies:***

- Small conveyors in all Industrial sub sectors
- Conveyor manufacturers and suppliers
- Provincial and federal government

***Constraints & Challenges:***

The most significant barriers are:

- Perception by production personnel that existing system should not be changed
- Relatively long payback periods
- Retrofitting main equipment and distribution system require systems to be out of operation and may interfere with production schedules
- Barriers to implementing premium efficiency controls include additional maintenance costs due to increased number of components in the system

***Opportunities & Synergies:***

- Better controlled conveyance may result in improved product quality

***Experience Related to Possible Participation Rates:***

## Opportunity Profile

### I6 – Motors

***Overview:***
Electric motors convert approximately 85% of industrial plant electricity use to torque to drive industrial end uses such as fans, pumps, material handling and a large portion of process loads. These motors range in size from 75 Watts to more than 25,000 kW, with corresponding efficiencies of 40%-98%. While inherently efficient in converting electricity to shaft or motive power, on average 5%-8% of this power is lost in motor inefficiencies that occur before the driven equipment losses. The three motor efficiency levels included in this study are standard (93.5% efficient), high efficiency (94.5% efficient) and premium efficiency (95.5% efficient). Premium efficiency motors apply to all sub sectors and end uses.

Synchronous belts, also called timing, positive drive or high torque drive belts, apply to all sub sectors and end uses. Often, industrial end uses are driven by pulleys that use V-Belts. By replacing the pulley sheaves with synchronous belt pulleys and installing synchronous belts onto the end use (e.g., fan) an efficiency gain of 3%-5% can be achieved because of reduced slippage and friction between the pulley and belt. Synchronous belts may require motor vibration sensors to prevent damage from continuous operation following a system failure.

***Target Technologies and Measures:***
- Premium efficiency motors
- Synchronous belts

***Opportunity Costs and Savings Profile***:
- A typical motor project has an implementation cost of $500 to $75,000
- The total economic potential for these measures is estimated to be 8.7 GWh/yr. by 2026
- Customer payback is in the range of 5-13 years
- The CCE for these opportunities is estimated to be $0.01 to $0.08/kWh

***Target Audience(s)& Potential Delivery Allies:***
- All Industrial sub sectors
- Motor manufacturers and suppliers
- Provincial and federal government

***Constraints & Challenges:***
The most significant barriers are:
- Relatively long payback periods
- Retrofitting motors on main process equipment require systems to be out of operation and may interfere with production schedules

***Opportunities & Synergies:***
- Better operating motors require less maintenance

***Experience Related to Possible Participation Rates:***

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# APPENDIX C

# Opportunity Profile Worksheets

## I1: Cooling / Refrigeration / Freezing

**Opportunities**
Premium efficiency equipment
Improved distribution system

| | |
|---|---|
| Typical project cost | $ 2,000 - $ 50,000 |
| Payback period | 12 years |
| CCE | $ 0.01 - 0.04 / kWh |
| Typical capacity | 50 HP |
| Estimated number of units | 400 - 550 |

**Retrofit**

| Milestone Year | Market Penetration Rate (%) | | | |
|---|---|---|---|---|
| | Reference Case | Achievable Lower | Achievable Upper | Economic Potential |
| 2006 | 10 | 10 | 10 | 10 |
| 2016 | 12 | | | 60 |
| 2026 | 15 | | | 100 |

## I2: Compressed Air

**Opportunities**
Premium efficiency equipment
Efficient control
Improved distribution system

| | |
|---|---|
| Typical project cost | $ 5,000 - $ 65,000 |
| Payback period | 6 - 13 years |
| CCE | $ 0.01 - 0.08 / kWh |
| Typical capacity | 200 HP |
| Estimated number of units | 351 - 400 |

**Retrofit**

| Milestone Year | Market Penetration Rate (%) | | | |
|---|---|---|---|---|
| | Reference Case | Achievable Lower | Achievable Upper | Economic Potential |
| 2006 | 15 | 15 | 15 | 15 |
| 2016 | 17 | | | 100 |
| 2026 | 20 | | | 100 |

## I3: Pumps

**Opportunities**
Premium efficiency equipment
Efficient control

| | |
|---|---|
| Typical project cost | $ 500 - $ 50,000 |
| Payback period | 2 - 8 years |
| CCE | $ 0.03 - 0.07 / kWh |
| Typical capacity | 50 - 200 HP |
| Estimated number of units | 2,500 - 3,000 |

**Retrofit**

| *Milestone Year* | *Market Penetration Rate (%)* | | | |
|---|---|---|---|---|
| | *Reference Case* | *Achievable Lower* | *Achievable Upper* | *Economic Potential* |
| ***2006*** | 20 | 20 | 20 | 20 |
| ***2016*** | 22 | | | 100 |
| ***2026*** | 25 | | | 100 |

## I4: Fans / Blowers

**Opportunities**
Premium efficiency equipment
Efficient control

| | |
|---|---|
| Typical project cost | $ 500 - $ 50,000 |
| Payback period | 2 - 9 years |
| CCE | $ 0.04 - 0.09 / kWh |
| Typical capacity | 50 - 200 HP |
| Estimated number of units | 800 – 1,800 |

**Retrofit**

| *Milestone Year* | *Market Penetration Rate (%)* | | | |
|---|---|---|---|---|
| | *Reference Case* | *Achievable Lower* | *Achievable Upper* | *Economic Potential* |
| ***2006*** | 20 | 20 | 20 | 20 |
| ***2016*** | 22 | | | 100 |
| ***2026*** | 25 | | | 100 |

## I5: Conveyors

**Opportunities**
Premium efficiency equipment
Efficient control

| | |
|---|---|
| Typical project cost | $ 4,000 - $ 20,000 |
| Payback period | 4 - 7 years |
| CCE | $ 0.04 - 0.06 / kWh |
| Typical capacity | 50 - 200 HP |
| Estimated number of units | 1,000 – 1,800 |

**Retrofit**

| Milestone Year | Market Penetration Rate (%) | | | |
|---|---|---|---|---|
| | Reference Case | Achievable Lower | Achievable Upper | Economic Potential |
| **2006** | 20 | 20 | 20 | 20 |
| **2016** | 22 | | | 100 |
| **2026** | 25 | | | 100 |

## I6: Motors

**Opportunities**
Premium efficiency equipment
Synchronous belts and VFDs

| | |
|---|---|
| Typical project cost | $ 500 - $ 75,000 |
| Payback period | 5 - 13 years |
| CCE | $ 0.01 - 0.08 / kWh |
| Typical capacity | 50 - 200 HP |
| Estimated number of units | 5,000 – 6,500 |

**Retrofit**

| Milestone Year | Market Penetration Rate (%) | | | |
|---|---|---|---|---|
| | Reference Case | Achievable Lower | Achievable Upper | Economic Potential |
| **2006** | 20 | 20 | 20 | 20 |
| **2016** | 22 | | | 100 |
| **2026** | 25 | | | 100 |

# CONSERVATION AND DEMAND MANAGEMENT (CDM) POTENTIAL

## Newfoundland and Labrador

## –Program Evaluation Guidelines–

*Prepared for:*

**Newfoundland and Labrador Hydro &**
**Newfoundland Power**

*Prepared by:*

**Marbek Resource Consultants Ltd.**

*In association with:*

**Bureau d'Études Zariffa Inc.**

*January 18, 2008*

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# 1. INTRODUCTION

## 1.1 BACKGROUND AND OBJECTIVES

Newfoundland and Labrador Hydro and Newfoundland Power (collectively the Utilities) have partnered to produce this study, recognizing the role that each has in energy conservation and least cost electric utility planning within the province. Increasing electricity costs and the expectations of a growing number of their customers and stakeholders have contributed to the increased focus on conservation and demand management (CDM) and resulted in a number of recent initiatives and projects targeting energy savings in the province. This study is the next step in the Utilities efforts to develop a comprehensive plan for CDM in Newfoundland and Labrador. The Utilities envision electricity conservation and demand management (CDM) to be a valuable component in meeting the province's future electricity requirements.

This study will also be a significant component in the further implementation of the Province's recently released Energy Plan. The Energy Plan establishes a long-term vision for how the province's energy resources will be developed and utilized to benefit the people of the province today as well as for future generations. Electricity conservation and demand management (CDM) are an important component of the provincial Energy Plan as are the conservation and demand management components for the other energy resources of the province.

This report meets, in part, the requirements of the Public Utilities Board Order PU 8 2007 requiring NLH to file this study and a five-year plan for implementation of CDM programs in 2008.

The objective of this study is to identify the potential contribution of specific CDM technologies and measures in the Residential, Commercial and Industrial sectors and to assess their economic costs and benefits. The Newfoundland and Labrador economy is expected to grow over the next 20 years, with an associated increase in energy consumption. The benefits of increased penetration of energy efficiency technologies include reduced energy costs for individuals and businesses, as well as environmental benefits through reduced pollution and greenhouse gas emissions.

The outputs from this study will assist the Utilities CDM planners and others to develop specific CDM programs for implementation and to optimize the contribution of CDM technologies and measures to the province's overall energy future.

## 1.2 STUDY ORGANIZATION AND REPORTS

This report is one of five that have been prepared for the *Newfoundland and Labrador Conservation and Demand Management (CDM) Potential Study*. It complements the three individual sector and summary reports, which provide a detailed analysis of CDM opportunities in, respectively, the Residential, Commercial and Industrial sectors. The results of those study components are presented under separate cover; they are titled:

- *Conservation and Demand Management Potential (2006 to 2026, Newfoundland and Labrador, Residential Sector*

- *Conservation and Demand Management Potential (2006 to 2026), Newfoundland and Labrador, Commercial Sector*

- *Conservation and Demand Management Potential (2006 to 2026), Newfoundland and Labrador, Industrial Sector*

- *Conservation and Demand Management Potential (2006 to 2026), Newfoundland and Labrador, Residential, Commercial and Industrial Sectors, Summary Report*

The technical and market analysis contained in the above reports provides a foundation for Utilities' personnel to design and implement CDM programs targeted to selected priority opportunities. Evaluation is an important component of the CDM program design and implementation cycle that is expected to follow the completion of this study. However, the identification of specific CDM programs is beyond the scope of this current study; consequently, it is not possible to present a program-specific evaluation plan at this time. Given these circumstances, this report provides program design personnel and program managers with high-level guidelines and points to consider when addressing evaluation issues as part of the detailed CDM program design process. More specifically, this report is organized and presented as follows:

- Section 2 provides an overview of the role of evaluation within the overall CDM program design and implementation cycle

- Section 3 provides high-level guidelines related to a number of specific program evaluation questions that were identified in consultation with Utilities' personnel

- Section 4 provides an overview of lessons learned for small markets related to selection of CDM program types and program evaluation priorities.

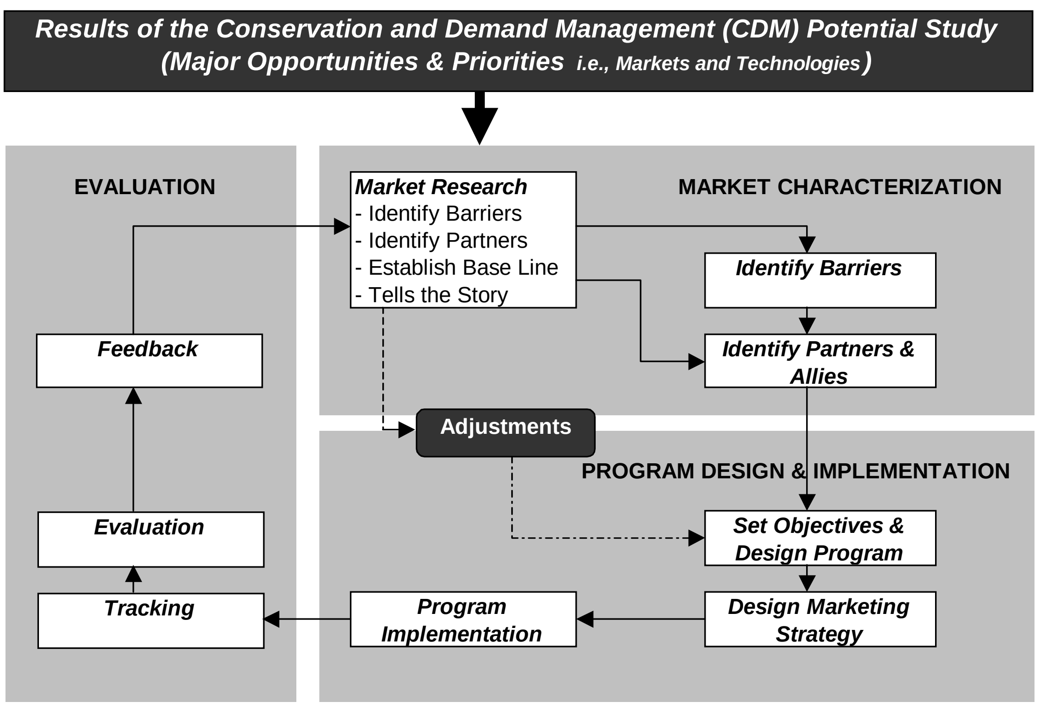
# 2. THE CDM PROGRAM DESIGN AND EVALUATION CYCLE

## 2.1 INTRODUCTION

Evaluation is part of an integrated CDM program cycle that combines effective program design and implementation with evaluation. Exhibit 2.1 provides an illustration of the three primary components of the CDM program cycle (market characterization, design and implementation, evaluation); it also illustrates the relationship of the CDM Potential Study to the CDM program cycle.

As illustrated in Exhibit 2.1, the results of the CDM Potential Study provide a foundation that supports the broader, on-going CDM program cycle. More specifically, the study identifies and provides a comprehensive assessment of the full range of potential CDM measures, including the identification of potential savings and costs by sub sector, end use and technology. These results assist the Utilities to identify priorities based on the availability of CDM program budgets or energy savings targets.

**Exhibit 2.1: CDM Program Cycle**




Once the Utilities have selected the first round of CDM priorities, the main components of the program cycle can be grouped into 3 categories:

- Market Characterization
- Program Design and Implementation
- Evaluation

The remainder of this section provides a brief overview of each component with particular emphasis on evaluation related considerations.

## 2.2 MARKET CHARACTERIZATION

For each of the selected CDM priorities, "market characterization" (MC) provides four important contributions to the CDM program cycle:

- It "tells the story" of the precise path of a given technology in a market from the manufacturer or importer to the end user.
- It identifies the types of barriers that prevent a given technology penetrating the market (e.g., financial, technological, commercial, informational or institutional barriers). Institutional barriers are, by far, the most difficult to overcome.
- It identifies the major partners who have a significant influence in that chain of acquisition in order to identify potential marketing or delivery partners or trade allies for a new program.
- It establishes a baseline and trends.

The story guides the marketing strategy for the new program. The *partners* will eventually be program delivery allies. Understanding the *barriers* will guide the type of supports that the program should offer and the *baseline* will help establish program objectives since it represents the starting point.

## 2.3 PROGRAM DESIGN AND IMPLEMENTATION

To support the evaluation process, there are two concepts that need to be defined during the program design phase, and be available for the evaluator's examination. They are: Program theory (PT) and logic model (LM). Each is briefly outlined below.

### 2.3.1 Program Theory

A program theory is a presentation of the goals of a program and the identification of the causal relationships between the activities and the program's effects. The theory describes, in detail, how the proposed activities will accomplish the program goals.

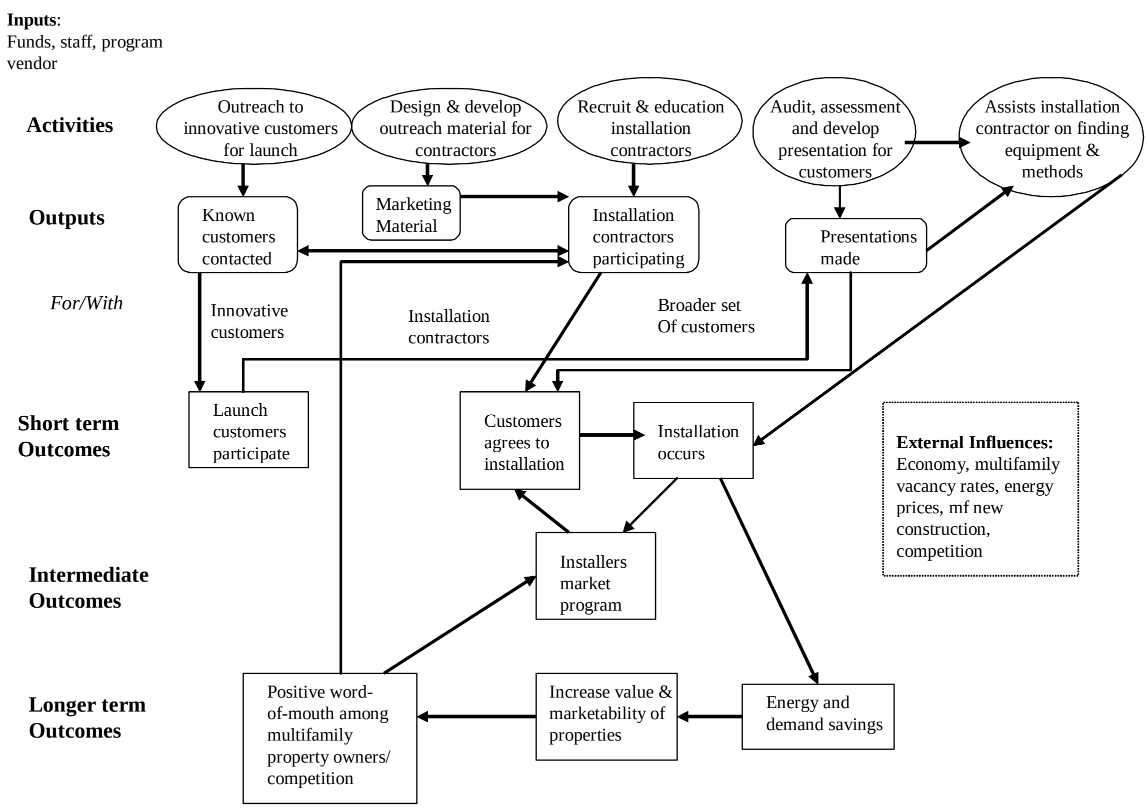
A well-developed PT should also describe the barriers to be overcome and how the program's activities are expected to overcome those barriers. A PT may also indicate (from the program developer's perspective) what progress and goal attainment metrics should be tracked to assess the program's effects.

### 2.3.2 Logic Model

PTs are sometimes called the program logic model (LM). A stricter definition would be to differentiate the PT as the textual description, while the LM is the graphical representation of the PT, showing the flow between activities, their outputs and subsequent short-term, intermediate and long-term outcomes.

The LM is often displayed with these elements in boxes with the causal flow shown by arrows from one to the others in the program logic. It can also be displayed as a table with the linear relationship presented by the rows in the table. The interactions between activities, outputs and outcomes are critical to understanding the program logic and argue for the need to have, or construct, both a program theory and a program logic model. Exhibit 2.2 is an example of a logic model diagram.

**Exhibit 2.2: CDM Program Logic Model**[1]




## 2.4 EVALUATION

The evaluation plan is also defined during the program design phase of the CDM program cycle. The evaluation plan defines how the evaluation will be implemented. Some utilities develop a detailed evaluation plan at the design phase of a given program; others simply define the pertinent evaluation information and data needs at the program's design phase to ensure that the necessary data will be available when the evaluation occurs at a later stage.

The latter approach is preferred since data availability, quality, precision and accuracy can seriously affect the evaluation methodology. It is important, however, to identify the necessary evaluation data and information as well as the collection method and sources. Program administers usually perform this task with the assistance of an experienced evaluator. At this

[1] California Evaluation Framework, op. cit., p. 48.

stage, the evaluator may identify program activity objectives that will be difficult or impossible to evaluate; such insight will provide the program designer with an opportunity to modify the proposed program framework and increase the likelihood of program success. Most of the data needs are related to the program theory, the baseline[2] or reference case and the implementation strategy's key performance indicators.

Exhibit 2.3 illustrates a typical program evaluation data-tracking plan. It describes the relationship between information needed from administrators and program evaluation. The key activities related to the data required from program administrators are shown in the oval-shaped boxes for each stage of the evaluation cycle. Typically, after examining the data provided by the administrators, the evaluator will define the researchable issues and develop a comprehensive research methodology. Tools to collect this information (mostly ex-post) will range from telephone surveys to focus groups, metering, billing analysis, simulations, site visits, mystery callers and mystery shoppers, etc. Most of the collection tools are usually pre-approved by utility CDM program staff, which allows them to be sure that specific subjects of concern are adequately addressed.

Energy-efficiency program evaluation is not an exact science.  This is because consumer behavior can vary from the most accurate predictions and because the evaluation cannot measure something that does not exist (energy saved). Hence, the evaluator will try to find a particular answer by using more than one deduction method to establish reasonable and credible results. This technique is called cross validation or triangulation. The California Energy Efficiency Evaluation Protocols provides examples of such data for different types of programs.[3]

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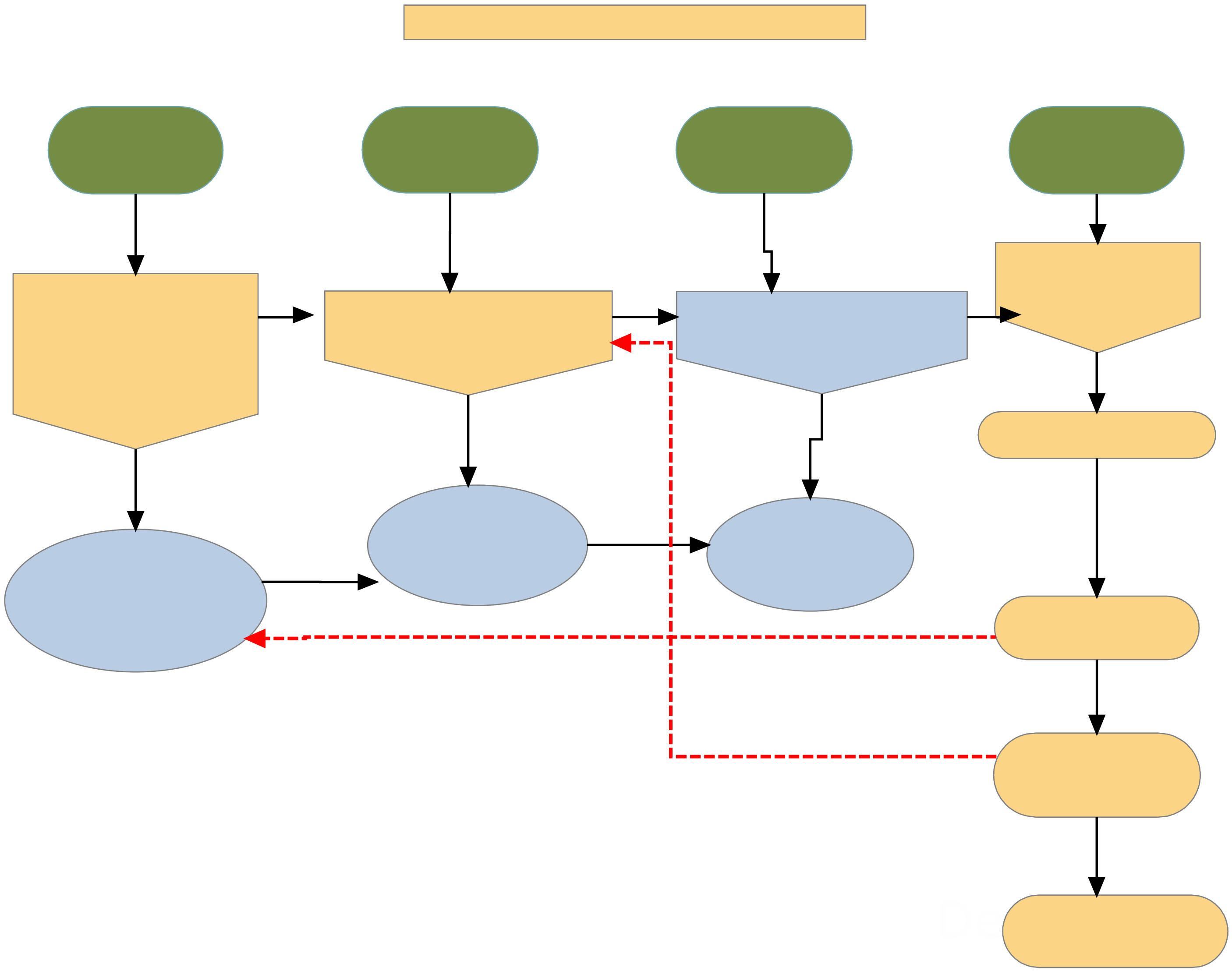
[2] A baseline is the starting point from which program staff set their objectives. It is usually dynamic and must be carefully monitored to differentiate between natural savings (savings that would have occurred anyway, without a strategic intervention such as a program), and the strategic savings that can be attributed to the program. Baseline is also an important tool for the evaluator.

[3] California Energy Efficiency Evaluation Protocols: Technical, Methodological, and Reporting Requirements for Evaluation Professionals. April 2006. p. 205.

**Exhibit 2.3: Data Tracking Plan for Program Evaluation**



# 3. EVALUATION GUIDELINES

## 3.1 INTRODUCTION

As noted in previously in Section 1, it is too early in the CDM program cycle to define a specific evaluation plan. Consequently, the consultant was asked to provide general guidelines or principles to be considered related to the following list of evaluation topics:

It is organized and presented in the following sub sections:

- Evaluation definitions and types
- Why evaluate and for whom?
- Who evaluates?
- When to evaluate?
- Evaluation budget, cost versus precision
- Program evaluation metrics.

***Caveat:*** The following sections provide some general information, based on best practices, related to the science of energy-efficiency program evaluation. It is expected that Utility CDM program staff (those who deliver the program) will select the most appropriate elements that apply to their particular context in terms of program types, market characteristics, available resources and the specific needs of stakeholders.

## 3.2 EVALUATION DEFINITION AND TYPES

Evaluation has two core functions: Summative and Formative. Summative refers to the documentation and measurement of the effects of a given program. Formative refers to understanding why those effects occurred and identifying ways to improve the program. Without these two functions, causal effects cannot be established and, therefore, no sound recommendations can be proposed.

- **Summative Evaluation**: Most parties agree that the single most important function of evaluation is to document and measure program effects. The impact of a program, or group of programs, is often a requirement for ensuring accountability of resources spent on the program. Summative evaluations are done once a program has been operating to document program impacts and are used to inform decisions on whether to continue, expand, cut back or end the program. Generally, impact evaluations in the energy-efficiency field are summative evaluations.

- **Formative Evaluation**: Formative evaluation provides understanding into why the observed effects occurred and identifies ways to improve program effectiveness. Formative evaluations are often conducted early in a program's operations, or in steady-state programs to obtain feedback and discover ways to improve a program. Process evaluations are typically used as formative evaluations.[4]

[4] California Evaluation Framework, prepared for the California Public Utilities Commission and the Project Advisory Group. June 2004. p. 28.

The importance of both evaluation functions can be seen through a simple example. Consider a situation where the observed impacts of a program are weak but the effect is due to an easily correctible problem in the program implementation. Reacting to the impact evaluation results alone might well lead to a technically accurate but policy-poor decision to terminate the program, whereas understanding why those results occurred and what can be done to improve the results can lead to improvements in the program implementation and ultimately a successful program.

Similarly, experts realize that new programs typically have to experience a "start-up" phase, where effectiveness is not yet optimized and initial costs are higher. It would be inappropriate to simply look at initial impact results and make a quick judgment about a program's potential without understanding where the program was in terms of its life cycle.

In summary, quality evaluation efforts incorporate both evaluation concepts into their energy program evaluation design:

- Summative or impact evaluation documents program impacts
- Formative or process evaluation provides for a better understanding of the observed results, the reasons for these results and identifies applicable opportunities for improving program performance.

### 3.1.1 Types of Program Evaluation

Technically, each energy-efficiency program requires a particular type of evaluation that is closely linked to its objectives. For example, a resource acquisition program requires a different type of evaluation than a market transformation program, a low-income program, a codes and standards program or a capacity building and awareness program. Although there are many types of evaluations,[5] they can be grouped into three broad categories:

- Process evaluation
- Market evaluation
- Impact evaluation.

**Process Evaluation**

A process evaluation is a systematic assessment of an energy-efficiency program for the purposes of (1) documenting program operations at the time of the examination, and (2) identifying and recommending improvements that can be made to the program to increase the program's efficiency or effectiveness for acquiring energy resources, while maintaining high levels of participant satisfaction.[6] This definition specifically excludes

[5] Examples include: process, direct market, indirect market, energy impact, demand impact, market transformation, non-energy benefits evaluations, etc.

[6] California Evaluation Framework, op. cit., p. 207.

the assessment of energy programs for purposes other than increasing the efficiency or effectiveness of the program to acquire energy resources, either directly or indirectly.[7]

In practice, the process evaluation is like a “pit stop” to check important program delivery issues that will help to inform whether and how adjustments may need to be made. The process evaluation will identify and recommend changes in a program’s operational procedures or systems that can be expected to improve the program’s efficiency or cost effectiveness.

**Market Evaluation**

The market effect of a program is defined as “a change in the structure of a market or the behavior of participants in a market that is reflective of an increase in the adoption of energy efficient products, services, or practices and is causally related to market intervention(s).”[8] Consequently, a market evaluation assesses a program’s short- and long-term market effects.

Strategically, a market evaluation will be a key part of an industry program evaluation plan because the program is designed to foster market transformation.

The program evaluation literature suggests that market evaluations be designed and implemented at the market level, rather than in relation to a specific program (i.e., the anticipated impacts of such a program are usually expected at the market level). However, in the case of a market transformation program, there is a direct relationship between the program’s activities and an anticipated market level effect, so it is defensible to conduct a market evaluation for the program.

**Impact Evaluation**

An impact evaluation estimates the “net” energy and demand savings of a program and its cost effectiveness to verify whether the expected program energy and demand savings are actually occurring in the field. Strategically, an industry program impact evaluation can also measure the possible non-energy benefits of the program, e.g., reduction of waste in the production of a given good, the reduction of inventory of raw or finished goods, the air quality in the plant and worker productivity, reduction of other valuable resources such as water, etc.

[7] For example, this definition excludes conducting management audits or evaluations for the purposes of supplementing a financial audit of a program unless these examinations, at least in part, are conducted for the purposes of reducing the net cost of acquiring the energy impacts.

[8] California Evaluation Framework, op. cit., p. 263.

An impact evaluation generates two types of energy savings estimates:

- Gross savings, which are calculated for program participants relative to their prior participation usage

- Net savings, which control for savings that would have occurred for these participants over the same time period whether the program was offered or not. As noted in the California Evaluation Protocols, "estimating net savings generally requires the use of a comparison group as a proxy for what the participants would have done absent the program, or self-reported information on what would have happened in the absence of the program when comparison groups cannot be reasonably identified."[9]

## 3.3 WHY EVALUATE AND FOR WHOM?

The primary purpose of program evaluation is to help ensure that good decisions are made regarding the investment of energy program resources by providing rigorous, independent evaluation studies and study results.

One of the primary ways in which evaluations provide information for making good decisions is by testing the implicit and explicit assumptions within the program theory and its marketing strategy. If the assumptions of a program theory are not validated in a real market context and/or if the program implementation strategy fails, the program will perform poorly, and vice versa.

Evaluation results are useful to different stakeholders, such as:

- Regulatory staff and policy makers
- Consultative groups
- Program partners
- Evaluation oversight managers and reviewers
- Program administrators and or program implementers
- Cost-effectiveness and avoided cost personnel
- Evaluation designers and managers
- Evaluators for all types of evaluation—impact, metering and monitoring, process, information and education programs, market transformation and market effects, and non-energy effects
- Statisticians and research data managers
- Portfolio managers.

All of these stakeholders are not necessarily present or active in every jurisdiction. Once the stakeholders are identified, the next step is to identify the "need to know" issues confronting them. This information is essential to guide and optimize evaluation efforts. Examples of common utility-specific issues that are addressed by evaluation results include:

- Was the specified work completed?

[9] California Evaluation Framework, op. cit., p. 96.

- Were the expected savings achieved?
- Did we get what we paid for?
- Is the customer satisfied?
- Will the savings persist?
- How should we direct future offerings?

Examples of common regulatory issues that are addressed by evaluation results include:

- Is the program meeting its objectives?
- Are efficiency funds being used responsibly?
- Is the public interest being met?
- Is it consistent with public policy?
- Are there economic development impacts?

Once again, these are examples of stakeholders and what they expect from a program delivery. Each jurisdiction should identify the stakeholders involved and their needs or specific expectations.

## 3.4 WHO EVALUATES?

To optimize credibility, post-implementation program evaluation should be conducted by an independent, experienced evaluator. That being said, if resources are limited, program staff should determine if some evaluation activities could be done internally. In such a case, an experienced staff member (who was not involved in the design and development of the program) should conduct the process evaluation.

Assigning different evaluators to do different types of evaluation at different times for the same program is neither cost effective nor efficient. To be effective, an evaluator needs to have a broad understanding of the program, including its progression and adjustments over time. Ideally, the evaluator serves as an ally to the utility CDM program staff, guiding them in a process of continuous program performance improvement over the program's life.

Any program research activities conducted throughout the program's life should be contracted to the same evaluator (assuming that his/her quality of work is satisfactory). This approach avoids discrepancies in research methods. For example, if the program authority needs to conduct research on a baseline or a survey in between two evaluations, these tasks should be given to the same program evaluator who will use the information as an input to the evaluation. Relying on the same evaluator allows the performance of the evaluator's recommendations to be measured over time, ensures greater depth of understanding of the issues and avoids a "hit and run" approach. Some may argue that by evaluating his/her own recommendations, the evaluator will be in a conflict of interest, but close monitoring of the evaluator's work by program staff should prevent any such conflict.

In addition, evaluators should be involved in the very early stage of any program design in order to avoid situations that could affect the evaluation cost or precision. Evaluators should have hands-on experience in the design, development, marketing and tracking of utility based energy-efficiency programs, not just evaluation of the program. This type of expertise offers a better understanding of the characteristics and specific difficulties related to energy-efficiency programs.

## 3.5 WHEN TO EVALUATE?

There is no strict agenda for the timing of program evaluation. However, the following principles provide useful guidelines:

- Process evaluation should be carried out in the early stages of program implementation when few participants or trade allies are involved. This early input will identify any necessary adjustments and ensure that the program is on track.

- Market and impact evaluation is typically conducted every two or three years, depending on the issues identified through the tracking process. For example:

  - A statistically significant number of participants
  - Ratio of actual number of participants vs. forecast number of participants for a given period
  - Actual spending versus predicted spending ratio for a given period
  - Actual savings versus predicted savings for a given period
  - A high or low level of customer service calls
  - Any other performance indicators that, in the opinion of the program managers, requires an evaluation to clarify or explain a given situation.

- A comprehensive evaluation should be performed at the end of a program's life cycle.[10]

## 3.6 EVALUATION BUDGET, COST VERSUS PRECISION

As noted previously, energy-efficiency program evaluation is not an exact science. The more precision that is required, the more the evaluation will cost. Program evaluation cost and precision also depends on the quality and quantity of data provided by the program administrator (see Exhibit 2.2).

Evaluation budgets can vary widely depending on the researchable issues and the type of program being evaluated. Among delivery agencies that run aggressive CDM programs (e.g., California public- or privately-owned utilities, U.S. northwest utilities and some U.S. midwest utilities), costs vary from about 3% to 8% of total program expenditures.

Some evaluation techniques are more capital intensive than others. For example, on-site metering, on-site visits and energy use simulations are more expensive than surveys or discussion groups. Similarly, homogeneous markets, such as the residential sector, typically have

[10] Program life cycle is the number of years a specific program will be offered in a given market. Technology life cycle refers to useful life duration of a given technology or product and is usually expressed in number of years. This is useful to calculate cumulative savings for cost-effectiveness tests in particular.

a much lower evaluation expenditure-to-program budget ratio than exogenous markets, such as the industrial sector.

### 3.6.1 California Energy Efficiency Evaluation Protocol

The California Energy Efficiency Evaluation Protocol[11] offers a set of technical, methodological and reporting requirements for evaluation professionals.

For each type of evaluation, the protocol outlines three levels of rigor: basic, standard and enhanced.

Each level defines a set of program evaluation methodologies; some of the methods refer to the different measurement scenarios (A to D) of the International Program Measurement and Verification Protocol (IPMVP).[12] The higher the rigor level scale, the more expensive the evaluation.

## 3.7 PROGRAM EVALUATION METRICS

**Two particularly important evaluation metrics are** net-to-gross energy savings and cost effectiveness.

### 3.7.1 Net-to-Gross Energy Savings

Gross demand or energy savings is the change in energy consumption and/or demand that results directly from program-related actions taken by participants in the CDM program, regardless of why they participated.

Net demand or energy impact is the total change in load that is attributable to the utility CDM program. This change in load or energy may include, implicitly or explicitly, the effects of free drivers, free riders[13], provincial or federal energy-efficiency standards, changes in the level of energy service and natural savings effects.

Net-to-gross ratio is a factor representing net program load impacts divided by gross program load impacts. It is also sometimes used to convert gross measure costs to net measure costs.

Hence, for attribution purposes, it is the net savings that are of greatest importance to the utility sponsoring a given program, as they are used to calculate the different cost-effectiveness tests. Exhibit 3.1 presents a sample illustration of the net-to-gross savings calculation before applying any distortion effect such as free riders.

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[11] California Energy Efficiency Evaluation Protocols, op. cit.

[12] International Performance Measurement and Verification Protocol. U.S. Department of Energy.

[13] "Free riders" typically refers to those who participate in a CDM program but would have implemented the CDM measures even in the absence of program's incentives. Free drivers, on the other hand, refers to those who implement the CDM measures being promoted by the CDM program without taking advantage of available incentives.

**Exhibit 3.1: Sample Illustration of Net-to-Gross Savings Calculation**

Assume the following situation:

- A customer has an old furnace with a seasonal energy efficiency of 70%.
- In the current market, most new furnace sales (standard market practice) have an average seasonal energy efficiency of 82%, either because it's the only type available on the market or it is imposed by regulation.
- The CDM program promotes condensing furnaces with an efficiency of 93% or more.

In the above example:

- The participant baseline (and the gross savings calculation) start at the consumption level associated with a furnace having an efficiency of 70%.
- The natural energy savings are calculated based on the efficiency improvement from 70% (baseline) to 82%.
- The net savings attributed to the program are calculated based on the efficiency improvement from 82% to 93%.

The objective is to encourage implementation of energy-efficiency measures or technologies that are over and above the market standard practices. The principle in this approach is that any level of efficiency considered as a standard practice should not be subsidized since this will reduce program savings and program attribution.

### 3.7.2 Cost-Effectiveness Tests

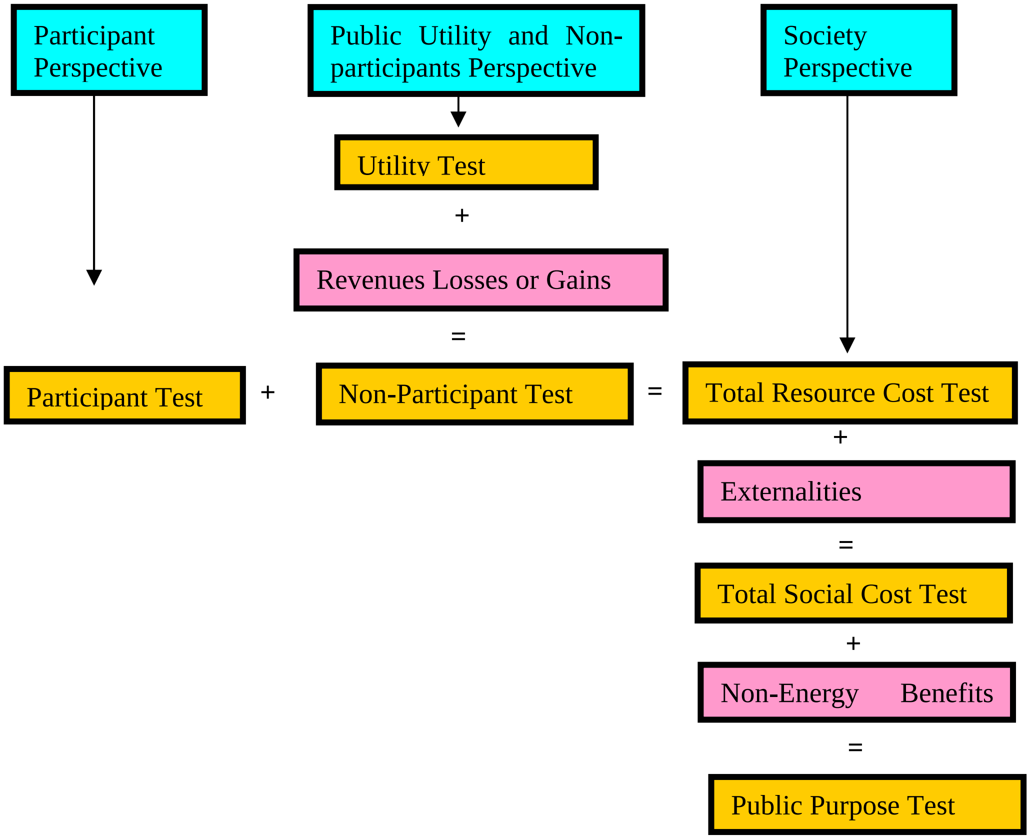
Cost-effectiveness tests are indicators of the relative performance or economic attractiveness of any energy-efficiency investment or practice when compared to the costs of energy produced and delivered in the absence of such an investment.

The different tests calculate the net present value (NPV) of the estimated benefits or losses produced by an energy-efficiency program as compared to the estimated total program's costs, from different perspectives:

- Participant perspective
- Utility perspective
- Non-participant perspective
- Both the utility and the participant perspective
- Society perspective.

Exhibit 3.2 illustrates the relationship between the different tests.

**Exhibit 3.2: Program Cost-Effectiveness Tests**




It is recommended that the primary metric for assessing a program's cost effectiveness be a hybrid of the Total Resource Cost (TRC) and the Societal Cost Test (SCT), defined below.

The TRC test, as defined in the California Standard Practice Manual, "measures the net costs of a demand-side management program as a resource option based on the total costs of the program, including both the participants' and the utility's costs. The test is applicable to conservation, load management, and fuel substitution programs."[14] A program assessed using the TRC test is considered cost effective if the ratio of benefits to costs is greater than or equal to one. The SCT is a variant on the TRC test in that it includes the effects of externalities (e.g., environmental) and uses a different (societal) discount rate.

The Rate Impact Measure (RIM) test measures the impact of CDM programs on a utility's rates; it is also used to assess the potential impacts that a CDM program may have on non-participants in the program. In this case, non-participants who do not implement energy saving measures could experience increased rates, and hence increased

[14] California Standard Practice Manual, Economic Analysis of Demand-Side Programs and Projects, October 2001. pg. 18.

electricity costs, as a result of the CDM program costs without realizing the benefits of a reduced demand for electricity.

The Ontario Energy Board (OEB) indicates that the RIM test is useful to ensure that a utility's portfolio of energy conservation programs do not impose an undue rate increase on an individual or class of customers.

# 4. PROGRAM AND EVALUATION LESSONS LEARNED

## 4.1 INTRODUCTION

This final section provides an overview of lessons learned for small markets and/or markets such as Newfoundland and Labrador where the Utilities are in a CDM program start-up mode. The information provided is based primarily on prior experience of study team members and is not necessarily comprehensive. Two areas are addressed:

- CDM Program Lessons Learned
- CDM Evaluation Lessons Learned

## 4.2 CDM PROGRAM LESSONS LEARNED

The Newfoundland and Labrador CDM market is relatively small and CDM program managers are likely to be confronted with a number of constraints, such as:

- Financial resource constraints
- Relatively small potential market (population of 500,000 people and 250,000 customers)
- Need to develop new programs
- Multiple delivery partners
- Limited trade ally networks
- Limited human resources.

The following CDM program design guidelines are provided based on the prior evaluation experience of study team members.

❑ **Some types of CDM programs are better suited to small markets**

A small team with limited financial resources can manage the following types of programs:

- Resource acquisition programs with a financial incentive that covers part of the incremental cost. Participant contribution is important to reduce free ridership (i.e., do not give away measures). The incentive is typically processed through a rebate coupon at the point of purchase with the collaboration of retailers, who then send the coupons to utility CDM program staff once a month with appropriate metrics for evaluation and tracking purposes.

- Awareness, educational and training programs. These can include labeling, youth education, capacity building sessions for professionals and Web sites that offer consumers energy-efficiency recommendations and references to energy-efficiency programs offered by the utility or other institutions.

- Codes, standards and building codes programs. These programs take time because they involve multiple parties. However, they are not capital intensive and the results are worth the efforts. Some codes and standards can also be adopted or adapted from other jurisdictions.

- **Some types of markets are easier to address**

Markets range from homogeneous to heterogeneous. Programs that address homogeneous markets, such as the Residential sector, are less capital and labour intensive than programs in the Industrial sector, which are heterogonous and need case-by-case attention.

- **Some programs require more resources to design and implement than others**

Experience has shown that the following types of programs are capital and labor intensive and require a well-established trade ally network:

- Renovation or retrofit programs. These programs require case-by-case analysis and are difficult to standardize.
- Savings by design programs. These types of programs, designed for new construction, require computer simulation with sophisticated software, such as DOE-2,[15] and some efforts for commissioning.
- Large industrial programs. These programs require a case-by-case approach and in-depth expertise of industrial processes.
- Performance type programs with multiple interactive measures. These types of programs require expertise in different systems interactions and are designed for existing installations.
- Programs that require the involvement of professionals for installation (as opposed to owner install).

- **Trade allies can be valuable program delivery partners**

Choosing the right partners or trade allies to assist in the delivery of a program reduces the workload for program staff. The right partner is one that has the most influence and credibility in a given market to encourage participation. Industry associations are typically very good delivery partners since members tend to be more influenced by their own association rather than by a utility. Professional electricians and plumbers, retail distributors and manufacturers are also good allies since the program represents additional sales for them, creating a “win-win” situation.

[15] http://www.doe2.com.

- **Institutions can be valuable program delivery partners**

Involving institutions as program partners is a good way to increase impact. For example, energy-intensive government buildings such as hospitals and schools could develop their own efficiency program with the guidance of the program managers.

- **Program administration is typically most effective when vertically integrated**

For any given program, all phases (e.g., research, design, development, implementation, tracking and evaluation) should be the responsibility of one program manager. This enables the program manager to have a comprehensive picture of the program and allows him/her to react rapidly if a problem arises. It is also necessary if the program manager is accountable for the program's performance. Allocating some of these tasks among different teams is not recommended.

## 4.3 CDM EVALUATION LESSONS LEARNED

The following presents a summary of the key lessons learned from CDM program evaluations.

- **Define evaluation data collection needs in the design phase**

Evaluation costs and efforts will be reduced if evaluation data needs are defined in the design phase and data are collected and validated as the program progresses.

- **Identify stakeholder information requirements early**

Identifying precisely what information is required by all the program stakeholders will avoid the need for research and evaluation on matters that are of no interest to them, thus reducing effort and cost.

- **Match types of evaluation with program timetable**

Three types of evaluation will eventually be needed: process, market and impact, and energy or load impact.

Process is essential in the early stages of the program for reasons described earlier. However, market and impact can wait until the program has a statistically significant number of participants, or fast-tracked if a given performance indicator shows that there is a particular problem. In the latter case, evaluation will focus on the particular problem.

When impact evaluation is required, both process and market evaluation are recommended. Impact evaluation will be summative, while process and market evaluation will inform why a given summative value has occurred. Doing one type of evaluation without the other will prevent the evaluator from establishing proper causal effects.

- **Track performance indicators**

Collection of key performance indicators is essential to determine when and what kind of evaluation is required. If the indicators show that the program is on target, there will be no urgency to conduct an evaluation.

- **When CDM programs are jointly implemented, attribute savings to the entity with revenue losses**

In some jurisdictions, multiple institutions offer a CDM program as partners. In such cases, overlapping can be avoided if one organization takes charge of the program evaluation, just as Hydro Québec is doing with the Agence de l’efficacité énergétique and Gas Métro.

For attribution considerations, the organization with no avoided costs or revenue losses is acknowledged for its support. Utilities, on the other hand, get credit for the energy savings that they provide, e.g., Hydro Québec will get attribution of electricity savings, and Gas Métro will get attribution for gas savings.

### 4.3.1 Additional Considerations

Once an initial portfolio of CDM programs is launched, the level of activity required to meet program evaluation needs can be constrained by establishing a program risk profile that enables evaluation resources to focus primarily on high-risk situations. This involves two steps:

The first step is to identify programs with the following characteristics or a combination of characteristics:

- Highest budget
- Highest savings
- Programs with highest cost to savings ratio. These program should be carefully monitored since, in theory they are less cost effective than others
- Highest number of participants
- Programs with highest non-participants test results: Since this test can impact electricity rates
- A high level of complaints from participants or trade allies in a given program.

The second step is to use the program tracking system to monitor ratios such as the following:

- Actual spending versus the predicted budget for a given program in a given period
- Actual savings versus the predicted savings in a given period
- Actual number of participants versus the predicted number of participants in a given period.

The above ratios can be examined to determine how far they are from 1 and, if there is a substantial gap, to determine the magnitude of the absolute value? Application of this approach results in four outcomes, only one of which would suggest additional short term evaluation effort.

***No concern:***

- If the gap is high but the absolute figure is low, there is no immediate concern.
- If the gap is low and the absolute figure is also low, there is no immediate concern.

***Concern:***

- If the gap is low but the absolute figure is high, there should be concern but an evaluation is not necessarily needed.
- If the gap and the absolute value are both high, then there should be concern, and an evaluation should be considered.

Exhibit 4.1 provides an illustration of the above approach.

**Exhibit 4.1 Illustration of Program Risk Screening Using Participant Ratios**

**Program 1:**

- Predicted number of participants for a given period: 100
- Monitored number of participants for the same period: 80
- The participant ratio is 80/100 or .8
- That 0.8 represents 20 participants as an absolute value

**Program 2:**

- Predicted number of participants for a given period: 1 600
- Monitored number of participants for the same period: 1 280
- The participant ratio is 1 280/1 600 or .8
- That 0.8 represents 320 participants as an absolute value

In this example, the participants ratio is the same (.8) for both programs. However, the absolute value in Program 2 is 16 times larger than in Program 1 (320 participants versus 20 participants). If these participants are in a similar market, or have the same weight, Program 2 should be of more concern and accorded higher evaluation priority.

MARBEK
Resource Consultants Ltd

# CONSERVATION AND DEMAND MANAGEMENT (CDM) POTENTIAL

## NEWFOUNDLAND and LABRADOR

## Residential, Commercial and Industrial Sectors

*Prepared for:*

**Newfoundland & Labrador Hydro and Newfoundland Power**

*Prepared by:*

**Marbek Resource Consultants Ltd.**

*January 18, 2008*

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# CONSERVATION AND DEMAND MANAGEMENT (CDM) POTENTIAL

# NEWFOUNDLAND and LABRADOR

## Residential, Commercial and Industrial Sectors

## *–Summary Report–*

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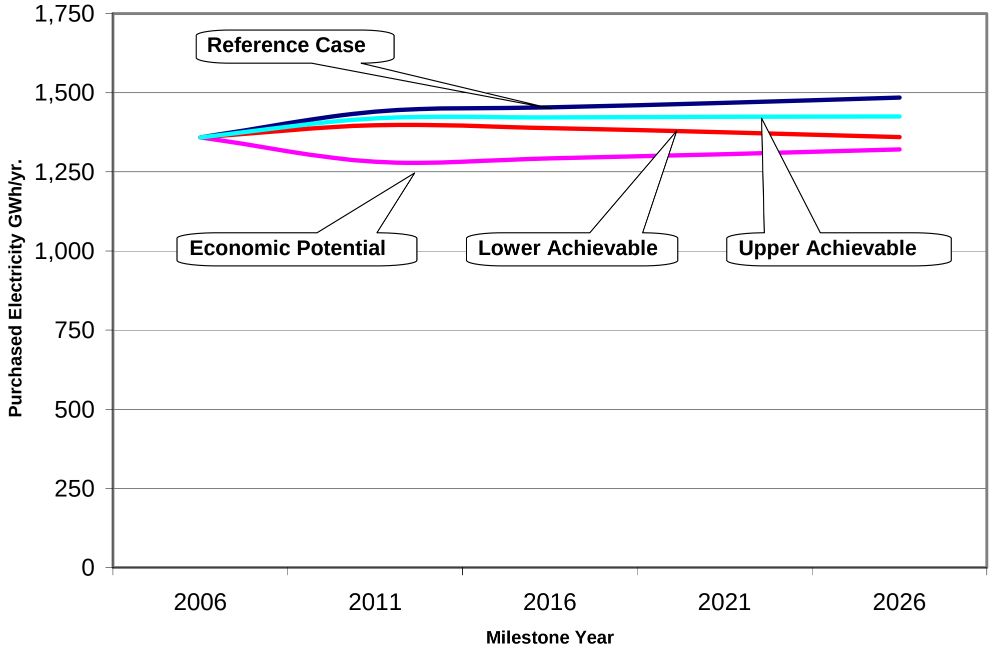

1,750
1,500
1,250
1,000
750
500
250
0
Reference Case
Economic Potential
Lower Achievable
Upper Achievable
Purchased Electricity GWh/yr.
2006
2011
2016
2021
2026
Milestone Year

# 1. INTRODUCTION

## 1.1 BACKGROUND AND OBJECTIVES

Newfoundland and Labrador Hydro and Newfoundland Power (collectively the Utilities) have partnered to produce this study, recognizing the role that each has in energy conservation and least cost electric utility planning within the province. Increasing electricity costs and the expectations of a growing number of their customers and stakeholders have contributed to the increased focus on conservation and demand management (CDM) and resulted in a number of recent initiatives and projects targeting energy savings in the province. This study is the next step in the Utilities efforts to develop a comprehensive plan for CDM in Newfoundland and Labrador. The Utilities envision electricity conservation and demand management (CDM) to be a valuable component in meeting the province's future electricity requirements.

This study will also be a significant component in the further implementation of the Province's recently released Energy Plan. The Energy Plan establishes a long-term vision for how the province's energy resources will be developed and utilized to benefit the people of the province today as well as for future generations. Electricity conservation and demand management (CDM) are an important component of the provincial Energy Plan as are the conservation and demand management components for the other energy resources of the province.

This report meets, in part, the requirements of the Public Utilities Board Order PU 8 2007 requiring NLH to file this study and a five-year plan for implementation of CDM programs in 2008.

The objective of this study is to identify the potential contribution of specific CDM technologies and measures in the Residential, Commercial and Industrial sectors and to assess their economic costs and benefits. The Newfoundland and Labrador economy is expected to grow over the next 20 years, with an associated increase in energy consumption. The benefits of increased penetration of energy efficiency technologies include reduced energy costs for individuals and businesses, as well as environmental benefits through reduced pollution and greenhouse gas emissions.

The outputs from this study will assist the Utilities CDM planners and others to develop specific CDM programs for implementation and to optimize the contribution of CDM technologies and measures to the province's overall energy future.

## 1.2 STUDY SCOPE

The scope of this study is summarized below.

- **Sector Coverage:** This study addresses the Residential, Commercial[1] and Industrial sectors. Consistent with the study's agreed upon scope, the Industrial sector is treated at a higher level than the Residential and Commercial sectors.

[1] The Commercial sector analysis includes street lighting.

- **Geographical Coverage**: The study addresses the customers of both utilities. Due to differences in cost and rate structures, the Utilities' customers are organized into two service regions, which in this report are referred to as: the Island and Isolated, and the Labrador Interconnected. For the purposes of this study, the isolated diesel system customers were combined with those in the Island service region due to their relatively small size and electricity usage.

- **Study Period**: This study covers a 20-year period. The Base Year is the calendar year 2006, with milestone periods at five-year increments: 2011, 2016, 2021 and 2026. The Base Year of 2006 was selected as it was the most recent calendar year for which complete customer data were available.

- **Technologies:** The study addresses conservation and demand management (CDM) measures. CDM refers to a broad range of potential measures; however, for the purposes of this study, it was agreed that the primary focus is on energy-efficiency measures. This includes measures that reduce electricity use as well as the associated electric demand. The study also provides a high-level treatment of selected demand management measures, such as direct control of space heating loads.[2]

## 1.3 MAJOR ANALYTIC STEPS

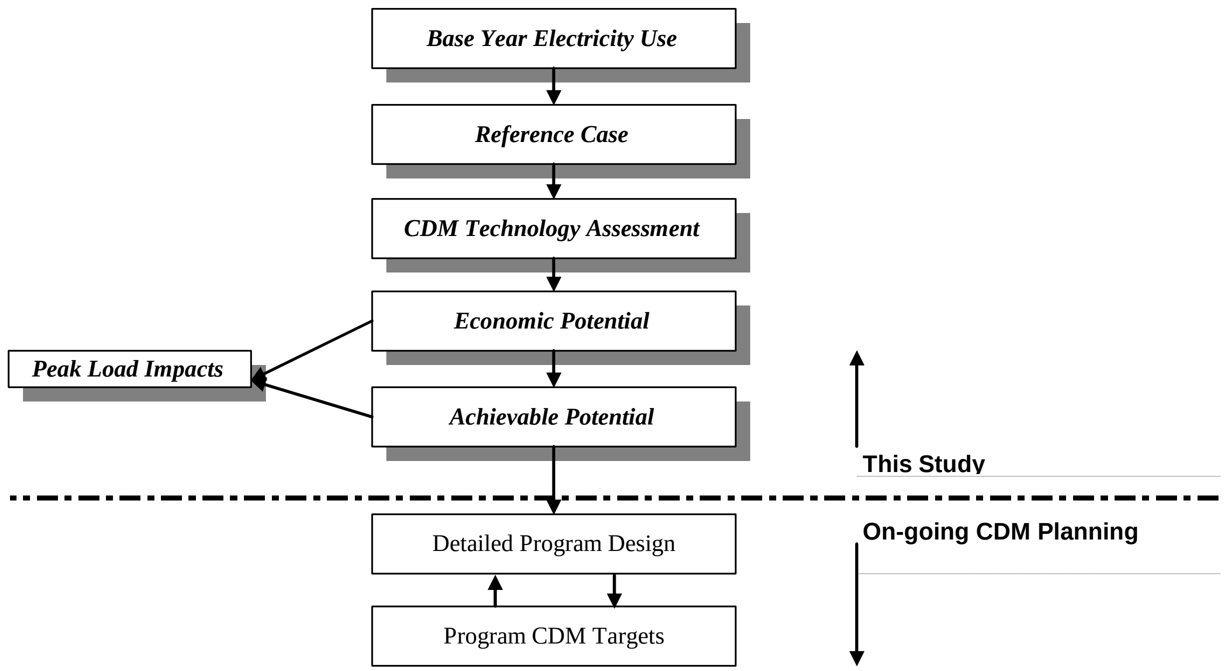
The major steps involved in the analysis are shown in Exhibit 1.1 and are discussed in greater detail in Section 1 of the individual sector reports. As illustrated in Exhibit 1.1, the results of this study, and in particular the estimation of Achievable Potential,[3] support the Utilities on-going work.

It should, however, be emphasized that the estimation of Achievable Potential is not synonymous with either the setting of specific targets or with program design. Both of these activities require additional market-specific investigation and planning.

[2] The information provided is based on the detailed analysis that Marbek is currently undertaking in other jurisdictions.

[3] The proportion of savings identified that could be achieved within the study period assuming specific customer, program and market conditions. Additional details are provided in the individual sector reports.

**Exhibit 1.1: Study Approach - Major Analytical Steps**




The analysis conducted within each of the three sectors followed a similar set of steps, as outlined below.

***Step 1: Develop Base Year Calibration Using Actual Utilities Sales Data***

The Base Year (2006) is the starting point for the analysis. It provides a detailed description of "where" and "how" electricity is currently used, based on actual electricity sales.

The consultants compiled the best available data and used sector-specific macro models to estimate electricity use; they then compared the results to the Utilities actual billing data to verify their accuracy.

***Step 2: Develop Reference Case***

The Reference Case uses the same sector-specific macro models to estimate the expected level of electricity consumption that would occur over the study period with no new (post-2006) Utilities' CDM initiatives. The Reference Case includes projected increases in electricity consumption based on expected rates of population and economic growth, using the growth rates included in the NLH 2006 load forecast.[4] The Reference Case also makes an estimate for some "natural" conservation, that is, conservation that occurs without Utilities' CDM programs. The Reference Case provides the point of comparison for the calculation of Economic and Achievable electricity saving potentials.

[4] Newfoundland & Labrador Hydro Long Term Planning (PLF) Review Forecast, Summer/Fall 2006.

***Step 3: Assess CDM Technologies***

The consultants researched a wide range of commercially available CDM technologies and practices that can enable the Utilities' customers to use electricity more efficiently. In each case, the consultants assessed how much electricity the CDM measures could save together with the expected cost, including purchase (capital), operating and maintenance costs.

For each CDM measure the consultants calculated a value for the cost per year per kilowatt-hour of saved electricity, referred to as the Cost of Conserved Energy (CCE). The CCE is calculated as the annualized incremental cost (including operating and maintenance) of the measure divided by the annual kilowatt-hour savings achieved, excluding any administrative or program costs to achieve full use of the measure. This approach allowed the consultants to compare a standardized cost for new technologies and measures with the cost of new electricity supply, or other electricity conserving measures, and to determine whether or not to include the CDM measure in the Economic Potential Forecast.

***Step 4: Estimate Economic Electricity Savings Potential***

To forecast the potential electricity savings that are defined as economic, the consultants used the sector-specific macro models to calculate the level of electricity consumption that would occur if the Utilities' customers installed all "cost-effective" technologies. "Cost effective" for the purposes of this study means that the CCE is less than or equal to the estimated cost of new electricity supply.

NLH determined that the avoided costs of new electricity supply to be used for this analysis are $0.0980/kWh for the Island and Isolated service region and $0.0432/kWh for the Labrador Interconnected service region. These avoided costs represent a future in which the Lower Churchill project is not built and there is no DC link from Labrador to the Island[5].

The Economic Potential Forecast incorporates all the CDM measures reviewed that have a CCE equal to or less than the avoided costs noted above. This forecast does not yet incorporate consideration of the many practical considerations that affect a customer's willingness to implement the CDM measures. Rather, it provides a valuable interim step towards determining the Achievable Potential (see Step 5).

NLH is currently studying the Lower Churchill/DC Link project. However, a decision on whether to proceed is not expected until 2009 and, even if the project proceeds, the earliest completion date would be in late 2014. This means that, regardless of the decision, the avoided cost values shown above will be in effect until the approximate mid point of the study period.

If the project does proceed, the avoided costs presented above are expected to change. To provide insight into the potential impacts of the Lower Churchill/DC Link project on this study, the consultants undertook a high-level financial sensitivity analysis.

[5] The avoided costs draw on the results of the earlier study conducted by NERA Economic Consulting, which is entitled: Newfoundland and Labrador Hydro. *Marginal Costs of Generation and Transmission*. May 2006. The avoided costs used in this study include generation, transmission and distribution.

***Step 5: Estimate Achievable Electricity Savings Potential***

The Achievable Potential is the proportion of the savings identified in the Economic Potential Forecast that could be achieved within the study period. Achievable Potential recognizes that it is difficult to induce customers to purchase and install all the electrical efficiency technologies that meet the criteria defined by the Economic Potential forecast. The results are, therefore, presented within an "upper" and "lower" range.[6]

The Upper Achievable Potential assumes a very aggressive program approach and a very supportive context, e.g., healthy economy, very strong public commitment to climate change mitigation, etc. However, the Upper Achievable Potential scenario also recognizes that there are limits to the scope of influence of any electric utility. It recognizes that some markets or submarkets may be so price sensitive or constrained by market barriers beyond the influence of CDM programs that they will only fully act if forced to by legal or other legislative means. It also recognizes that there are practical constraints related to the pace that existing inefficient equipment can be replaced by new, more efficient models or that existing building stock can be retrofitted to new energy performance levels

For the purposes of this study, the Upper Achievable Potential can, informally, be described as: "*Economic Potential less those customers that "can't" or "won't" participate."*

The Lower Achievable Potential assumes that existing CDM programs and the scope of technologies addressed are expanded, but at a more modest level than in the Upper Achievable Potential. Market interest and customer commitment to energy efficiency and sustainable environmental practices remain approximately as current. Similarly, federal, provincial and municipal government energy-efficiency and GHG mitigation efforts remain similar to the present

It is important to note that the Upper and Lower Achievable numbers are intended to bracket savings which could be expected to be attainable given the assumptions and scope of the study. As noted previously, Achievable Potential, although complementary, is not synonymous with the actual CDM targets that are established as part of the more detailed CDM program design process (which is beyond the scope of this current study).

***Step 6: Estimate Peak Load Impacts of Electricity Savings***

The electricity (electric energy) savings (GWh) calculated in the preceding steps were converted to peak load (electric demand) savings (MW)[7]. The study defined the Newfoundland and Labrador system peak period as:

> *The morning period from 7 am to noon and the evening period from 4 to 8 pm on the four coldest days during the December to March period; this is a total of 36 hours per year.*

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[6] The Achievable Potential savings assume program start-up in 2007. Consequently, electricity savings in the first milestone year of 2011 will need to be adjusted to reflect actual program initiation dates. This step will occur during the detailed program design phase, which will follow this study.

[7] Peak load savings were modelled using Applied Energy Group's Cross-Sector Load Shape Library Model (LOADLIB).

The conversion of electricity savings to hourly demand drew on a library of specific sub sector and end use electricity use load shapes. Using the load shape data, the following steps were applied:

- Annual electricity savings for each combination of sub sector and end use were disaggregated *by month*
- Monthly electricity savings were then further disaggregated *by day type* (weekday, weekend day and peak day)
- Finally, each day type was disaggregated *by hour*.

## 1.4 CAVEATS

The reader should use the results presented in this report as best available estimates; major assumptions, information sources and caveats are noted throughout each of the main sector reports. Specific areas are noted below.

### 1.4.1 Data Quality and Assumptions

As in any study of this type, the results presented are based on a large number of important assumptions. Assumptions such as those related to the current penetration of energy-efficient technologies, the rate of future growth in the province's building stock and customer willingness to implement new CDM measures are particularly influential.

Wherever possible, the assumptions used in this study are consistent with those used by the Utilities and are based on best available information, which in many cases includes the professional judgment of the consultant team, Utilities personnel and local experts. The reader should use the results presented in this report as best available estimates; major assumptions, information sources and caveats are noted throughout the individual sector reports.

### 1.4.2 Interactive Effects

A systems approach was used to model the energy impacts of the CDM measures presented in the Economic and Achievable Potential phases of the study. In the absence of a systems approach, an accurate assessment of the total contribution of the energy-efficient upgrades would not be possible.

One of the reasons that this approach is necessary is to ensure that the interactive effects are appropriately considered. For example, in the Residential sector, the electricity savings from more efficient appliances and lighting result in reduced waste heat. During the space heating season, this appliance and lighting waste heat contributes to the building's internal heat gains, which lower the amount of heat that must be provided by the space heating system.

The magnitude of the interactive effects can be significant. Based on selected building energy use simulations, a 100 kWh savings in appliance or lighting electricity use could result in an increased space heating load of 50 kWh to 70 kWh in this jurisdiction, depending on housing dwelling type and geographical location. This is higher than the ratio of approximately 0.5 that is typical of other jurisdictions and is related largely to the length of the heating season, rather than its severity.

Newfoundland and Labrador experience more months in which heating is required than most other jurisdictions in Canada. Nonetheless, given that some fraction of the heat energy from lighting and other end uses escapes to the outside, the simulation may somewhat overstate the interaction. A ratio of 0.6 has been incorporated into the model to account for this uncertainty.

### 1.4.3 Program Design and Implementation Costs

The study results presented in this Summary Report and in the individual sector reports do not yet include expenditures related to program design and implementation. These costs are considered at the detailed program design phase, which will be completed following this study[8].

## 1.5 STUDY ORGANIZATION AND REPORTS

The study was organized and conducted by sector using a common methodology, as outlined above. The results for each sector are presented in three individual reports that are entitled:

- *Conservation and Demand Management Potential (2006 to 2026), Newfoundland and Labrador, Residential Sector*
- *Conservation and Demand Management Potential (2006 to 2026), Newfoundland and Labrador, Commercial Sector*
- *Conservation and Demand Management Potential (2006 to 2026), Newfoundland and Labrador, Industrial Sector*

The results of the individual sector reports are combined into this Summary Report. Finally, the study also prepared a brief CDM program evaluation report, which is presented under separate cover and is entitled:

- *Conservation and Demand Management Potential (2006 to 2026), Newfoundland and Labrador, Program Evaluation Guidelines*.

### 1.5.1 Summary Report Outline

This report presents a summary of the study results and is organized as follows:

- Section 2 presents the combined electricity and peak load savings for the three sectors.

[8] Addition of these costs may negatively impact the economic attractiveness of some measures currently included in the Achievable Potential estimates.

- Sections 3, 4 and 5 present a summary of the electricity and peak load savings for, respectively, the Residential, Commercial and Industrial sectors.

- Section 6 presents conclusions and next steps.

# 2. SUMMARY OF STUDY FINDINGS

The study findings confirm the existence of significant potential cost-effective opportunities for CDM in Newfoundland and Labrador's Residential, Commercial and Industrial sectors.

## 2.1 ELECTRICITY SAVINGS POTENTIAL

Exhibits 2.1 and 2.2 summarize the total combined electricity savings for the Residential, Commercial and Industrial sectors that have been identified in each of the individual sector reports for, respectively, the Island and Isolated and the Labrador Interconnected service regions.[9]

Highlights of the results for the Island and Isolated service region are shown in Exhibit 2.1. They include:

- In the Reference Case, total electricity consumption for the Island and Isolated service region increases from approximately 6,468 GWh/yr. in 2006 to about 7,685 GWh/yr. by 2026, an increase of about 19%

- In the Upper Achievable Potential scenario, electricity savings for the Island and Isolated service region are about 211 GWh/yr. in 2011 and increase to about 951 GWh/yr. by 2026. The electricity savings of 951 GWh/yr. in 2026 means that total electricity consumption would increase to about 6,737 GWh/yr., a decrease of about 12% relative to the Reference Case

- In the Lower Achievable Potential scenario, electricity savings for the Island and Isolated service region are about 117 GWh/yr. in 2011 and increase to about 556 GWh/yr. by 2026. The electricity savings of 556 GWh/yr. in 2026 means that total electricity consumption would increase to about 7,129 GWh/yr., a decrease of about 7% relative to the Reference Case.

**Exhibit 2.1: Achievable Electricity Savings Potential for the Island and Isolated Service Region**

| Milestone Year | Reference Case | Achievable Savings (GWh/yr.) | | Achievable Savings As % of Reference Case | |
|---|---|---|---|---|---|
| | | *Upper* | *Lower* | *Upper* | *Lower* |
| 2006 | 6,468 | - | - | - | - |
| 2011 | 6,888 | 211 | 117 | 3.1 | 1.7 |
| 2016 | 7,139 | 437 | 261 | 6.1 | 3.7 |
| 2021 | 7,427 | 679 | 414 | 9.1 | 5.6 |
| 2026 | 7,685 | 951 | 556 | 12.4 | 7.2 |

[9] Analysis for the two service regions was combined for the Industrial sector. Industrial reference electricity use and savings are included in Exhibit 2.1 only and refer exclusively to purchased electricity.

Highlights of the results for the Labrador Interconnected service region are shown in Exhibit 2.2. They include:

- In the Reference Case, total electricity consumption for the Labrador Interconnected service region increases from approximately 465 GWh/yr. in 2006 to about 540 GWh/yr. by 2026, an increase of about 16%

- In the Upper Achievable Potential scenario, electricity savings for the Labrador Interconnected service region are about 12 GWh/yr. in 2011 and increase to about 51 GWh/yr. by 2026. The electricity savings of 51 GWh/yr. in 2026 means that total electricity consumption for the Island and Isolated service region would increase to about 489 GWh/yr., a decrease of about 9% relative to the Reference Case

- In the Lower Achievable Potential scenario, electricity savings for the Labrador Interconnected service region are about 8 GWh/yr. in 2011 and increase to about 31 GWh/yr. by 2026. The electricity savings of 31 GWh/yr. in 2026 means that total electricity consumption for the Island and Isolated service region would increase to about 509 GWh/yr., a decrease of about 6% relative to the Reference Case.

**Exhibit 2.2: Achievable Electricity Savings Potential for the Labrador Interconnected Service Region**

| Milestone Year | Reference Case | Achievable Savings (GWh/yr.) | | Achievable Savings As % of Reference Case | |
|---|---|---|---|---|---|
| | | *Upper* | *Lower* | *Upper* | *Lower* |
| 2006 | 465 | - | - | - | - |
| 2011 | 499 | 12 | 8 | 2.4 | 1.6 |
| 2016 | 512 | 24 | 16 | 4.7 | 3.1 |
| 2021 | 525 | 37 | 23 | 7.0 | 4.4 |
| 2026 | 540 | 51 | 31 | 9.4 | 5.7 |

## 2.2 PEAK LOAD SAVINGS

The electricity savings noted above also result in a reduction in peak load requirements (MW), which can be of particular value to the Utilities during periods of high electricity demand[10].

The resulting peak load savings are presented in Exhibit 2.3.[11] As illustrated, the total peak load savings were estimated to be 154 MW and 89 MW by 2026 in, respectively, the Upper and Lower scenarios. In each case, the reductions are an average value over the peak period and are defined relative to the Reference Case.

[10] See Section 1.3 for peak period definition.

[11] Peak load impact was analyzed for the residential and commercial sectors only. Exhibit 2.3 presents the combined results for these two sectors.

## Exhibit 2.3: Total Achievable Peak Load Savings Potential

| **Service Region** | **Milestone Year** | **Peak Load Savings (MW)** | |
|---|---|---|---|
| | | Upper Achievable | Lower Achievable |
| Island and Isolated | 2011 | 27 | 14 |
| | 2016 | 60 | 36 |
| | 2021 | 99 | 61 |
| | 2026 | 144 | 83 |
| Labrador Interconnected | 2011 | 1.4 | 0.9 |
| | 2016 | 3.8 | 2.4 |
| | 2021 | 6.4 | 3.8 |
| | 2026 | 9.7 | 5.5 |

# 3. RESIDENTIAL SECTOR

The Residential sector includes single-family homes, attached dwellings and apartments as well as a small number of isolated and other dwellings.

## 3.1 APPROACH

The detailed end-use analysis of electrical efficiency opportunities in the Residential sector employed two linked modelling platforms: **HOT2000,** a commercially supported residential building energy-use simulation software, and **RSEEM** (Residential Sector Energy End-use Model), a Marbek in-house spreadsheet-based macro model. Peak load savings were modelled using Applied Energy Group's Cross-Sector Load Shape Library Model (LOADLIB).

The major steps in the general approach to the study are outlined in Section 1.3 above (*Major Analytic Steps*). Specific procedures for the Residential sector were as follows:

- **Modelling of Base Year –** The consultants used the Utilities' customer data to break down the Residential sector by four factors:

  - Type of dwelling (single detached, attached, apartment, etc.)
  - Heating category (electric or non-electric heat)
  - The age of the building (new versus existing)
  - Service region.

  To estimate the electricity used for space heating, the consultants factored in building characteristics such as insulation levels, floor space and airtightness using a variety of data sources, including the Energuide for Houses database, Utilities' billing data, local climate data and discussions with local contractors. They also used the results of Utilities' customer surveys that provided data on type of heating system, number and age of household appliances, renovation activity, etc. Based on the available data sources, the consultants calculated an average electricity use by end use for each dwelling type. The consultant's models produced a close match with actual Utilities' sales data.

- **Reference case calculations –** For the Residential sector, the consultants developed profiles of new buildings for each type of dwelling. They estimated the growth in building stock using the same data as that contained in the Utilities' most recent load forecast and estimated the amount of electricity used by both the existing building stock and the projected new buildings and appliances. As with the Base Year calibration, the consultants' projection closely matches the Utilities own 2006 forecast of future electricity requirements.

- **Assessment of CDM measures** –To estimate the economic and achievable electricity savings potentials, the consultants assessed a wide range of commercially available CDM measures and technologies such as:

  - Improved lighting systems
  - Thermal upgrades to the walls, roofs and windows of existing buildings
  - More efficient space heating equipment and controls
  - Measures to reduce hot water usage

- Improved designs for new buildings
- Reduced standby losses in computers and electronic equipment
- More efficient household appliances and other plug-in equipment.

## 3.2 ELECTRICITY SAVINGS

In, respectively, the Upper and Lower Achievable Potential scenarios, Residential Sector electricity savings are estimated to be between 439 and 236 GWh/yr. by 2026 in the Island and Isolated service region.[12]

A summary of the levels of annual electricity consumption contained in each of the forecasts addressed by the study is presented in Exhibits 3.1 and 3.2, by milestone year, and discussed briefly in the paragraphs below.

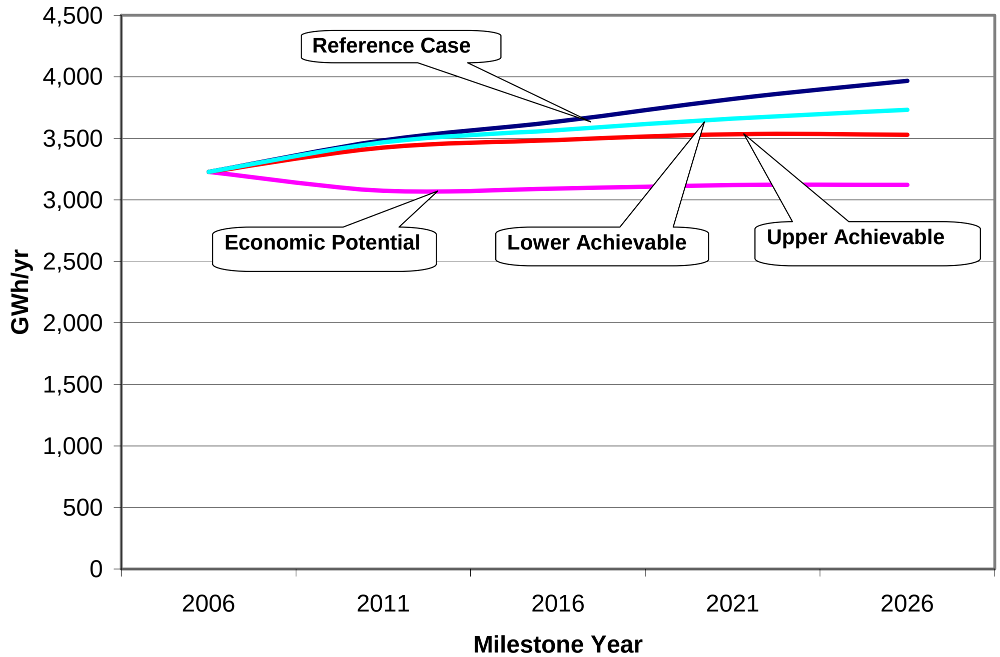
**Exhibit 3.1: Summary of Forecast Results for the Island and Isolated Service Region – Annual Electricity Consumption, Residential Sector (GWh/yr.)**

| Annual Consumption (GWh/yr.) | | | | Potential Annual Savings (GWh/yr.) | |
|---|---|---|---|---|---|
| Milestone Year | Reference Case | Achievable | | Achievable | |
| | | Upper | Lower | Upper | Lower |
| 2006 | 3,228 | | | | |
| 2011 | 3,483 | 3,425 | 3,468 | 58 | 16 |
| 2016 | 3,637 | 3,486 | 3,568 | 151 | 69 |
| 2021 | 3,821 | 3,533 | 3,660 | 288 | 161 |
| 2026 | 3,968 | 3,529 | 3,732 | 439 | 236 |

**Results are measured at the customer's point-of-use and do not include line losses.*

[12] The comparable results in 2026 for the Labrador Interconnected service region are between 24 and 12 GWh/yr. in, respectively, the Upper and Lower achievable scenarios. Additional details are provided in the Residential sector report and accompanying appendices.

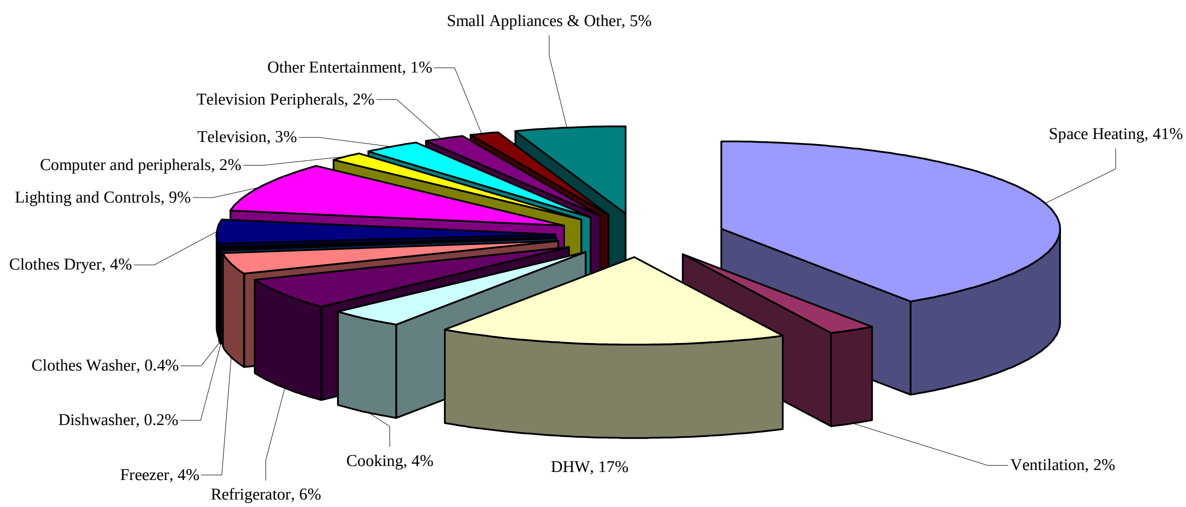
**Exhibit 3.2: Graphic of Forecast Results for the Island and Isolated Service Region – Annual Electricity Consumption, Residential Sector (GWh/yr.)**




## Base Year Electricity Use

In the Base Year of 2006, the Residential sector in the Island and Isolated service region consumed about 3,228 GWh. Exhibit 3.3 shows that space heating accounts for about 41% of total residential electricity use.[13] Domestic hot water (DHW) accounts for about 17% of the total electricity use, followed by kitchen appliances (14%) and lighting (9%). Household electronics (i.e., computers and peripherals, televisions and television peripherals) account for about 8% of electricity use.

**Exhibit 3.3: Base Year Electricity Use by End Use in the Island and Isolated Service Region, Residential Sector[14]**




13 Values are for all residential dwellings. Space heating share is much higher in electrically heated homes.

14 Values may not add to 100% due to rounding.

The overwhelming majority of residential electricity use in the Island and Isolated service region occurs in single detached dwellings (81%). The remaining electricity use is in attached dwellings (11%) followed by apartments (6%). Isolated and other residential buildings each account for about 1%.

***Reference Case***

In the absence of new Utilities' CDM initiatives, the study estimates that electricity consumption in the Residential sector will grow from 3,228 GWh/yr. in 2006 to about 3,968 GWh/yr. by 2026 in the Island and Isolated service region. This represents an overall growth of about 23% in the period and compares very closely with NLH's load forecast, which also included consideration of the impacts of "natural conservation."

***Economic Potential Forecast***

Under the conditions of the Economic Potential Forecast,[15] the study estimated that electricity consumption in the Residential sector would decline to about 3,124 GWh/yr. by 2026 in the Island and Isolated service region. Annual savings relative to the Reference Case are 846 GWh/yr. or about 21%.

***Achievable Potential***

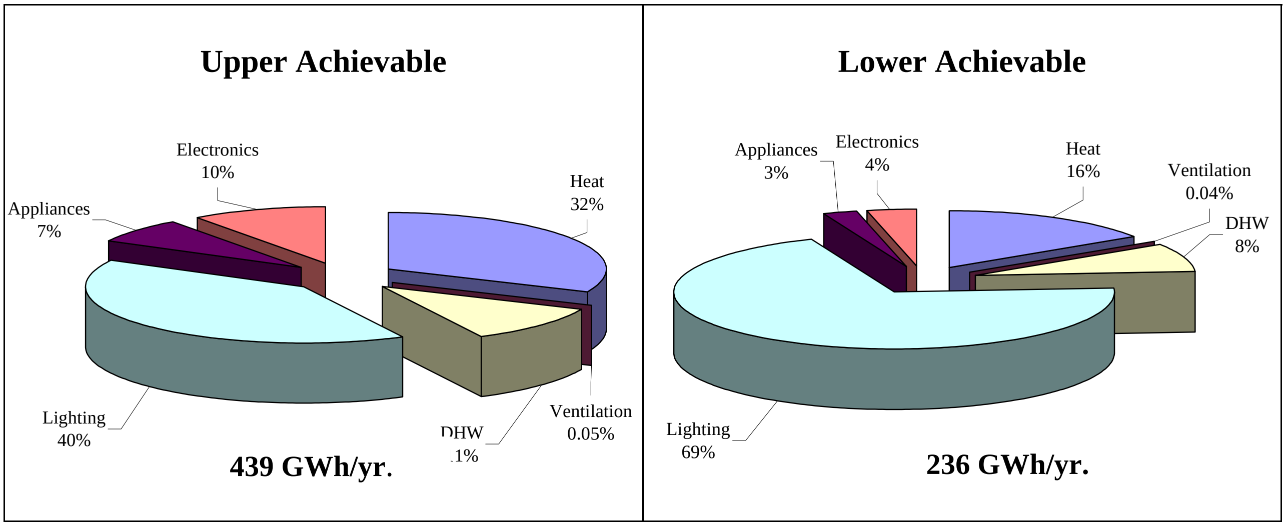
The Achievable Potential is the proportion of the economic electricity savings (as noted above) that could realistically be achieved within the study period. In the Residential sector within the Island and Isolated service region, the Achievable Potential for electricity savings was estimated to be 439 GWh/yr. and 236 GWh/yr. by 2026 in, respectively, the Upper and Lower scenarios.

The most significant Achievable savings opportunities were in the actions that addressed lighting and space heating, followed by water heating, household electronics (e.g., computers and peripherals, televisions and television peripherals) and large appliances.

Exhibit 3.4 shows the distribution of electricity savings in 2026 by end use in the Upper and Lower Achievable Potential scenarios.

[15] The level of electricity consumption that would occur if all equipment and building envelopes were upgraded to the level that is cost effective against future avoided electricity costs.

**Exhibit 3.4: Distribution of Electricity Savings by Major End Use in the Upper and Lower Achievable Scenarios, Island and Isolated Service Region, Residential Sector**[16]




## 3.3 PEAK LOAD SAVINGS

The electricity savings noted above also result in a reduction in peak load requirements (MW), which can be of particular value to the Utility during periods of high electricity demand[17].

The resulting Residential sector peak load savings for the Island and Isolated service region are presented in Exhibit 3.5.

**Exhibit 3.5: Peak Load Savings from Electricity Savings in the Island and Isolated Service Region, Residential Sector**

| Milestone Year | Electricity Savings (GWh/yr.) | | Peak Load Savings (MW) | |
|---|---|---|---|---|
| | Upper Achievable | Lower Achievable | Upper Achievable | Lower Achievable |
| 2011 | 58 | 16 | 11 | 3 |
| 2016 | 151 | 69 | 29 | 13 |
| 2021 | 288 | 161 | 58 | 32 |
| 2026 | 439 | 236 | 91 | 49 |

As illustrated in Exhibit 3.5, the Residential sector peak load savings was estimated to be 91 MW and 49 MW by 2026 in, respectively, the Upper and Lower scenarios. In each case, the reductions are an average value over the peak period and are defined relative to the Reference Case.[18]

[16] Values may not add to 100% due to rounding.

[17] See Section 1.3 for peak period definition.

[18] The comparable results for the Labrador Interconnected service region are between 6.5 and 3.3 MW in, respectively, the Upper and Lower achievable scenarios. Additional details are provided in the Residential sector report and accompanying appendices.

# 4. COMMERCIAL SECTOR

The Commercial sector includes office and retail buildings, hotels and motels, restaurants, warehouses and a wide variety of small buildings. In this study, it also includes buildings that are often classified as "institutional," such as hospitals and nursing homes, schools and universities. Street lighting is also included in the Commercial sector.

Throughout this report, use of the word "commercial" includes both commercial and institutional buildings unless otherwise noted.

## 4.1 APPROACH

The detailed end-use analysis of electrical efficiency opportunities in the Commercial sector employed two linked modelling platforms: **CEEAM** (Commercial Electricity and Emissions Analysis Model), a Marbek in-house simulation model developed in conjunction with Natural Resources Canada (NRCan) for modelling electricity use in commercial/institutional building stock, and **CSEEM** (Commercial Sector Energy End-use Model), an in-house spreadsheet-based macro model. Peak load savings were modelled using Applied Energy Group's Cross-Sector Load Shape Library Model (LOADLIB).

The major steps in the general approach to the study were outlined earlier in Section 1.3 (*Major Analytic Steps*). Specific procedures for the Commercial sector were as follows:

- **Modelling of Base Year –** Marbek compiled data that defines "where" and "how" electricity is currently used in existing commercial buildings. The consultants then created building energy use simulations for each type of commercial building and calibrated the models to reflect actual Utilities' customer sales data. Estimated savings for the Small Commercial, Other and Isolated categories were derived from the results of the modelled segments. They did not directly model those categories because they are extremely diverse and the electricity use of individual categories is relatively small. The consultant's model produced a close match with actual Utilities' sales data.

- **Reference case calculations –** For the Commercial sector, Marbek developed detailed profiles of new buildings in each of the building segments, estimated the growth in building stock and estimated "natural" changes affecting electricity consumption over the study period. As with the Base Year calibration, the consultants' projection closely matches the Utilities 2006 forecast of future electricity requirements.

- **Assessment of CDM Measures –** To estimate the economic and achievable electricity savings potentials, the consultants assessed a wide range of commercially available CDM measures and technologies such as:

  - More efficient lighting systems and office equipment
  - Improved construction in new buildings
  - Upgraded heating, ventilating and cooling systems.

## 4.2 ELECTRICITY SAVINGS

In, respectively, the Upper and Lower Achievable Potential scenarios, Commercial Sector electricity savings are estimated to be between 387 and 261 GWh/yr. by 2026 in the Island and Isolated service region. [19]

A summary of the levels of annual electricity consumption contained in each of the forecasts addressed by the study is presented in Exhibits 4.1 and 4.2, by milestone year, and discussed briefly in the paragraphs below.

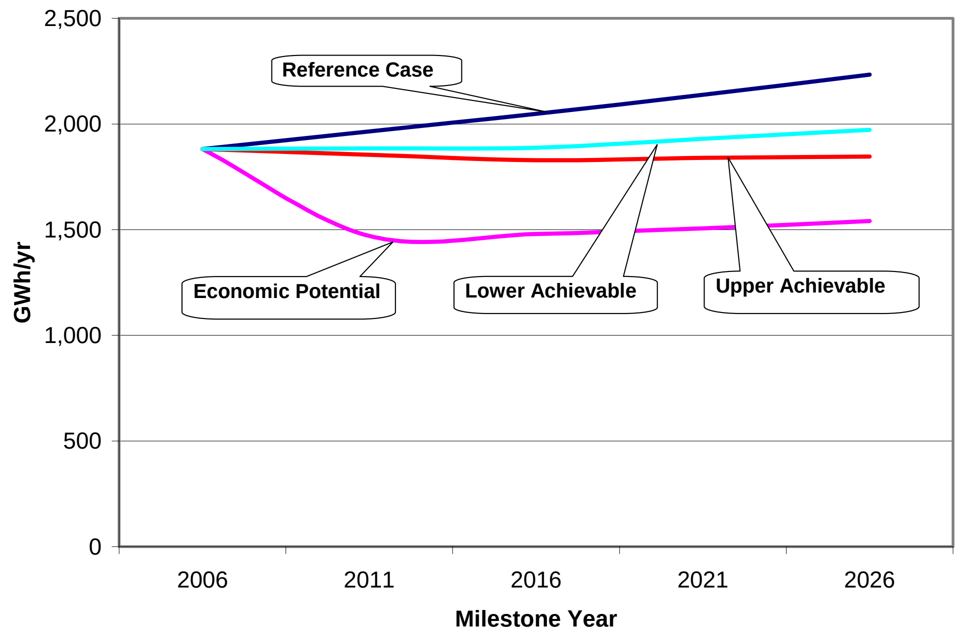
**Exhibit 4.1: Summary of Forecast Results for the Island and Isolated Service Region – Annual Electricity Consumption, Commercial Sector (GWh/yr.)**

| Annual Consumption (GWh/yr.) Commercial Sector | | | | | | Potential Annual Savings (GWh/yr.) | | |
|---|---|---|---|---|---|---|---|---|
| Milestone Year | Base Year | Reference Case | Economic | Achievable | | Economic | Achievable | |
| | | | | Upper | Lower | | Upper | Lower |
| 2006 | 1,881 | 1,881 | | | | | | |
| 2011 | | 1,965 | 1,471 | 1,855 | 1,884 | 494 | 110 | 80 |
| 2016 | | 2,048 | 1,479 | 1,828 | 1,888 | 569 | 220 | 160 |
| 2021 | | 2,138 | 1,506 | 1,840 | 1,930 | 632 | 298 | 209 |
| 2026 | | 2,233 | 1,541 | 1,846 | 1,972 | 693 | 387 | 261 |

*****Results are measured at the customer's point-of-use and do not include line losses.*

[19] The comparable results for the Labrador Interconnected service region are between 27 and 19 GWh/yr. in, respectively, the Upper and Lower achievable scenarios. Additional details are provided in the Commercial sector report and accompanying appendices.

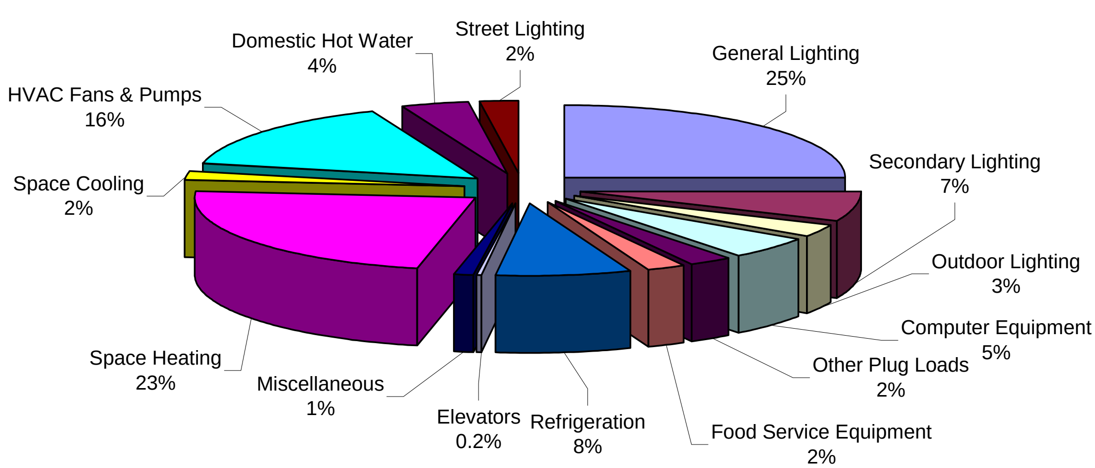
**Exhibit 4.2: Graphic of Forecast Results for the Island and Isolated Service Region – Annual Electricity Consumption, Commercial Sector (GWh/yr.)**




## Base Year Electricity Use

In the Base Year of 2006, the Commercial sector in the Island and Isolated service region consumed about 1,881 GWh. Exhibit 4.3 shows that space lighting accounts for about 32% of total commercial electricity use, space heating accounts for about 23%, followed by HVAC fans and pumps (16%) and refrigeration (8%).

**Exhibit 4.3: Base Year Electricity Use by End Use in the Island and Isolated Service Region, Commercial Sector[20]**




[20] Values may not add to 100% due to rounding.

In the Island and Isolated Service Region, the Small commercial sub sector accounts for the largest share of the total electricity consumption at 28%, followed by Office at 17%, Other Buildings at 8% and Food Retail at 7%.

### *Reference Case*

In the absence of new Utility initiatives, the study estimates that electricity consumption in the Commercial sector will grow from 1,881 GWh/yr. in 2006 to about 2,233 GWh/yr. by 2026 in the Island and Isolated service region. This represents an overall growth of about 19% in the period and compares very closely with NLH's load forecast, which also included consideration of the impacts of "natural conservation."

### *Economic Potential Forecast*

Under the conditions of the Economic Potential Forecast,[21] the study estimated that electricity consumption in the Commercial sector would fall to about 1,541 GWh/yr. by 2026 in the Island and Isolated service region. Annual savings relative to the Reference Case are 693 GWh/yr., or about 31%.

### *Achievable Potential*

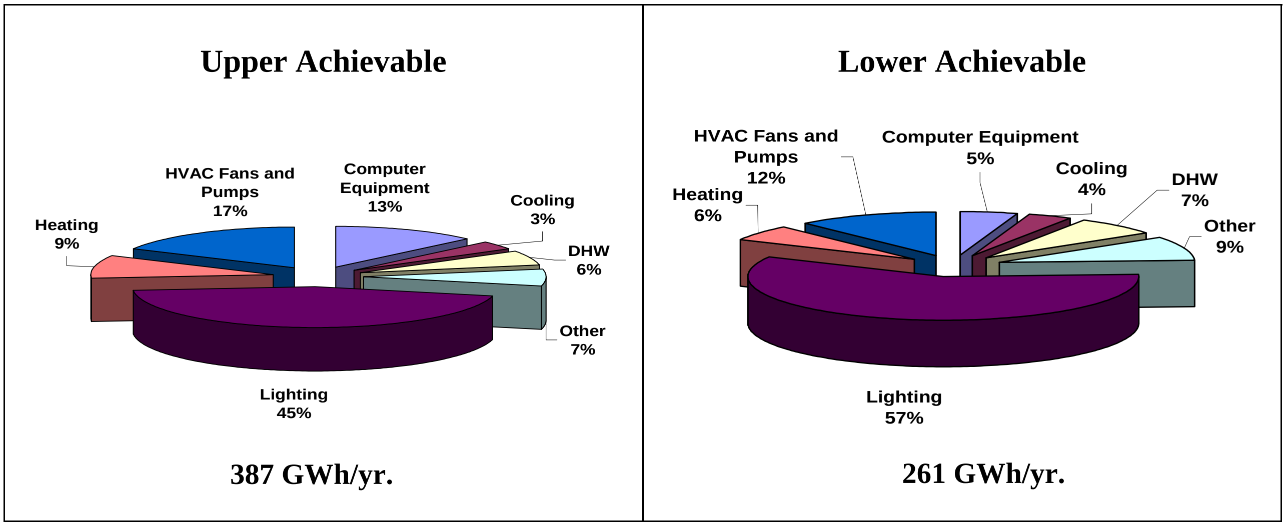
The Achievable Potential is the proportion of the economic electricity savings (as noted above) that could realistically be achieved within the study period. In the Commercial sector within the Island and Isolated service region, the Achievable Potential for electricity savings was estimated to be 387 GWh/yr. and 261 GWh/yr. by 2026 in, respectively, the Upper and Lower scenarios.

The most significant achievable savings opportunities were in the actions that addressed lighting, HVAC fans and pumps and space heating.

Exhibit 4.4 shows the distribution of electricity savings in 2026 by end use in the Upper and Lower Achievable Potential scenarios.

[21] The level of electricity consumption that would occur if all equipment and building envelopes were upgraded to the level that is cost effective against future avoided electricity costs.

**Exhibit 4.4: Distribution of Electricity Savings by Major End Use in the Upper and Lower Achievable Scenarios, Island and Isolated Service Region, Commercial Sector**[22]




## 4.3 PEAK LOAD SAVINGS

The electricity savings noted above also result in a reduction in peak load requirements (MW), which can be of particular value to the Utility during periods of high electricity demand[23].

The resulting Commercial sector peak load savings are presented in Exhibit 4.5.

**Exhibit 4.5: Peak Load Savings from Electricity Savings in the Island and Isolated Service Region, Commercial Sector**

| Milestone Year | Energy Savings (GWh/yr.) | | Peak Demand Reduction (MW) | |
|---|---|---|---|---|
| | Upper Achievable | Lower Achievable | Upper Achievable | Lower Achievable |
| 2011 | 110 | 80 | 16 | 11 |
| 2016 | 220 | 160 | 32 | 23 |
| 2021 | 298 | 209 | 42 | 28 |
| 2026 | 387 | 261 | 54 | 35 |

As illustrated in Exhibit 4.5, the Commercial sector peak load savings were estimated to be 54 MW and 35 MW by 2026 in, respectively, the Upper and Lower scenarios. In each case, the reductions are an average value over the peak period and are defined relative to the Reference Case.[24]

[22] Values may not add to 100% due to rounding.

[23] See Section 1.3 for peak period definition.

[24] The comparable results for the Labrador Interconnected service region are between 3.2 and 2.2 MW in, respectively, the Upper and Lower achievable scenarios. Additional details are provided in the Commercial sector report and accompanying appendices.

# 5. INDUSTRIAL SECTOR

The Industrial sector consists of large transmission level customers from the Mining, Pulp and Paper and Oil Refining sub sectors that use more than 50 GWh of electricity annually and over 400 small and medium facilities that use less than 50 GWh annually, including Fishing and Fish Processing, Manufacturing and Other customer categories.

## 5.1 APPROACH

The detailed end-use analysis of electrical efficiency opportunities in the Industrial sector employed Marbek's customized spreadsheet model. The model is organized by major industrial sub sector and major end use.

Electricity end-use profiles were developed for the six sub sectors described above. The profiles map proportionally how much electricity is used by each of the end uses for each sub sector. These profiles represent the sub sector archetypes and are used in the model to calculate the electricity used by each end use for each sub sector.

Three archetype profiles were developed for large industry based on the results of a survey of the six facilities included in these sub sectors.[25] In each case, site personnel provided data, which addressed both the allocation of electricity use by end use and general best practices implemented at the sites. A copy of the survey instrument is contained in Appendix A of the industrial sector report.

Experience from previous industry studies in other Canadian jurisdictions provided the necessary archetype end-use profiles for the three Small and Medium industrial sub sectors. These profiles were reviewed by industry experts familiar with industry in Newfoundland and Labrador and were revised to be representative of the province's industrial sub sectors.

The major steps in the general approach to the study are outlined in Section 1.3 above (*Major Analytic Steps*). Specific procedures for the Industrial sector were as follows:

- **Modelling of Base Year –** The consultants compiled data on Newfoundland and Labrador's Industrial sector from the Utilities Load Forecasting Department and from a survey questionnaire that was completed by each of the large customers. The macro model results produced a close match with actual Utilities' sales data.

- **Reference Case calculations -** The consultants prepared a Reference Case forecast based on projected growth forecasts provided by NLH, which includes anticipated closing of existing facilities and opening of new facilities. The possibility of new industrial load on the system, related to the processing of nickel from Voisey's Bay in Labrador, is not included due to the uncertainty with the processing technology. The self-generated electricity consumption was frozen for the 20-year forecast.

- **Assessment of CDM Measures –**To estimate the economic and achievable electricity savings potentials, the consultants assessed a wide range of commercially available CDM

[25] The results were also compared with those from detailed studies of similar industries undertaken by Marbek and were found to compare well.

measures and technologies such as more efficient systems for pumps, air displacement (fans), compressed air, material conveyance (such as conveyor belts and chains), industrial refrigeration as well as more efficient, industrial lighting, electric motors, etc.

## 5.2 ELECTRICITY SAVINGS

In, respectively, the Upper and Lower Achievable Potential scenarios, Industrial Sector electricity savings are estimated to be between 125 and 59 GWh/yr. by 2026 in the Island and Isolated and Labrador Interconnected service regions.[26]

A summary of the levels of annual electricity consumption contained in each of the forecasts addressed by the study is presented in Exhibits 5.1 and 5.2, by milestone year, and discussed briefly in the paragraphs below.

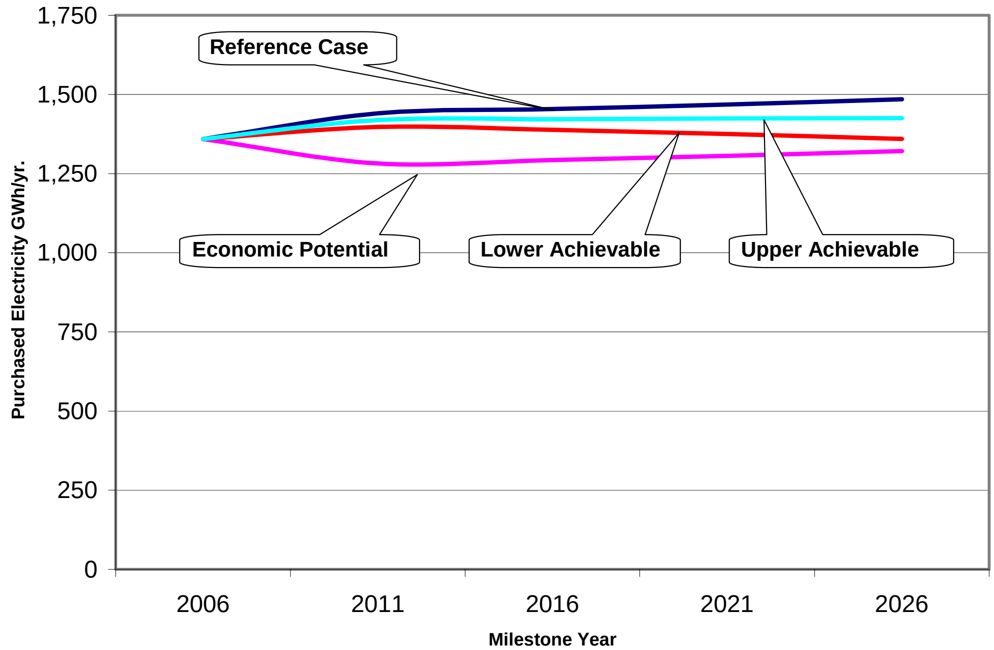
**Exhibit 5.1: Summary of Forecast Results for the Island and Isolated and Labrador Interconnected Service Regions – Annual Electricity Consumption, Industrial Sector (GWh/yr.)**

| Annual Consumption (GWh/yr.) Industrial Sector | | | | | | Potential Annual Savings (GWh/yr.) | | |
|---|---|---|---|---|---|---|---|---|
| Milestone Year | Base Year | Reference Case | Economic | Achievable | | Economic | Achievable | |
| | | | | Upper | Lower | | Upper | Lower |
| 2006 | 1,359 | 1,359 | | | | | | |
| 2011 | | 1,440 | 1,282 | 1,397 | 1,419 | 158 | 43 | 21 |
| 2016 | | 1,454 | 1,293 | 1,388 | 1,422 | 161 | 66 | 32 |
| 2021 | | 1,468 | 1,306 | 1,375 | 1,424 | 162 | 93 | 44 |
| 2026 | | 1,484 | 1,321 | 1,360 | 1,425 | 164 | 125 | 59 |

**Results are measured at the customer's point-of-use and do not include line losses.*

26 Analysis for the two service regions was combined for the Industrial sector.

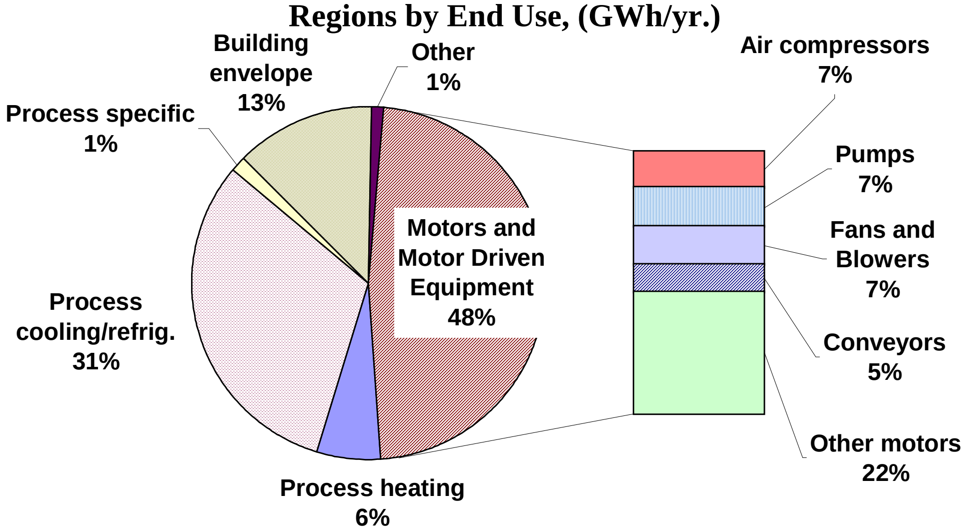
**Exhibit 5.2: Reference Case versus Upper and Lower Achievable Potential Electricity Consumption in the Industrial Sector (GWh/yr.)**




### *Base Year Electricity Use*

In the Base Year of 2006, the Island and Isolated and Labrador Interconnected Service Regions consumed about 4,558 GWh, of which 1,359 GWh was purchased electricity[27]. The Large industrial sub sector consumed 79% of the total purchased electricity. Exhibit 5.3 shows the purchase electricity use by end use for the Small and Medium industrial sector. Most of the electricity is used by motor and motor drive equipment (48% of the total) and process cooling and refrigeration/freezing (31% of the total).

**Exhibit 5.3: Small and Medium Industry Base Year Modelled Annual Purchased Electricity Consumption for the Island and Isolated and Labrador Interconnected Service Regions by End Use, (GWh/yr.)**




[27] Self-generated electricity was beyond the study scope.

***Reference Case***

In the absence of new Utilities' CDM initiatives, the study estimates that purchased electricity consumption in the Industrial sector will grow from 1,359 GWh/yr. in 2006 to about 1,484 GWh/yr. by 2026 in the Island and Isolated and Labrador Interconnected service regions. This represents an overall growth of about 9% in the period and compares very closely with NLH's load forecast, which also included consideration of the impacts of "natural conservation."

***Economic Potential Forecast***

Under the conditions of the Economic Potential Forecast,[28] the study estimated that electricity consumption in the Industrial sector would decline to about 1,321 GWh/yr. by 2026 in the Island and Isolated and Labrador Interconnected Service Regions. Annual savings relative to the Reference Case are 164 GWh/yr. or about 11%.

***Achievable Potential***

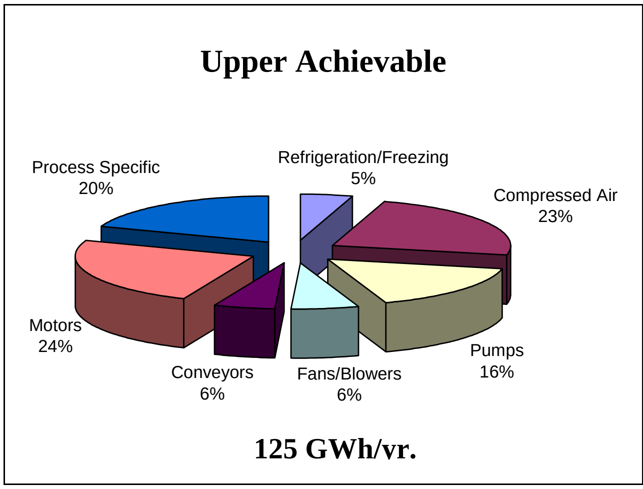
The Achievable Potential is the proportion of the economic electricity savings (as noted above) that could realistically be achieved within the study period. In the Industrial sector within the Island and Isolated and Labrador Interconnected service regions, the Achievable Potential for electricity savings was estimated to be 125 GWh/yr. and 59 GWh/yr. by 2026 in, respectively, the Upper and Lower scenarios.

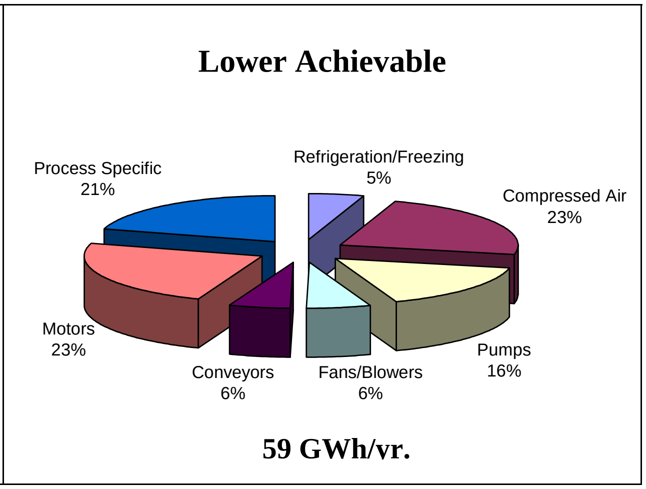
The most significant Achievable savings opportunities were in the actions that addressed motors and compressed air for the Small and Medium Sector, and process specific equipment in the Large industrial sector.

Exhibit 5.4 shows the distribution of electricity savings in 2026 by end use in the Upper and Lower Achievable Potential scenarios.

[28] The level of electricity consumption that would occur if all equipment were upgraded to the level that is cost effective against future avoided electricity costs.

**Exhibit 5.4: Distribution of Electricity Savings by Major End Use in the Upper and Lower Achievable Scenarios, Industrial Sector[29]**




## 5.3 PEAK LOAD SAVINGS

The study did not attempt to estimate peak load savings for the Industrial sector. This approach is consistent with the study scope and recognizes both the greater level of complexity posed by this sector and the absence of the required load shape data.

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[29] Values may not add to 100% due to rounding.

# 6. CONCLUSIONS AND NEXT STEPS

This study has confirmed the existence of significant cost-effective CDM potential within Newfoundland and Labrador's Residential, Commercial and Industrial sectors. The study results provide:

- Specific estimates of the potential CDM savings opportunities, defined by sector, sub sector, end use and, in several cases, specific technology(s)
- A baseline set of energy technology penetrations and energy use practices that can assist in the design of specific programs.

The next step[30] in this process involves the selection of a cost-effective portfolio of CDM programs and the setting of specific CDM targets and spending levels as well as deciding how to best account for CDM expenditures.

## 6.1 CDM SPENDING LEVELS

To provide a preliminary reference point for this next step in the program development process, the study team conducted a brief literature search in an attempt to identify typical CDM spending levels in other jurisdictions. The literature search identified two (relatively) recent studies that had addressed similar issues on behalf of other Canadian utilities. The two studies are:

- *Demand-Side Management: Determining Appropriate Spending Levels and Cost-Effectiveness Testing,* which was prepared by Summit Blue Consulting and the Regulatory Assistance Project for the Canadian Association of Members of Public Utility Tribunals (CAMPUT). The study was completed in January 2006.
- *Planning and Budgeting for Energy Efficiency/Demand-Side Management Programs*, which was prepared by Navigant Consulting for Union Gas (Ontario) Limited. The study was completed in July 2005.

The CAMPUT study, which included a review of U.S. and Canadian jurisdictions, concluded that an annual CDM expenditure equal to about 1.5% of annual electricity revenues might be appropriate for a utility (or jurisdiction) that is in the early stages of CDM[31] programming. This level of funding recognizes that it takes time to properly introduce programs into the market place.

The same study found that once program delivery experience is gained, a ramping up to a level of about 3% of annual electricity revenues is appropriate. The study also notes that higher percentages may be warranted if rapid growth in electricity demand is expected or if there is an increasing gap between demand and supply due to such things as plant retirements or siting limitations. The current emphasis on climate change mitigation measures would presumably also fall into a similar category of potential CDM drivers.

[30] Full treatment of these next steps is beyond the scope of the current project.

[31] The term DSM (demand-side management) and CDM are used interchangeably in this section.

The CAMPUT study also notes that even those states with 3% of annual revenues as their CDM target have found that there are more cost-effective CDM opportunities than could be met by the 3% funding. The finding is consistent with the situation in British Columbia. In the case of BC Hydro, CDM expenditures over the past few years have been about 3.3% of electricity revenues.[32] However, the results of BC Hydro's recently completed study (Conservation Potential Review (CPR) 2007) identified over 20,000 GWh of remaining cost-effective CDM opportunities by 2026. The magnitude of remaining cost-effective CDM opportunities combined with the aggressive targets set out in British Columbia's provincial Energy Plan suggest that BC Hydro's future CDM expenditures are likely to increase significantly if the new targets are to be met.

***Additional notes:***

- Neither of the studies noted above found any one single, simple model for setting CDM spending levels and targets. Rather, the more general conclusion is that utilities use a number of different approaches that are reasonable for their context. In fact, the CAMPUT report identified seven approaches to setting CDM spending levels.

    - Based on cost-effective CDM potential estimates
    - Based on percentages of utility revenues
    - Based on Mills/kWh of utility electric sales
    - Levels set through resource planning process
    - Levels set through the restructuring process
    - Tied to projected load growth
    - Case-by-case approach.

- The CAMPUT study also notes that, although not always explicit, a key issue in most jurisdictions is resolving the trade off between wanting to procure all cost-effective energy-efficiency measures and concerns about the resulting short-term effect on rates. The study concluded that CDM budgets based on findings from an Integrated Resource Plan or a benefit-cost assessment tend to accept whatever rate effects are necessary to secure the overall resource plan, inclusive of the cost-effective energy-efficiency measures.

## 6.2 COST ACCOUNTING OF CDM EXPENDITURES

The benefits of CDM programs include reduced energy costs for customers, reduced capital requirements and improved operating costs for utilities and environmental and economic benefits for society. However, the realization of these benefits can require significant expenditures. CDM expenditures include the cost of the efficient technology or action to the customer and the cost to the utility of the policy or program to encourage its use; in the case of many electric utilities, the related costs of CDM programs may also include revenue losses. The cost accounting of the related CDM expenditures is, therefore, another important consideration in the process of developing and implementing CDM programs.

One of the important considerations in the treatment of CDM expenditures is whether to expense or capitalize them. To provide preliminary insight into this issue, the study conducted a brief

[32] CAMPUT, 2006. p. 14.

literature review and held discussions with personnel involved with BC Hydro's Power Smart program.

The allocation of CDM program costs involves deciding between those that are expensed in the given year, and those that are capitalized and, hence, depreciated over a number of years. The results of the brief literature review indicated that both practices occur throughout jurisdictions in North America.

On the one hand, the expensing of CDM costs tends to be less expensive in the long run because there are no carrying costs included. However, in the short term, especially where programs are being developed for the first time, there may be rate impacts. On the other hand, capitalizing of CDM costs reduces the immediate cost to implement the program but the carrying cost of the non-amortized balances add to the overall costs of implementing the program.[33]

Discussions with BC Hydro Power Smart personnel indicated that the utility wrestled with this issue during the initiation of their CDM programs. The following points provide a rough framework for how that utility addresses this allocation issue:[34]

- Upfront development costs, such as market assessments, program planning, etc., are allocated to annual operation and maintenance (O&M) budgets and are, therefore, expensed.
- Electricity savings that occur as a result of CDM program implementation-related costs are considered to be an asset. Hence, once a CDM program reaches the implementation phase, all related expenses are linked to the acquisition of that electricity saving asset. All related expenses are, therefore, capitalized (deferred capital).
- In theory, the depreciation period for the capital asset (electricity savings) should be approximately the same as the life of the measures being implemented. For example, if the CDM measure promotes implementation of compact fluorescent lamps (CFLs), which have an average life of about five years, then the depreciation period should also be five years.
- In practice, most CDM program initiatives are likely to involve multiple measures, each having a different life span. In response, BC Hydro uses an average depreciation life in the range of 10 to 12 years for all their CDM initiatives.
- Inevitably, "grey" program cost areas will be encountered. In these cases, the experience to date suggests that it may be preferable to err towards capitalizing the cost item. This approach helps to smooth out multi-year CDM program budgets by reducing program exposure in a given year.

Based on the results of the preliminary review undertaken for this study, it appears that the approach to the treatment of future CDM expenditures by the Utilities can be better defined at

[33] *Demand-Side Management: Determining Appropriate Spending Levels and Cost-Effectiveness Testing.* Prepared by Summit Blue Consulting and the Regulatory Assistance Project for the Canadian Association of Members of Public Utility Tribunals (CAMPUT). January 30, 2006. p. 34.

[34] Discussion with Murray Bond, Manager of Evaluation, Measurement and Verification. Power Smart. November 12, 2007.

such time as there is more certainty regarding expenditure levels, funding sources, and potential impacts on customer rates.

# CONSERVATION AND DEMAND MANAGEMENT (CDM) POTENTIAL

# NEWFOUNDLAND and LABRADOR

## Residential Sector

***–Final Report–***

*Prepared for:*

**Newfoundland & Labrador Hydro and**
**Newfoundland Power**

*Prepared by:*

**Marbek Resource Consultants Ltd.**

*In association with:*

**Sustainable Housing and Education Consultants**
**and**
**Applied Energy Group**

*January 18, 2008*

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# EXECUTIVE SUMMARY

## ❑ Background and Objectives

Newfoundland and Labrador Hydro and Newfoundland Power (collectively the Utilities) have partnered to produce this study, recognizing the role that each has in energy conservation and least cost electric utility planning within the province. Increasing electricity costs and the expectations of a growing number of their customers and stakeholders have contributed to the increased focus on conservation and demand management (CDM) and resulted in a number of recent initiatives and projects targeting energy savings in the province. This study is the next step in the Utilities efforts to develop a comprehensive plan for CDM in Newfoundland and Labrador. The Utilities envision electricity conservation and demand management (CDM) to be a valuable component in meeting the province's future electricity requirements.

This study will also be a significant component in the further implementation of the Province's recently released Energy Plan. The Energy Plan establishes a long-term vision for how the province's energy resources will be developed and utilized to benefit the people of the province today as well as for future generations. Electricity conservation and demand management (CDM) are an important component of the provincial Energy Plan as are the conservation and demand management components for the other energy resources of the province.

This report meets, in part, the requirements of the Public Utilities Board Order PU 8 2007 requiring NLH to file this study and a five-year plan for implementation of CDM programs in 2008.

The objective of this study is to identify the potential contribution of specific CDM technologies and measures in the Residential, Commercial and Industrial sectors and to assess their economic costs and benefits. The Newfoundland and Labrador economy is expected to grow over the next 20 years, with an associated increase in energy consumption. The benefits of increased penetration of energy efficiency technologies include reduced energy costs for individuals and businesses, as well as environmental benefits through reduced pollution and greenhouse gas emissions.

The outputs from this study will assist the Utilities CDM planners and others to develop specific CDM programs for implementation and to optimize the contribution of CDM technologies and measures to the province's overall energy future.

## ❑ Scope and Organization

This study covers a 20-year study period from 2006 to 2026 and addresses the Residential, Commercial and Industrial sectors as well as street lighting. The study addresses the customers from both utilities. Due to differences in cost and rate structures, the Utilities' customers are organized into two service regions, which in this report are referred to as the Island and Isolated, and the Labrador Interconnected. For the purposes of this study, the isolated diesel system customers have been combined with those in the Island service region due to their relatively small size and electricity usage.

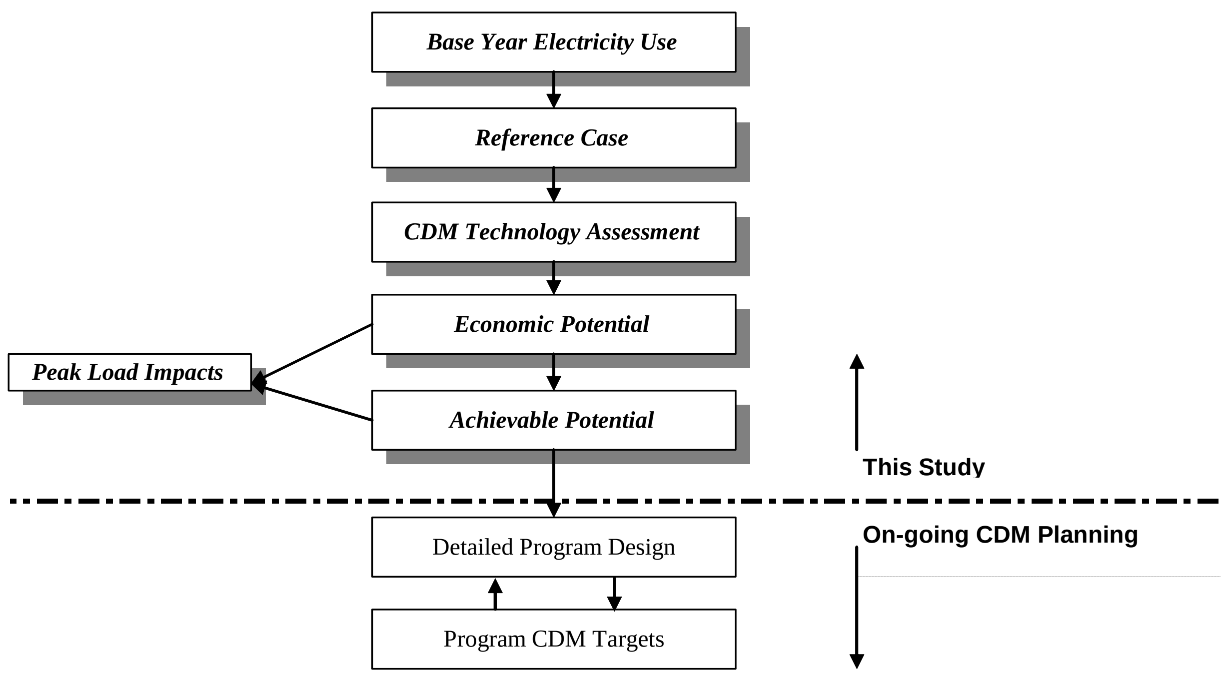
The study reviews all commercially viable electrical efficiency technologies or measures. In addition, the study also reviews selected peak load reduction and fuel switching measures.

## ❑ Approach

The detailed end-use analysis of electrical efficiency opportunities in the Residential sector employed two linked modelling platforms: **HOT2000,** a commercially supported residential building energy-use simulation software, and **RSEEM** (Residential Sector Energy End-use Model), a Marbek in-house spreadsheet-based macro model. Peak load savings were modelled using Applied Energy Group's Cross-Sector Load Shape Library Model (LOADLIB).

The major steps involved in the analysis are shown in Exhibit ES1 and are discussed in greater detail in Chapter 1. As illustrated in Exhibit ES1, the results of this study, and in particular the estimation of Achievable Potential,[1] support the on-going work of the Utilities; however, it should be emphasized that the estimation of Achievable Potential is not synonymous with either the setting of specific targets or with program design.

**Exhibit ES1: Study Approach - Major Analytical Steps**




## ❑ Overall Study Findings[2]

As in any study of this type, the results presented in this report are based on a large number of important assumptions. Assumptions such as those related to the current penetration of energy-efficient technologies, the rate of future growth in the province's building stock and customer willingness to implement new CDM measures are particularly influential. Wherever possible, the assumptions used in this study are consistent with those used by the Utilities and are based on

[1] The proportion of savings identified that could realistically be achieved within the study period without consideration for budgetary constraints.
[2] Consistent with the study scope, the results presented in this Executive Summary address the Island and Isolated service region. The main report provides a similar breakdown for the Labrador Interconnected service region.

best available information, which in many cases includes the professional judgement of the consultant team, Utilities' personnel and local experts. The reader should, therefore, use the results presented in this report as best available estimates; major assumptions, information sources and caveats are noted throughout the report.

The study findings confirm the existence of significant potential cost-effective opportunities for CDM in Newfoundland and Labrador's Residential sector. Electricity savings from efficiency improvements within the Island and Isolated service region would provide between 439 and 236 GWh/yr. of electricity savings by 2026 in, respectively, the Upper and Lower Achievable scenarios. The most significant Achievable Savings opportunities were in the actions that addressed lighting, space heating and household electronics (e.g., computers and peripherals, televisions and television peripherals).

The study also assessed the peak load reductions that would result from the electricity savings (noted above). Electricity savings would provide peak load reductions of approximately 103 to 55 MW during the Utilities' typical Winter Peak Day[3] by 2026 in, respectively, the Upper and Lower Achievable scenarios.

## ❑ Summary of Electricity Savings

A summary of the levels of annual electricity consumption contained in each of the forecasts addressed by the study is presented in Exhibits ES2 and ES3, by milestone year, and discussed briefly in the paragraphs below.

**Exhibit ES2: Summary of Forecast Results for the Island and Isolated Service Region – Annual Electricity Consumption, Residential Sector (GWh/yr.)**

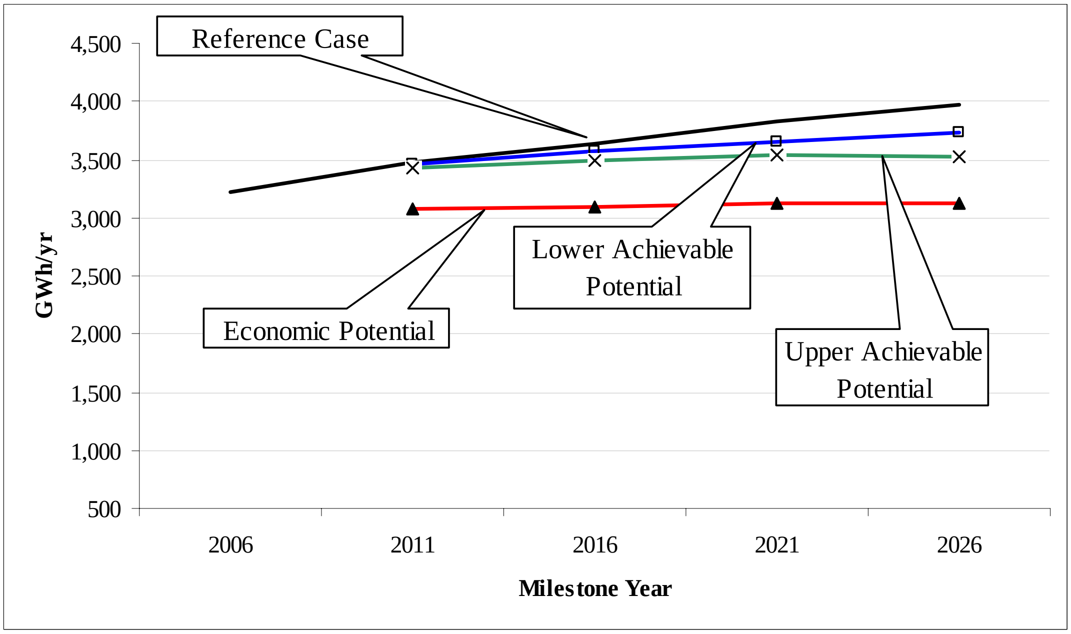
| Annual Consumption (GWh/yr.) Residential Sector | | | | | | Potential Annual Savings (GWh/yr.) | | |
|---|---|---|---|---|---|---|---|---|
| Milestone Year | Base Year | Reference Case | Economic | Achievable | | Economic | Achievable | |
| | | | | Upper | Lower | | Upper | Lower |
| 2006 | 3,228 | 3,228 | | | | | | |
| 2011 | | 3,483 | 3,074 | 3,425 | 3,468 | 409 | 58 | 16 |
| 2016 | | 3,637 | 3,092 | 3,486 | 3,568 | 545 | 151 | 69 |
| 2021 | | 3,821 | 3,120 | 3,533 | 3,660 | 701 | 288 | 161 |
| 2026 | | 3,968 | 3,122 | 3,529 | 3,732 | 846 | 439 | 236 |

*Results are measured at the customer's point-of-use and do not include line losses.

[3] Winter Peak Day is defined as the weekday hours from 7 am to noon and 4 pm to 8 pm on the four coldest days in the December to March period; totals 36 hours.

**Exhibit ES3: Graphic of Forecast Results for the Island and Isolated Service Region – Annual Electricity Consumption, Residential Sector (GWh/yr.)**

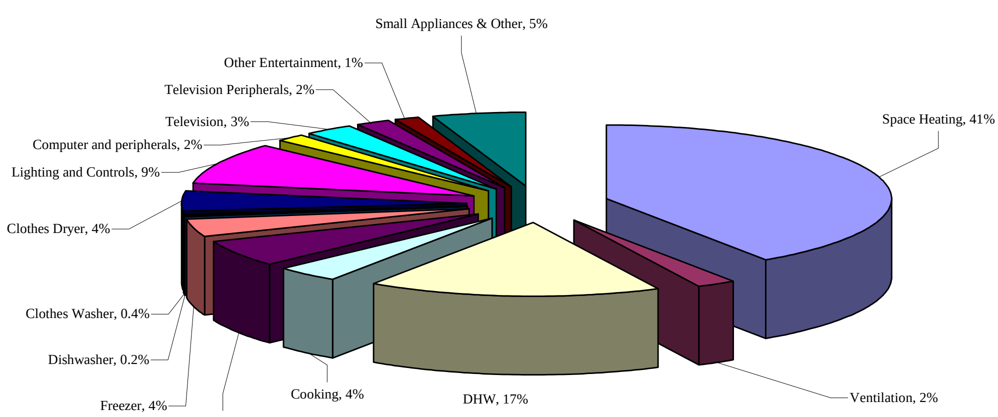
**Base**




## Year Electricity Use

In the Base Year of 2006, the Residential sector in the Island and Isolated service region consumed about 3,228 GWh. Exhibit ES4 shows that space heating accounts for about 41% of total residential electricity use.[4] Domestic hot water (DHW) accounts for about 17% of the total electricity use, followed by kitchen appliances (14%) and lighting (9%). Household electronics (i.e., computers and peripherals, televisions and television peripherals) account for about 8% of electricity use.

**Exhibit ES4: Base Year Electricity Use by End Use in the Island and Isolated Service Region, Residential Sector**




*Totals may not add to 100% due to rounding.*

[4] Values are for all residential dwellings. Space heating share is much higher in electrically heated homes.

The overwhelming majority of residential electricity use in the Island and Isolated service region occurs in single detached dwellings (81%). The remaining electricity use is in attached dwellings (11%) followed by apartments (6%). Isolated and other residential buildings each account for about 1%.

***Reference Case***

In the absence of new utility CDM initiatives, the study estimates that electricity consumption in the Residential sector will grow from 3,228 GWh/yr. in 2006 to about 3,968 GWh/yr. by 2026 in the Island and Isolated service region. This represents an overall growth of about 23% in the period and compares very closely with NLH's load forecast, which also included consideration of the impacts of "natural conservation."

***Economic Potential Forecast***

Under the conditions of the Economic Potential Forecast,[5] the study estimated that electricity consumption in the Residential sector would decline to about 3,124 GWh/yr. by 2026 in the Island and Isolated service region. Annual savings relative to the Reference Case are 844 GWh/yr. or about 21%.

***Achievable Potential***

The Achievable Potential is the proportion of the economic electricity savings (as noted above) that could realistically be achieved within the study period. In the Residential sector within the Island and Isolated service region, the Achievable Potential for electricity savings was estimated to be 439 GWh/yr. and 236 GWh/yr. by 2026 in, respectively, the Upper and Lower scenarios.

Consistent with the results in the Economic Potential Forecast, the most significant Achievable savings opportunities were in the actions that addressed lighting and space heating, followed by water heating, household electronics (e.g., computers and peripherals, televisions and television peripherals) and large appliances.

- ❑ **Peak Load Savings**

The electricity savings noted above also result in a reduction in capacity requirements (MW), which can be of particular value to the Utilities during periods of high electricity demand. The study defined the Newfoundland Labrador system peak period as:

> *The morning period from 7 am to noon and the evening period from 4 to 8 pm on the four coldest days during the December to March period; this is a total of 36 hours per year.*

The resulting peak load reductions are presented in Exhibit ES5. As illustrated in Exhibit ES5, the Residential sector peak load savings was estimated to be 103 MW and 55 MW by 2026 in, respectively, the Upper and Lower scenarios. In each case, the reductions are an average value over the peak period and are defined relative to the Reference Case.

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[5] The level of electricity consumption that would occur if all equipment and building envelopes were upgraded to the level that is cost effective against future avoided electricity costs.

**Exhibit ES5: Peak Load Savings from Electricity Savings in the Island and Isolated Service Region, Residential Sector**

| Milestone Year | Electricity Savings (GWh/yr.) | | Peak Load Savings (MW) | |
|---|---|---|---|---|
| | Upper Achievable | Lower Achievable | Upper Achievable | Lower Achievable |
| 2011 | 58 | 16 | 11 | 3 |
| 2016 | 151 | 69 | 29 | 13 |
| 2021 | 288 | 161 | 58 | 32 |
| 2026 | 439 | 236 | 91 | 49 |

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**APPENDICES**

**List of Exhibits**

# 1. INTRODUCTION

## 1.1 BACKGROUND AND OBJECTIVES

Newfoundland and Labrador Hydro and Newfoundland Power (collectively the Utilities) have partnered to produce this study, recognizing the role that each has in energy conservation and least cost electric utility planning within the province. Increasing electricity costs and the expectations of a growing number of their customers and stakeholders have contributed to the increased focus on conservation and demand management (CDM) and resulted in a number of recent initiatives and projects targeting energy savings in the province. This study is the next step in the Utilities efforts to develop a comprehensive plan for CDM in Newfoundland and Labrador. The Utilities envision electricity conservation and demand management (CDM) to be a valuable component in meeting the province's future electricity requirements.

This study will also be a significant component in the further implementation of the Province's recently released Energy Plan. The Energy Plan establishes a long-term vision for how the province's energy resources will be developed and utilized to benefit the people of the province today as well as for future generations. Electricity conservation and demand management (CDM) are an important component of the provincial Energy Plan as are the conservation and demand management components for the other energy resources of the province.

This report meets, in part, the requirements of the Public Utilities Board Order PU 8 2007 requiring NLH to file this study and a five-year plan for implementation of CDM programs in 2008.

The objective of this study is to identify the potential contribution of specific CDM technologies and measures in the Residential, Commercial and Industrial sectors and to assess their economic costs and benefits. The Newfoundland and Labrador economy is expected to grow over the next 20 years, with an associated increase in energy consumption. The benefits of increased penetration of energy efficiency technologies include reduced energy costs for individuals and businesses, as well as environmental benefits through reduced pollution and greenhouse gas emissions.

The outputs from this study will assist the Utilities CDM planners and others to develop specific CDM programs for implementation and to optimize the contribution of CDM technologies and measures to the province's overall energy future.

## 1.2 STUDY SCOPE

The scope of this study is summarized below.

- **Sector Coverage:** This study addresses the Residential, Commercial and Industrial sectors as well as street lighting. It was agreed that the Industrial sector would be treated at a much higher level than the Residential and Commercial sectors.

- **Geographical Coverage**: The study addresses the customers from both utilities. Due to differences in cost and rate structures, the Utilities' customers are organized into two service regions, which in this report are referred to a: the Island and Isolated, and the Labrador Interconnected. For the purposes of this study, the isolated diesel system customers have been combined with those in the Island service region due to their relatively small size and electricity usage.

- **Study Period**: This study covers a 20-year period. The Base Year is the calendar year 2006, with milestone periods at five-year increments: 2011, 2016, 2021 and 2026. The Base Year of 2006 was selected as it was the most recent calendar period for which complete customer data were available.

- **Technologies:** The study addresses conservation and demand management (CDM) measures. CDM refers to a broad range of potential measures (see Section 1.3, Definitions); however, for the purposes of this study, it was agreed that the primary focus is on energy-efficiency measures. This includes measures that reduce electricity use as well as the associated capacity impact on a winter peak period. The study also provides a high-level treatment of selected demand management measures, such as direct control of space heating loads, etc.[6]

### 1.2.1 Data Caveat

As in any study of this type, the results presented in this report are based on a large number of important assumptions. Assumptions such as those related to the current penetration of energy-efficient technologies, the rate of future growth in the province's building stock and customer willingness to implement new CDM measures are particularly influential. Wherever possible, the assumptions used in this study are consistent with those used by the Utilities and are based on best available information, which in many cases includes the professional judgement of the consultant team, Utilities' personnel and local experts. The reader should, therefore, use the results presented in this report as best available estimates; major assumptions, information sources and caveats are noted throughout the report.

## 1.3 DEFINITIONS

This study uses numerous terms that are unique to analyses such as this one and consequently it is important to ensure that readers have a clear understanding of what each term means when applied to this study.

***Base Year Electricity Use*** The Base Year is the starting point for the analysis. It provides a detailed description of "where" and "how" electrical energy is currently used in the existing Residential sector building stock. Building electricity use simulations were undertaken for the major dwelling types and calibrated to actual utility customer billing data for the Base Year. As noted previously, the Base Year for this study is the calendar year 2006.

[6] The information provided is based on the detailed analysis that Marbek is currently undertaking in other jurisdictions.

***Reference Case Electricity Use (includes Natural Conservation)***

The Reference Case Electricity Use estimates the expected level of electrical energy consumption that would occur over the study period in the absence of new (post-F2006) utility-based CDM initiatives. It provides the point of comparison for the subsequent calculation of "economic" and "achievable" electrical energy potentials. Creation of the Reference Case required the development of profiles for new buildings in each of the dwelling types, estimation of the expected growth in building stock and appliances and, finally, an estimation of "natural" changes affecting electricity consumption over the study period. The Reference Case aligns well with the NLH Long Term Planning (PLF) Review Forecast, Summer/Fall 2006.

***Conservation and Demand Management (CDM) Measures***

CDM refers to a broad range of potential measures that can include: energy efficiency (use more efficiently), energy conservation (use less), demand management (use less during peak periods), fuel switching (use a different fuel to provide the energy service) and self-generation/co-generation (displace load off of grid).

As noted in Section 1.2, it was agreed that the primary focus is on energy-efficiency measures. This includes measures that reduce electricity use as well as the associated capacity impact on a winter peak period.

***The Cost of Conserved Energy (CCE)***

The CCE is calculated for each energy-efficiency measure and operating and maintenance (O&M) practice. The CCE is the annualized incremental capital and O&M cost of the upgrade measure divided by the annual energy savings achieved, excluding any administrative or program costs. The CCE represents the cost of conserving one kWh of electricity; it can be compared directly to the cost of supplying one new kWh of electricity.

***Economic Potential Electricity Forecast***

The Economic Potential Electricity Forecast is the level of electricity consumption that would occur if all equipment and building envelopes were upgraded to the level that is cost effective against the future avoided cost of electricity in the Newfoundland and Labrador Hydro service area (for this study, the value was set at $0.0980/kWh for the Island and Isolated service region and $0.0432/kWh for the Labrador Interconnected service region).[7] All the energy-efficiency upgrades included in the technology assessment that had a CCE equal to, or less than, the preceding avoided costs of new electricity supply were incorporated into the Economic Potential Forecast.

[7] Sensitivity analysis was also conducted using avoided cost values expected to prevail if the Lower Churchill/DC Link project is completed.

***Achievable Potential*** The Achievable Potential is the proportion of the savings identified in the Economic Potential Forecast that could realistically be achieved within the study period. Achievable Potential recognizes that it is difficult to induce customers to purchase and install all the electrical efficiency technologies that meet the criteria defined by the Economic Potential Forecast. The results are presented as a range, defined as "upper" and "lower."

## 1.4 APPROACH

To meet the objectives outlined above, the study was conducted within an iterative process that involved a number of well-defined steps. At the completion of each step, the client reviewed the results and, as applicable, revisions were identified and incorporated into the interim results. The study then progressed to the next step. A summary of the steps is presented below.

***Step 1:*** **Develop Base Year Electricity Calibration Using Actual Utility Billing Data**

- Compile and analyze available data on Newfoundland and Labrador's existing building stock.
- Develop detailed technical descriptions of the existing building stock.
- Undertake computer simulations of electricity use in each building type and compare these with actual building billing and audit data.
- Compile actual utility billing data.
- Create sector model inputs and generate results.
- Calibrate sector model results using actual utility billing data.

***Step 2:*** **Develop Reference Case Electricity Use**

- Compile and analyze building design, equipment and operations data and develop detailed technical descriptions of the new building stock.
- Develop computer simulations of electricity use in each new building type.
- Compile data on forecast levels of building stock growth and "natural" changes in equipment efficiency levels and/or practices.
- Define sector model inputs and create forecasts of electricity use for each of the milestone years.
- Compare sector model results with NLH load forecast for the study period.

***Step 3:*** **Identify and Assess Energy-efficiency Measures**

- Develop list of energy-efficiency upgrade measures.
- Compile detailed cost and performance data for each measure.
- Identify the baseline technologies employed in the Reference Case, develop energy-efficiency upgrade options and associated electricity savings for each option and determine the CCE for each upgrade option.

***Step 4:*** **Estimate Economic Electricity Savings Potential**

- Compile utility economic data on the forecast cost of new electricity generation; costs of $0.0980/kWh and $0.0432/kWh were selected as the economic screens for, respectively, the Island and Isolated and Labrador Interconnected service regions.

- Screen the identified energy-efficiency upgrade options from Step 3 against the utility economic data.
- Identify the combinations of energy-efficiency upgrade options and building types where the cost of saving one kilowatt of electricity is equal to, or less than, the cost of new electricity generation.
- Apply the economically attractive electrical efficiency measures from Step 3 within the energy use simulation model developed previously for the Reference Case.
- Determine annual electricity consumption in each building type and end use when the economic efficiency measures are employed.
- Compare the electricity consumption levels when all economic efficiency measures are used with the Reference Case consumption levels and calculate the electricity savings.

***Step 5:*** **Estimate Achievable Potential Electricity Savings**

- "Bundle" the electricity and peak load reduction opportunities identified in the Economic Potential Forecasts into a set of opportunities.
- For each of the identified opportunities, create an Opportunity Profile that provides a high-level implementation framework, including measure description, cost and savings profile, target sub sectors, potential delivery allies, barriers and possible synergies.
- Review historical achievable program results and prepare preliminary Assessment Worksheets.
- Conduct a full day workshop involving the client, the consultant team and technical experts to reach general agreement on "upper" and "lower" range of achievable potential.

***Step 6:*** **Estimate Peak Load Impacts of Electricity Savings**

- The electricity (electric energy) savings (GWh) calculated in the preceding steps were converted to peak load (electric demand) savings (MW).[8]
- The study defined the Newfoundland and Labrador system peak period as the morning period from 7 am to noon and the evening period from 4 to 8 pm on the four coldest days of the year during the December to March period; this is a total of 36 hours per year.
- The conversion of electricity savings to hourly demand drew on a library of specific sub sector and end use electricity load shapes. Using the load shape data, the following steps were applied:
  - Annual electricity savings for each combination of sub sector and end use were disaggregated *by month*
  - Monthly electricity savings were then further disaggregated *by day type* (weekday, weekend day and peak day)
  - Finally, each day type was disaggregated *by hour*.

[8] Peak load savings were modeled using Applied Energy Group's Cross-Sector Load Shape Library Model (LOADLIB).

## 1.5 ANALYTICAL MODELS

The analysis of the Residential sector employed two linked modelling platforms:

- HOT2000, a commercially supported, residential building energy-use simulation software
- RSEEM (Residential Sector Energy End-use Model), a Marbek in-house spreadsheet-based macro model.

HOT2000 was used to define household heating, cooling and domestic hot water (DHW) electricity use for each of the residential building archetypes. HOT2000 uses state-of-the-art heat loss/gain and system modelling algorithms to calculate household electricity use. It addresses:

- Electric, natural gas, oil, propane and wood space heating systems
- DHW systems from conventional to high-efficiency condensing systems
- The interaction effect between space heating appliances and non-space heating appliances, such as lights and refrigerators.

The outputs from HOT2000 provide the space heating/cooling energy-use intensity (EUI) inputs for the Thermal Archetype module of RSEEM.

RSEEM consists of three modules:

- A General Parameters module that contains general sector data (e.g., number of dwellings, growth rates, etc.)
- A Thermal Archetype module, as noted above, which contains data on the heating and cooling loads in each archetype
- An Appliance Module that contains data on appliance saturation levels, fuel shares, unit electricity use, etc.

RSEEM combines the data from each of the modules and provides total use of electricity by service region, dwelling type and end use. RSEEM also enables the analyst to estimate the impacts of the electrical efficiency measures on the Utilities' on-peak system demand.

## 1.6 STUDY ORGANIZATION AND REPORTS

The study was organized and conducted by sector using a common methodology, as outlined above. The results for each sector are presented in individual reports as well as in a summary report. They are entitled:

- *Conservation and Demand Management Potential (2006 to 2026), Newfoundland and Labrador, Residential Sector*

- *Conservation and Demand Management Potential (2006 to 2026), Newfoundland and Labrador, Commercial Sector*

- *Conservation and Demand Management Potential (2006 to 2026), Newfoundland and Labrador, Industrial Sector*

- *Conservation and Demand Management Potential (2006 to 2026), Newfoundland and Labrador, Residential, Commercial and Industrial Sectors, Summary Report*

The study also prepared a brief CDM program evaluation report, which is entitled:

- *Conservation and Demand Management Potential (2006 to 2026), Newfoundland and Labrador, Program Evaluation Guidelines*.

This report presents the Residential sector results; it is organized as follows:

- Section 2 presents a profile of Residential sector Base Year electricity use in Newfoundland and Labrador, including a discussion of the major steps involved and the data sources employed.

- Section 3 presents a profile of Residential sector Reference Case electricity use in Newfoundland and Labrador for the study period 2006 to 2026, including a discussion of the major steps involved.

- Section 4 identifies and assesses the economic attractiveness of the selected energy-efficiency technology measures for the Residential sector.

- Section 5 presents the Residential sector Economic Potential Electricity Forecast for the study period 2006 to 2026.

- Section 6 presents the estimated Upper and Lower Achievable Potential for electricity savings for the study period 2006 to 2026.

- Section 7 presents conclusions and next steps.

- Section 8 presents a listing of major references.

# 2. BASE YEAR (2006) ELECTRICITY USE

## 2.1 INTRODUCTION

This section provides a profile of Base Year (2006) electricity use in Newfoundland and Labrador's Residential sector. The discussion is organized into the following sub sections:

- Segmentation of Base Year Housing Stock
- Definition of End Uses
- Estimation of Net Space Heating Loads
- Development of Thermal Archetypes
- Annual Appliance Electricity Use
- Appliance Saturation
- Estimation of Fuel Share, by End Use
- Average Electricity Use Per Unit
- Summary of Model Results.

## 2.2 SEGMENTATION OF BASE YEAR HOUSING STOCK

The first major task in developing the Base Year electricity calibration involved the segmentation of the residential building stock on the basis of four factors:

- Dwelling type
- Service region
- Vintage
- Heating category (electrically heated versus non-electrically heated).

Based on discussions with the Utilities' personnel, it was agreed that Newfoundland and Labrador's existing residential stock would be segmented into the following dwelling types:

- Single-family detached, pre-2007 – electric space heat
- Single-family detached, pre-2007 – non-electric space heat
- Attached,[9] pre-2007 – electric space heat
- Attached, pre-2007 – non-electric space heat
- Apartment,[10] pre-2007 – electric space heat
- Apartment, pre-2007 – non-electric space heat
- Isolated (all residences in diesel communities)
- Other – includes very low use facilities and non-dwellings such as garages, sheds, wells, etc.
- Vacant and Partial – includes dwelling units that are either vacant all the time (such as homes owned by people who have moved away) or are used only seasonally (including cottages). The energy consumption of this residential stock is not reported in the remainder of this document.

[9] Includes the main dwellings above a basement apartment.
[10] Includes basement apartments, which make up about 50% of the units defined under this category.

Utility customer billing data was used to develop a breakdown of the Residential sector into the above dwelling types. The same customer data was also used to further divide the total population of each dwelling type by service region and primary heating type.

A summary is provided in Exhibit 2.1 and highlights are presented below:

- The Utilities currently service about 228,000 residential dwelling units between the two service regions; the Island and Isolated service region accounts for approximately 96.5% of the total residential customers served by the Utilities.
- 8% of residential dwellings are currently listed as vacant or partially occupied. This includes seasonal homes or cottages as well as vacant residences. These buildings have been separated out from the other dwelling types in the Base Year as their inclusion may result in an understating of the energy consumption.
- Of those residential units that are currently fully occupied, approximately 76% are single-family detached, followed by 11% attached units, 9% apartment units, and 2% other types of dwellings. The remaining 2% is made up of isolated dwellings.
- Electricity is the primary space heating fuel in approximately 55% of the provincial housing stock in the Island and Isolated service region and 92% of the provincial housing stock in the Labrador Interconnected service region.
- The inclusion of single-family dwellings with a basement apartment in the dwelling type “Attached,” may result in energy consumption in this segment being slightly higher than is typical of other areas of Canada.

**Exhibit 2.1: Existing Newfoundland and Labrador Residential Units by Dwelling Type, Service Region and Primary Heating Source**

| Dwelling Type | Units | | |
|---|---|---|---|
| | Island and Isolated | Labrador Interconnected | Total |
| Single Family Detached, Electric Heat | 80,300 | 5,031 | **85,331** |
| Single Family Detached, Non-Electric Heat | 74,231 | 103 | **74,334** |
| Attached, Electric Heat | 15,227 | 1,663 | **16,890** |
| Attached, Non-Electric Heat | 5,060 | 34 | **5,094** |
| Apartment, Electric Heat | 16,399 | 462 | **16,861** |
| Apartment, Non-Electric Heat | 2,728 | 9 | **2,737** |
| Isolated | 3,491 | 0 | **3,491** |
| Other | 3,512 | 606 | **4,118** |
| Vacant and Partial | 18,970 | 0 | **18,970** |
| **Subtotal** | **219,918** | **7,908** | **227,826** |

*Source: NLH-NP customer billing data.*

## 2.3 DEFINITION OF END USES

Electricity use within each of the dwelling types noted above is further defined on the basis of specific end uses. In this study, an end use is defined as, "the final application or final use to which energy is applied. End uses are the services of economic value to the users of energy."

A summary of the major Residential sector end uses used in this study is provided in Exhibit 2.2, together with a brief description of each.

**Exhibit 2.2: Residential Electric End Uses**

| End Use | Description |
|---|---|
| Space heating | All space heating, including both central heating and supplementary heating |
| Space cooling | Saturation of space cooling is very low in Newfoundland and Labrador; the model includes any space cooling energy use under "Small Appliance & Other" |
| Ventilation | Primarily the furnace fan, but also includes the fan in heat recovery ventilators as well as kitchen and bathroom fans |
| Domestic Hot Water (DHW) | Heating of water for DHW use. Does not include hydronic space heating |
| Cooking | Includes ranges, separate ovens and cook tops and microwave ovens |
| Refrigerator | |
| Freezer | |
| Dishwasher | |
| Clothes washer | |
| Clothes dryer | |
| Lighting | Includes interior, exterior and holiday lighting |
| Computer and peripherals | Printers, scanners, modems, faxes, PDA and cell phone chargers |
| Television | |
| Television peripherals | Set top boxes, including digital cable converters and satellite converters |
| Other electronics | Stereos, DVD players, VCRs, boom boxes, radios, video gaming systems, security systems |
| Small Appliance & Other | There are hundreds of additional items within this category, each accounting for a fraction of a percent of household energy use, e.g., hair dryers, doorbells, garage door openers, block heaters, home medical equipment, electric lawnmowers |

## 2.4 ESTIMATION OF NET SPACE HEATING LOADS

Net space heating load is the space heating load of a building that must be met by the space heating system. This is equal to the total heat loss through the building envelope minus solar and internal gains.

The net space heating loads for each combination of dwelling type and service region were developed based on the following combination of data sources:

- Marbek's database of residential energy consumption from other jurisdictions
- Current utility sales data combined with knowledge of the energy consumption and saturation of other end uses.

The net space heating load for each dwelling type is given by the following equation:

$$NetHL_1 = HL_1 + a_{i,1} * s_{i,1}$$

Where: $NetHL_1$ = Net heating load for dwelling type #1
$HL_1$ = Load on primary heating appliance for dwelling type #1
$a_{i,1}$ = Average consumption for supplementary heating in dwelling type #1
$s_{i,1}$ = Saturation of supplementary heating in dwelling type #1

$HL_1$ was estimated for each dwelling type and service region, based on the Utilities' customer sales data for electric and non-electrically heated dwellings combined with data on the electricity consumption of non-space heating end uses. The values for $a_{i1}$ and $s_{i1}$ were developed based on the estimated share of space heating that is provided by electricity (versus supplementary fuels), as taken from the Utilities' Residential End-use Surveys (REUS). The net space heating loads are presented in Exhibit 2.3 by dwelling type and service region.

It should be noted that the values shown in Exhibit 2.3 are not fuel specific; rather, they represent the total tertiary space heat load for each dwelling. The efficiency of the space heating appliances used to meet these loads are considered in subsequent stages of the analysis.

**Exhibit 2.3: Existing Residential Units, 2006 (kWh/yr.) Net Space Heating Loads by Dwelling Type[11]**

| Dwelling Type | Island and Isolated | Labrador Interconnected |
|---|---|---|
| Single Family Detached, Electric Heat | 12,554 | 29,379 |
| Single Family Detached, Non-Electric Heat | 16,700 | 39,081 |
| Attached, Electric Heat | 11,377 | 27,294 |
| Attached, Non-Electric Heat | 15,134 | 36,309 |
| Apartment, Electric Heat | 5,742 | 8,745 |
| Apartment, Non-Electric Heat | 5,742 | 8,745 |
| Isolated | 12,293 | N/A |
| Other | 10,036 | 5,411 |

[11] Net space heating load is the space heating load of a building that must be met by the space heating system over a full year. This is equal to the total heat loss through the building envelope minus solar and internal gains. Values shown for non-electrically heated dwellings are shown in kilowatt hours for format consistency. Work in other jurisdictions has shown significantly higher space heating energy consumption in homes with oil and gas furnaces than in homes with electric heat, even after accounting for furnace efficiency. The reasons for this require more research, but may include factors such as greater air leakage where air intake is required for combustion or homeowners turning down individual electric baseboards in unoccupied rooms.

### 2.4.1 Development of Thermal Archetypes – Existing Stock

The next major step involved the development of a thermal archetype for each of the major dwelling types noted in Exhibit 2.3 using HOT2000.

Each HOT2000 file contains a comprehensive physical description of the size, layout and thermal characteristics of each dwelling type. HOT2000 then uses these inputs to create a full computer model of the residence, calculating loads, interactive effects and energy consumption. In each case, the net heating and cooling loads simulated by HOT2000 were calibrated to the values shown in Exhibit 2.3, which had been established on the basis of the sources described above. The process of calibrating simulation models to the loads estimated from available data served to further confirm the estimated loads. Adjustments were made to the estimates as required.

The physical and operating characteristics of each residential thermal archetype were researched using a number of sources, including:

- Database of EnerGuide for Houses (EGH) evaluations in Newfoundland and Labrador
- Natural Resources Canada (NRCan) and Statistics Canada housing data
- Consultations with energy auditors and residential housing experts located in Newfoundland and Labrador.

For the existing housing stock, archetypes were created for the two primary dwelling types in each service region: single-family detached and attached. A brief description of each housing archetype is provided below.

❑ **Single-family Dwellings**

For the Island and Isolated service region, a “typical” existing, single-detached dwelling can be defined as a single-story bungalow of approximately 93.5$m^2$ (1000 $ft^2$), with a finished basement. This home has 7.7 $m^2$ (83 $ft^2$) of windows, defined as double-glazed, mostly with wood or vinyl frames. Walls are represented by RSI-2.4 (R-13.5) insulation values, ceilings RSI-4.5 (R-25.5) and the basement is insulated to a value of RSI-0.6 (R-3.5). The houses are typically not very airtight with about five air changes per hour (ac/h) at 50 Pascal (Pa) depressurization. Typically, there is no central ventilation system.

For the Labrador Interconnected service region, a “typical” existing, single-detached dwelling can be defined as a single-story bungalow of approximately 85 $m^2$ (915 $ft^2$), with a heated basement. This home has 6.1 $m^2$ (66 $ft^2$) of windows, defined as double-glazed, mostly with wood or vinyl frames. Walls are represented by RSI-2.1 (R-12) insulation values, ceilings RSI-4 (R-23) and there is no insulation in the basement. The houses are typically not very airtight with about seven air changes per hour (ac/h) at 50 Pascal (Pa) depressurization. Typically, there is no central ventilation system.

- **Attached Dwellings**

For the Island and Isolated service region, a "typical" existing, attached dwelling can be defined as a two-story middle-unit of approximately 104 $m^2$ (1120 $ft^2$), with a finished basement. This home has 7.2 $m^2$ (77 $ft^2$) of windows, defined as double-glazed, mostly with wood or vinyl frames. Walls are represented by RSI-2.4 (R-13.5) insulation values, ceilings RSI-4.5 (R-25.5) and the basement is insulated to a value of RSI-0.6 (R-3.5). The houses are typically not very airtight with about five air changes per hour (ac/h) at 50 Pascal (Pa) depressurization. Typically, there is no central ventilation system.

For the Labrador Interconnected service region, a "typical" existing, attached dwelling can be defined as a two-story middle-unit of approximately 104 $m^2$ (1120 $ft^2$) with a heated basement. This home has 7.2 $m^2$ (77 $ft^2$) of windows, defined as double-glazed, mostly with wood or vinyl frames. Walls are represented by RSI-2.1 (R-12) insulation values, ceilings RSI-4 (R-23) and there is no insulation in the basement. The houses are typically not very airtight with about seven air changes per hour (ac/h) at 50 Pascal (Pa) depressurization. Typically, there is no central ventilation system.

## 2.5 ANNUAL APPLIANCE ELECTRICITY USE

The next major task involved the development of estimated average annual unit electricity consumption (UEC) values for each of the major residential appliances.

While most appliances have increased in efficiency over time, there is no evident correlation or available data that links the age of the dwelling and the age of the appliances in it. Older homes likely have had major appliances replaced several times and newer homes can have old appliances transferred from previous residences. Lacking any definite relation between the age of the home and the age of an appliance, an average value for all in-place appliances was used for all existing vintages. This was based on an appliance stock model that takes into account the expected useful life of each type of appliance, the rate of purchase and retirement of appliances, the average annual consumption of newly purchased appliances in a given year and the average annual consumption of appliances being retired in a given year. The stock average consumption thus evolves with time. In any specific year, the average age of appliances in place is assumed to be half of the expected useful life of the appliance and the stock average is built up of all the appliances purchased and installed up to that point.

Exhibits 2.4 and 2.5 summarize the estimated average annual UEC for major end-use appliances in, respectively, the Island and Isolated and Labrador Interconnected service regions.

The values shown in Exhibits 2.4 and 2.5 apply to the current stock mix. Further discussion is provided below.

**Exhibit 2.4: Annual Appliance Electricity Use (UEC) for the Island and Isolated Service Region, (kWh/yr.)**

| Dwelling Type | Ventilation | DHW | Cooking | Refrigerator | Freezer | Dishwasher | Clothes washer | Clothes dryer | Lighting | Computer etc. | Television | TV peripherals | Other electronics | Small apps & Other |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Single Family Detached, Electric Heat | 121 | 3,301 | 633 | 830 | 650 | 75 | 64 | 820 | 1,515 | 394 | 178 | 226 | 159 | 902 |
| Single Family Detached, Non-Electric Heat | 800 | 3,301 | 633 | 830 | 650 | 75 | 64 | 820 | 1,515 | 394 | 178 | 226 | 159 | 902 |
| Attached, Electric Heat | 110 | 2,991 | 488 | 830 | 650 | 58 | 48 | 615 | 1,373 | 394 | 178 | 226 | 159 | 428 |
| Attached, Non-Electric Heat | 725 | 2,991 | 488 | 830 | 650 | 58 | 48 | 615 | 1,373 | 394 | 178 | 226 | 159 | 428 |
| Apartment, Electric Heat | 55 | 2,239 | 378 | 560 | 370 | 49 | 41 | 490 | 693 | 394 | 178 | 226 | 159 | 135 |
| Apartment, Non-Electric Heat | 275 | 2,239 | 378 | 560 | 370 | 49 | 41 | 490 | 693 | 394 | 178 | 226 | 159 | 135 |
| Isolated | 118 | 3,301 | 806 | 813 | 827 | 73 | 63 | 803 | 1,483 | 385 | 174 | 221 | 156 | 883 |
| Other | 97 | 2,639 | 506 | 664 | 520 | 60 | 51 | 656 | 1,211 | 315 | 142 | 180 | 127 | 721 |

**Exhibit 2.5: Annual Appliance Electricity Use (UEC) for the Labrador Interconnected Service Region, (kWh/yr.)**

| Dwelling Type | Ventilation | DHW | Cooking | Refrigerator | Freezer | Dishwasher | Clothes washer | Clothes dryer | Lighting | Computer etc. | Television | TV peripherals | Other electronics | Small apps & Other |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Single Family Detached, Electric Heat | 121 | 3,961 | 633 | 830 | 650 | 75 | 64 | 820 | 1,818 | 394 | 178 | 226 | 159 | 902 |
| Single Family Detached, Non-Electric Heat | 800 | 3,961 | 633 | 830 | 650 | 75 | 64 | 820 | 1,818 | 394 | 178 | 226 | 159 | 902 |
| Attached, Electric Heat | 112 | 3,680 | 488 | 830 | 650 | 58 | 48 | 615 | 1,689 | 394 | 178 | 226 | 159 | 428 |
| Attached, Non-Electric Heat | 743 | 3,680 | 488 | 830 | 650 | 58 | 48 | 615 | 1,689 | 394 | 178 | 226 | 159 | 428 |
| Apartment, Electric Heat | 36 | 2,687 | 378 | 560 | 370 | 49 | 41 | 490 | 832 | 394 | 178 | 226 | 159 | 135 |
| Apartment, Non-Electric Heat | 179 | 2,687 | 378 | 560 | 370 | 49 | 41 | 490 | 832 | 394 | 178 | 226 | 159 | 135 |
| Other | 22 | 730 | 117 | 153 | 120 | 14 | 12 | 151 | 335 | 72 | 33 | 42 | 29 | 166 |

### ❑ Occupancy

Occupancy rates[12] for each dwelling type were based on residential utility data from other jurisdictions. They are used, as applicable, to estimate electricity use for occupant-sensitive end uses, such as DHW, laundry and lighting. Exhibit 2.6 summarizes the occupancy rates, by dwelling type. The table indicates, for example, that 12% of single-family dwellings are occupied by only one person, 42% by two persons and 46% by three or more persons.

**Exhibit 2.6: Occupancy Rates by Dwelling Type**

| Occupants | SFD | Attached | Apt |
|---|---|---|---|
| 1 | 12% | 27% | 54% |
| 2 | 42% | 40% | 35% |
| 3+ | 46% | 33% | 12% |

### ❑ Ventilation

Ventilation electricity is associated with fan/blower electricity in heating systems, kitchen fans, bathroom fans and heat recovery ventilators.

A furnace fan UEC of 700 kWh (heat mode only) is assumed for single-family dwellings having central forced air heating systems. This value is towards the upper range of Canadian end-use metered data, as reported in a study conducted for Natural Resources Canada, and is consistent with the relatively longer heating season experienced in Newfoundland and Labrador.[13]

For the purpose of estimating kitchen and bathroom fan electricity, it was assumed that a typical exhaust fan is rated at 75 Watts and operates, on average, for two hours per day. In homes with heat supplied by baseboard electric or by hydronic systems, these exhaust fans are the predominant ventilation load. With two such fans in a typical house, consumption would be approximately 100-110 kWh/yr.

The UEC for a forced air system includes the energy from both the furnace fan and the exhaust fans. The UEC for a baseboard electric system includes only the energy from the latter. The ventilation UEC values shown in Exhibits 2.4 and 2.5 for electrically heated dwellings in Newfoundland and Labrador reflect the mix between forced air systems (under 2% of electrically heated homes) and baseboard systems.

### ❑ Domestic Hot Water

UEC estimates for DHW assume a per capita hot water consumption of 45 litres per person per day and a temperature rise of 45°C. Exhibit 2.7 shows the distribution of DHW load by major end use.

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[12] Electricity use related to personal consumption increases with number of occupants in dwelling.

[13] This area is the focus of extensive research efforts. *See*: Gusdorf, John, *Final Report on the Project to Measure the Effects of ECM Furnace Motors on Gas Use at the CCHT Research Facility,* Natural Resources Canada, January 2003. Current estimates of fan energy use vary widely; upper range estimates (heat mode only) exceed 1,000 kWh/yr. Continuous ventilation or use with space cooling equipment would increase fan motor consumption.

**Exhibit 2.7: Distribution of DHW Electricity Use by End Use in Existing Stock, (kWh/yr.)**

| End Use | Sample Electricity Use Single Family Detached (kWh/yr.) | % |
|---|---|---|
| Personal Use | 1,155 | 35 |
| Dishwashing | 759 | 23 |
| Clothes Washing | 891 | 27 |
| Standby Losses | 495 | 15 |
| Total | 3,301 | 100 |

*Note: Any differences in totals are due to rounding.*

The DHW values shown in Exhibit 2.7 are based on a combination of sources including available data from other jurisdictions, NRCan studies (NRCan, 2005) and the results of conditional demand analysis and customer survey work done by both NP and NLH in the 1990s.[14]

### ❑ Cooking Appliances, Refrigerator, Freezer and Dishwasher

UEC estimates for the existing stock of this group of food preparation and storage appliances were obtained from *The End Use Energy Data Handbook* (NRCan, 2005). The values shown for dishwashers are for mechanical electricity only; hot water use is included with the DHW UEC.

### ❑ Clothes Washer and Dryer

Appliance UEC data was obtained from *The End Use Energy Data Handbook* (NRCan, 2005) and adjusted by region and dwelling type based on previous data. The values shown for clothes washers are for mechanical electricity only; hot water use is included with the DHW UEC.

### ❑ Computers

UEC data for computers is based on Marbek's current work for BC Hydro.[15] UEC varies with occupancy rate by region and dwelling type.

### ❑ Lighting

The lighting loads shown in Exhibits 2.4 and 2.5 were developed from the following sources:

- Residential utility data on lighting types and usage patterns from other jurisdictions
- *The End Use Energy Data Handbook* (NRCan, 2005).

Exhibit 2.8 shows the derivation of lighting UECs.

[14] The values shown in Exhibit 2.7 do not include combustion efficiency; therefore, if the water is heated using oil or propane, the on-site energy consumption would be higher than shown in Exhibit 2.7.
[15] Marbek Resource Consultants, *Conservation Potential Review – 2007*. Prepared for BC Hydro. 2007.

**Exhibit 2.8: Derivation of Lighting UECs**

| | | |
|---|---|---|
| **Incandescent** | | |
| *Number of regularly used bulbs* | | |
| SFD/Duplex | 16 | |
| Row | 15 | |
| Apt | 8 | |
| Mobile/Other | 8 | |
| Average wattage | 60 | |
| Average Hours/year | 1,200 | |
| **Fluorescent** | | |
| (includes linear tubes and CFLs) | | |
| *Number of regularly used linear lamps/CFLs* | *Linear* | *CFL* |
| SFD/Duplex | 2 | 2 |
| Row | 2 | 3 |
| Apt | 1 | 3 |
| Mobile/Other | 1 | 2 |
| Average wattage (including ballast) | 48 | 15 |
| Average Hours/year | 1,200 | 1,200 |
| **Holiday/Other Lighting** | | |
| (includes garden and other outdoor lighting) | | |
| Average wattage | | |
| SFD/Duplex | 350 | |
| Row | 250 | |
| Apt | 0 | |
| Mobile/Other | 225 | |
| Average Hours/year | 300 | |
| **Total Base Year Energy Use** | | |
| SFD/Duplex | 1,388 | |
| Row | 1,373 | |
| Apt | 693 | |

## ❑ Television

UEC data for televisions was obtained from *Technology and Market Profile: Consumer Electronics* (Marbek, 2006). Saturation of televisions (number of sets per household) is adjusted by dwelling type based on data from the “Frequency Per Dwelling Type 2005” Survey (see Section 2.6) but consumption per television is not varied by dwelling type in this study.

## ❑ Television Peripherals

UECs, saturations and numbers per household for television peripherals were obtained from *Technology and Market Profile: Consumer Electronics* (Marbek, 2006) and other published data. A weighted UEC for the end use as a whole was generated from these numbers as shown in Exhibit 2.9. UEC varies with occupancy rate by dwelling type and region.

**Exhibit 2.9: Derivation of UEC for Television Peripherals**

| | % of TV households | UEC kWh/yr |
|---|---|---|
| **Digital Cable Service** | 17% | |
| Digital Adaptor | 17% | 82 |
| Standard Digital STB | 14% | 194 |
| Advanced Digital STB | 3% | 325 |
| | Average UEC | 299 |
| **Satellite Service** | 21% | |
| Standard Satellite STB | 17% | 141 |
| Advanced Satellite STB | 4% | 273 |
| | Average UEC | 166 |
| | **Total Weighted UEC** | **226** |

## ❑ Other Electronics

Due to the large presence of electronic entertainment devices in many residential dwellings, this end use was separated from the general "Other" category. UECs were obtained from *Technology and Market Profile: Consumer Electronics* (Marbek, 2006), *Residential Miscellaneous Electricity Use* (LBL) and other published data. A weighted UEC for the end use as a whole was then generated from these numbers as shown in Exhibit 2.10.

**Exhibit 2.10: Derivation of UECs for Other Electronics**

| | Penetration | Number Per Household | UEC (kWh/yr) | Weighted UEC (kWh/yr) |
|---|---|---|---|---|
| DVD | 72% | 1.2 | 35 | 30 |
| VCR | 69% | 1.3 | 55 | 49 |
| Audio System | 29% | 1.3 | 55 | 21 |
| Surround Sound | 25% | 1 | 50 | 13 |
| Compact Audio | 79% | 1.5 | 25 | 30 |
| Game Console | 25% | 1.3 | 55 | 18 |
| | | | **Total Weighted UEC** | **160** |

## ❑ Small Appliances and Other

"Other" end uses include a wide range of appliances and equipment found in most homes. Reliable data on the actual annual electricity use of this collection of appliances and equipment within Newfoundland and Labrador is not available.

Exhibit 2.11 illustrates the major items included in this end use and presents sample UEC data estimated in earlier studies undertaken in other jurisdictions.[16] It should be noted that actual UECs for individual appliances will vary from those shown in Exhibit 2.11 and are affected by factors such as saturations by dwelling type, occupancy rates and service region. Saturation

[16] Lawrence Berkeley National Laboratory (LBL), *Residential Miscellaneous Electricity Use*, 1997.

information from LBL was not applied for this study because reliable information for Newfoundland and Labrador was not available. The "Other" category is not built up based on detailed analysis, but is an approximation only. The LBL data provided should be treated as being illustrative of the types of energy-using items in the category and how much electricity they typically use.

**Exhibit 2.11: Typical UECs for Selected "Other" Appliances**

| Appliance | UEC (kWh/yr) | Appliance | UEC (kWh/yr) |
|---|---|---|---|
| Home radio, small/clock | 18 | Timer | 18 |
| Battery Charger | 21 | Hot Plate | 30 |
| Clock | 18 | Stand Mixers | 1 |
| Power Strip | 3 | Hand-Held Rechargeable | 16 |
| Vacuum | 31 | Hand-Held Electric Vacuum | 4 |
| Hand Mixers | 2 | Air Corn Popper | 6 |
| Iron | 53 | Security System | 195 |
| Hair Dryer | 36 | Perc Coffee | 65 |
| Toaster | 39 | Deep Fryer | 20 |
| Auto Coffee Maker | 116 | Waterbed Heaters | 900 |
| Blender | 7 | Humidifier | 100 |
| Heating Pads | 3 | Electric Toothbrush | 20 |
| Doorbell | 18 | Hot Oil Corn Popper | 2 |
| Answering Machine | 29 | Women's Shaver | 12 |
| Can Opener | 3 | Aquariums | 548 |
| Slow Cooker | 16 | Espresso Maker | 19 |
| Curling Iron | 1 | Electric Lawn Mower | 100 |
| Food Slicer | 1 | Mounted Air Cleaner | 500 |
| Garbage Disposer | 10 | Multi-fcn Device | 41 |
| Electric Knife | 1 | Heat Tape | 100 |
| Portable Fans | 8 | Auto Engine Heaters | 250 |
| Men's Shaver | 13 | Electric Kettle | 75 |
| Waffle Iron/Sandwich Grill | 25 | Bottled Water Dispenser | 300 |
| Electric Blankets | 120 | Central Vacuum | 24 |
| Garage Door Opener | 30 | Grow Lights | 800 |
| Hair Setter | 10 | Home Medical Equipment | 400 |

## 2.6 APPLIANCE SATURATION

Exhibits 2.12 and 2.13 summarize the saturation levels that are used in the present analysis for, respectively, the Island and Isolated and Labrador Interconnected service regions. In each case, the assumed saturation levels are developed from the most recent utility REUS. Saturations were obtained through querying the database, by end use and dwelling type; minor refinements were made in selected cases to assist in calibration.

## Exhibit 2.12: Appliance Saturation Levels for Island and Isolated in 2006, (%)

| Dwelling Type | Ventilation | DHW | Cooking | Refrigerator | Freezer | Dishwasher | Clothes washer | Clothes dryer | Lighting | Computer etc. | Television | TV peripherals | Other electronics | Small apps & Other |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Single Family Detached, Electric Heat | 100% | 100% | 100% | 119% | 108% | 48% | 99% | 96% | 100% | 77% | 242% | 158% | 147% | 100% |
| Single Family Detached, Non-Electric Heat | 100% | 100% | 100% | 119% | 108% | 48% | 99% | 96% | 100% | 77% | 242% | 158% | 147% | 100% |
| Attached, Electric Heat | 100% | 100% | 110% | 121% | 74% | 40% | 96% | 92% | 100% | 83% | 234% | 153% | 143% | 100% |
| Attached, Non-Electric Heat | 100% | 100% | 110% | 121% | 74% | 40% | 96% | 92% | 100% | 83% | 234% | 153% | 143% | 100% |
| Apartment, Electric Heat | 100% | 100% | 100% | 101% | 50% | 15% | 55% | 54% | 100% | 58% | 166% | 109% | 101% | 100% |
| Apartment, Non-Electric Heat | 100% | 100% | 100% | 101% | 50% | 15% | 55% | 54% | 100% | 58% | 166% | 109% | 101% | 100% |
| Isolated | 100% | 100% | 99% | 67% | 116% | 23% | 86% | 87% | 100% | 34% | 157% | 103% | 96% | 100% |
| Other | 50% | 20% | 0% | 5% | 5% | 0% | 5% | 5% | 100% | 0% | 5% | 3% | 3% | 100% |

## Exhibit 2.13: Appliance Saturation Levels for Labrador Interconnected in 2006, (%)

| Dwelling Type | Ventilation | DHW | Cooking | Refrigerator | Freezer | Dishwasher | Clothes washer | Clothes dryer | Lighting | Computer etc. | Television | TV peripherals | Other electronics | Small apps & Other |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Single Family Detached, Electric Heat | 100% | 100% | 100% | 99% | 105% | 62% | 93% | 94% | 100% | 60% | 177% | 116% | 108% | 100% |
| Single Family Detached, Non-Electric Heat | 100% | 100% | 100% | 99% | 105% | 62% | 93% | 94% | 100% | 60% | 177% | 116% | 108% | 100% |
| Attached, Electric Heat | 100% | 100% | 100% | 89% | 98% | 66% | 98% | 98% | 100% | 64% | 170% | 112% | 104% | 100% |
| Attached, Non-Electric Heat | 100% | 100% | 100% | 89% | 98% | 66% | 98% | 98% | 100% | 64% | 170% | 112% | 104% | 100% |
| Apartment, Electric Heat | 100% | 100% | 100% | 75% | 58% | 17% | 58% | 58% | 100% | 17% | 142% | 93% | 86% | 100% |
| Apartment, Non-Electric Heat | 100% | 100% | 100% | 75% | 58% | 17% | 58% | 58% | 100% | 17% | 142% | 93% | 86% | 100% |
| Other | 50% | 20% | 0% | 5% | 5% | 0% | 5% | 5% | 100% | 0% | 5% | 3% | 3% | 100% |

## 2.7 ESTIMATION OF FUEL SHARE, BY END USE

Data on fuel shares, for all end uses except space heating, is taken from the most recent utility REUS. In the case of space heating, the starting point was the distribution of space heating appliances, by fuel type, as reported in the REUS and in the EnerGuide for Houses database:

- Electricity in non-electrically heated dwellings, and
- Non-electric sources in electrically heated dwellings.

Exhibits 2.14 and 2.15 summarize the electricity fuel shares assumed for each of the end uses included in the present analysis for, respectively, the Island and Isolated and Labrador Interconnected service regions. The space heating fuel shares presented in these exhibits[17] have been selected on the basis that they provide a reasonable fit with:

- General market description (i.e., known distribution of heating appliances by fuel)
- Electricity sales to different categories of homes.

The market share of electricity for space heating is a combination of the fuel shares shown in the exhibits below and the relative numbers of dwellings in the electric category and the non-electric category. For example, Exhibit 2.15 shows 94% of the space heating energy in electrically-heated homes is supplied by electricity (the rest is assumed to be provided by auxiliary heating sources such as wood stoves. As shown earlier in Exhibit 2.1, 98% of single-family dwellings in the Labrador Interconnected service region are in the electrically heated category. Therefore, the assumption used for market share of electric heat in single-family dwellings in the Labrador Interconnected service region is 98% x 94% = 92%. The market share of electricity for both space heating and water heating is very high in the Labrador Interconnected service region, largely due to the very low retail price of electricity.

[17] Adjustment of fuel shares for space heating was done in tandem with the adjustment of space heating loads described in Section 2.4 above.

**Exhibit 2.14: Electricity Fuel Shares for the Island and Isolated in 2006, (%)**

| Dwelling Type | Space Heating | Ventilation | DHW | Cooking | Refrigerator | Freezer | Dishwasher | Clothes washer | Clothes dryer | Lighting | Computer etc. | Television | TV peripherals | Other electronics | Small apps & Other |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Single Family Detached, Electric Heat | 95% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% |
| Single Family Detached, Non-Electric Heat | 4% | 100% | 63% | 98% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% |
| Attached, Electric Heat | 95% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% |
| Attached, Non-Electric Heat | 4% | 100% | 25% | 98% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% |
| Apartment, Electric Heat | 95% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% |
| Apartment, Non-Electric Heat | 4% | 100% | 56% | 98% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% |
| Isolated | 5% | 100% | 83% | 98% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% |
| Other | 52% | 100% | 50% | 98% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% |

**Exhibit 2.15: Electricity Fuel Shares for Labrador Interconnected in 2006, (%)**

| Dwelling Type | Space Heating | Ventilation | DHW | Cooking | Refrigerator | Freezer | Dishwasher | Clothes washer | Clothes dryer | Lighting | Computer etc. | Television | TV peripherals | Other electronics | Small apps & Other |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Single Family Detached, Electric Heat | 94% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% |
| Single Family Detached, Non-Electric Heat | 0% | 100% | 99% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% |
| Attached, Electric Heat | 94% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% |
| Attached, Non-Electric Heat | 0% | 100% | 99% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% |
| Apartment, Electric Heat | 94% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% |
| Apartment, Non-Electric Heat | 0% | 100% | 99% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% |
| Other | 100% | 100% | 99% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% |

## 2.8 AVERAGE ELECTRICITY USE PER UNIT

Exhibits 2.16 and 2.17 combine the building stock, efficiency, saturation and fuel share data presented in the preceding exhibits and show the resulting electricity use, by end use, for each dwelling type in, respectively, the Island and Isolated and Labrador Interconnected service regions.

## Exhibit 2.16: Average Electricity Use per Dwelling Unit for the Island and Isolated Service Region in 2006, (kWh/yr.)

| Dwelling Type | Space Heating | Ventilation | DHW | Cooking | Refrigerator | Freezer | Dishwasher | Clothes washer | Clothes dryer | Lighting | Computer etc. | Television | TV peripherals | Other electronics | Small apps & Other | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Single Family Detached, Electric Heat | 11,956 | 121 | 3,301 | 634 | 985 | 703 | 36 | 64 | 787 | 1,515 | 305 | 430 | 358 | 235 | 902 | **22,330** |
| Single Family Detached, Non-Electric Heat | 621 | 800 | 2,085 | 622 | 985 | 703 | 36 | 64 | 787 | 1,515 | 305 | 430 | 358 | 235 | 902 | **10,446** |
| Attached, Electric Heat | 10,835 | 110 | 2,991 | 539 | 1,006 | 482 | 23 | 46 | 564 | 1,373 | 328 | 417 | 346 | 227 | 428 | **19,716** |
| Attached, Non-Electric Heat | 563 | 725 | 743 | 529 | 1,006 | 482 | 23 | 46 | 564 | 1,373 | 328 | 417 | 346 | 227 | 428 | **7,800** |
| Apartment, Electric Heat | 5,469 | 55 | 2,239 | 378 | 567 | 185 | 7 | 23 | 263 | 693 | 226 | 296 | 246 | 161 | 135 | **10,944** |
| Apartment, Non-Electric Heat | 214 | 275 | 1,258 | 370 | 567 | 185 | 7 | 23 | 263 | 693 | 226 | 296 | 246 | 161 | 135 | **4,920** |
| Isolated | 615 | 118 | 2,740 | 778 | 541 | 958 | 17 | 54 | 697 | 1,483 | 132 | 274 | 227 | 149 | 883 | **9,666** |
| Other | 4,215 | 48 | 264 | 0 | 33 | 26 | 0 | 3 | 33 | 1,211 | 0 | 7 | 6 | 4 | 2,884 | **8,734** |

## Exhibit 2.17: Average Electricity Use per Dwelling Unit for Labrador Interconnected Service Region in 2006, (kWh/yr.)

| Dwelling Type | Space Heating | Ventilation | DHW | Cooking | Refrigerator | Freezer | Dishwasher | Clothes washer | Clothes dryer | Lighting | Computer etc. | Television | TV peripherals | Other electronics | Small apps & Other | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Single Family Detached, Electric Heat | 27,616 | 121 | 3,961 | 633 | 824 | 680 | 46 | 60 | 770 | 1,818 | 236 | 314 | 261 | 171 | 902 | **38,412** |
| Single Family Detached, Non-Electric Heat | 1,954 | 800 | 3,921 | 633 | 824 | 680 | 46 | 60 | 770 | 1,818 | 236 | 314 | 261 | 171 | 902 | **13,389** |
| Attached, Electric Heat | 25,656 | 112 | 3,680 | 488 | 736 | 635 | 38 | 47 | 601 | 1,689 | 250 | 303 | 252 | 165 | 428 | **35,082** |
| Attached, Non-Electric Heat | 1,815 | 743 | 3,643 | 488 | 736 | 635 | 38 | 47 | 601 | 1,689 | 250 | 303 | 252 | 165 | 428 | **11,835** |
| Apartment, Electric Heat | 8,220 | 36 | 2,687 | 378 | 420 | 216 | 8 | 24 | 286 | 832 | 66 | 252 | 209 | 137 | 135 | **13,907** |
| Apartment, Non-Electric Heat | 437 | 179 | 2,660 | 378 | 420 | 216 | 8 | 24 | 286 | 832 | 66 | 252 | 209 | 137 | 135 | **6,240** |
| Other | 5,411 | 11 | 144 | 0 | 8 | 6 | 0 | 1 | 8 | 335 | 0 | 2 | 1 | 1 | 747 | **6,675** |

## 2.9 SUMMARY OF MODEL RESULTS

This section presents the results of the model runs for the Base Year 2006. The results are measured at the customer's point-of-use and do not include line losses; they are presented in four separate exhibits:

- Exhibits 2.18 and 2.19 present the model results for the Island and Isolated service region. The results are broken out by dwelling type and end use.
- Exhibits 2.20 and 2.21 present the model results for the Labrador Interconnected service region. The results are broken out by dwelling type and end use.

### ❑ By Dwelling Type

Single detached dwellings account for the overwhelming majority of residential electricity use in both service regions: approximately 81% of residential electricity consumed in the Island and Isolated service region and 73% in the Labrador Interconnected service region.

In the Island and Isolated service region, the remaining electricity use is in attached dwellings (11%) followed by apartments (6%). Isolated and other residential buildings each account for about 1%.

In the Labrador Interconnected service region, the remaining electricity use is in attached dwellings (22%) followed by apartments (2%). Other residential buildings account for the remaining electricity use (2%).

### ❑ By End Use

Space heating accounts for the largest share of residential electricity use in both service regions: approximately 41% of residential electricity consumed in the Island and Isolated service region and 71% in the Labrador Interconnected service region. The larger space heating share in the Labrador Interconnected service region is due to the colder climate and the very high share of heating load met by electricity. The large electric space heating share reflects the low electricity prices in that region.

DHW is the second largest electricity end use in both service regions: approximately 17% of residential electricity consumed in the Island and Isolated service region and 11% in the Labrador Interconnected service region.

In the Island and Isolated service region, other significant end uses include lighting (9%) and refrigerators (6%). The electronic end uses (computers, televisions and peripherals, other electronics) combined account for approximately 8% of residential electricity use.

In the Labrador Interconnected service region, other significant end uses include lighting (5%), refrigerators (2%), freezers (2%) and cooking (2%). The electronic end uses (computers, televisions and peripherals, other electronics) combined account for approximately 3% of residential electricity use.

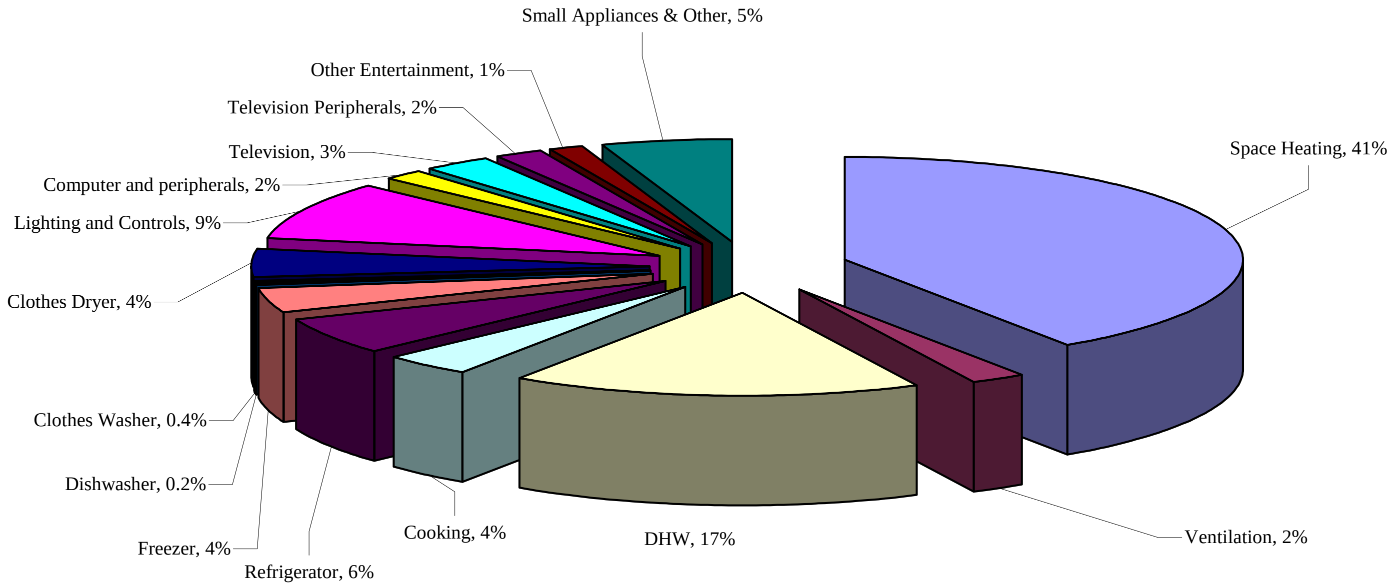
**Exhibit 2.18: Electricity Consumption for the Island and Isolated Service Region, Modelled by End Use and Segment in the Base Year (2006), (GWh/yr.)[18]**

| Dwelling Type | Milestone Year | Residential | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Total | Space Heating | Ventilation | DHW | Cooking | Refrigerator | Freezer | Dishwasher | Clothes Washer | Clothes Dryer | Lighting and Controls | Computer and peripherals | Television | Television Peripherals | Other Entertainment | Small Appliances & Other |
| Single-Family | 2006 | 2,569 | 1,006 | 69 | 420 | 97 | 152 | 109 | 6 | 10 | 122 | 234 | 47 | 67 | 55 | 36 | 139 |
| Attached | 2006 | 340 | 168 | 5 | 49 | 11 | 20 | 10 | 0.5 | 1 | 11 | 28 | 7 | 8 | 7 | 5 | 9 |
| Apartment | 2006 | 193 | 90 | 2 | 40 | 7 | 11 | 4 | 0.1 | 0 | 5 | 13 | 4 | 6 | 5 | 3 | 3 |
| Isolated | 2006 | 34 | 2 | 0.4 | 10 | 3 | 2 | 3 | 0.1 | 0 | 2 | 5 | 0.5 | 1 | 1 | 1 | 3 |
| Other | 2006 | 31 | 15 | 0.2 | 1 | 0.0 | 0.1 | 0.1 | 0.00 | 0.01 | 0.1 | 4 | 0 | 0.02 | 0.02 | 0.01 | 10 |
| TOTAL | 2006 | 3,166 | 1,281 | 77 | 520 | 118 | 186 | 125 | 6 | 11 | 141 | 285 | 59 | 82 | 68 | 44 | 164 |

*Note: Any differences in totals are due to rounding.*

[18] Electricity consumption in this exhibit does not include the "vacant and partially occupied" category of dwellings. Consumption data for the vacant and partial group must be added to these figures to obtain a total that matches the Utilities' forecast data.

**Exhibit 2.19: Distribution of Electricity Consumption, by End Use in the Base Year (2006) for the Island and Isolated Service Region**



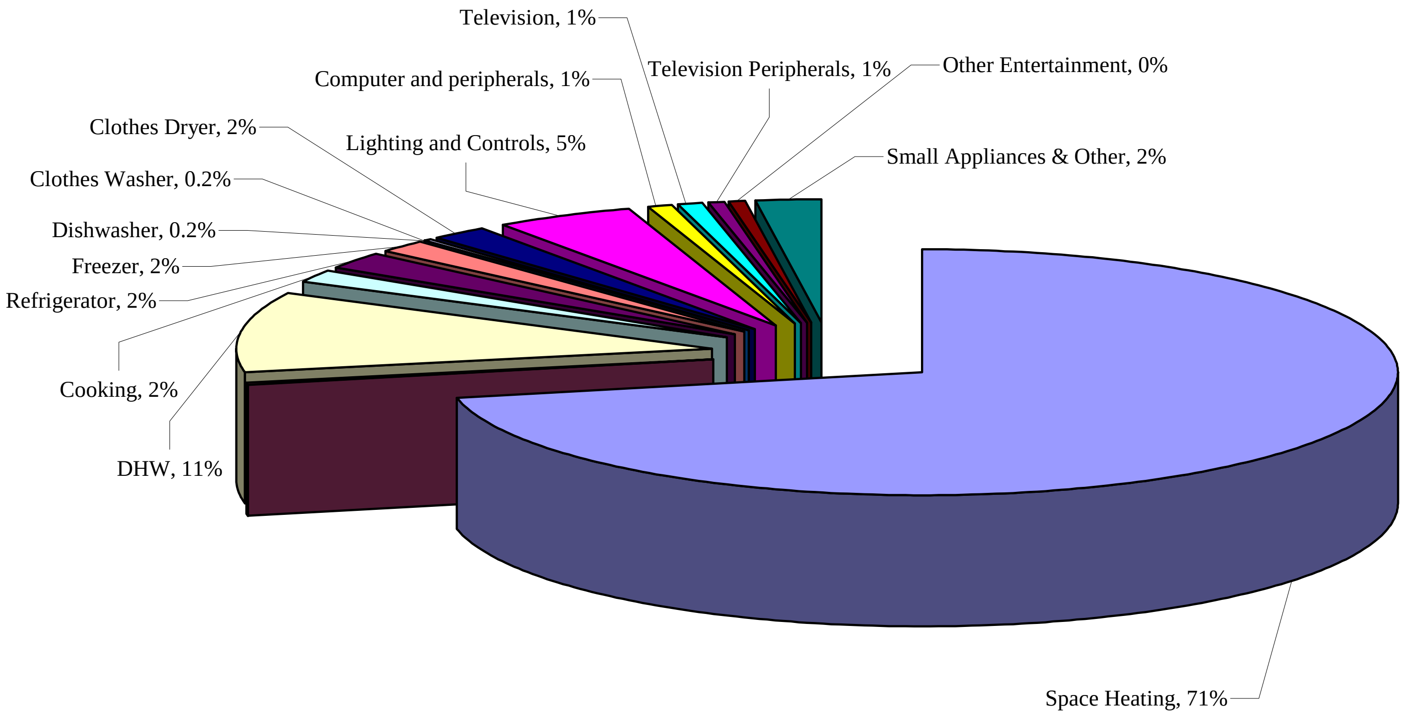

*Totals may not add to 100% due to rounding.*

**Exhibit 2.20: Electricity Consumption for the Labrador Interconnected Service Region, Modelled by End Use and Segment in the Base Year (2006), (GWh/yr.)**

| Dwelling Type | Milestone Year | Residential | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Total | Space Heating | Ventilation | DHW | Cooking | Refrigerator | Freezer | Dishwasher | Clothes Washer | Clothes Dryer | Lighting and Controls | Computer and peripherals | Television | Television Peripherals | Other Entertainment | Small Appliances & Other |
| Single-Family | 2006 | 195 | 139 | 1 | 20 | 3 | 4 | 3 | 0.2 | 0.3 | 4 | 9 | 1 | 2 | 1 | 1 | 5 |
| Attached | 2006 | 59 | 43 | 0.2 | 6 | 1 | 1 | 1 | 0.1 | 0.1 | 1 | 3 | 0.4 | 1 | 0.4 | 0.3 | 1 |
| Apartment | 2006 | 6 | 4 | 0.02 | 1 | 0.2 | 0.2 | 0.1 | 0.004 | 0.01 | 0.1 | 0.4 | 0.03 | 0.1 | 0.1 | 0.1 | 0.1 |
| Other | 2006 | 4.0 | 3.3 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.5 |
| TOTAL | 2006 | 264 | 189 | 1 | 28 | 4 | 6 | 5 | 0.3 | 0.4 | 5 | 13 | 2 | 2 | 2 | 1 | 6 |

*Note: Any differences in totals are due to rounding.*

**Exhibit 2.21: Distribution of Electricity Consumption, by End Use in the Base Year (2006) for the Labrador Interconnected Service Region**




*Totals may not add to 100% due to rounding.*

# 3. REFERENCE CASE ELECTRICITY USE

## 3.1 INTRODUCTION

This section presents the Residential sector Reference Case for the study period (2006 to 2026). The Reference Case estimates the expected level of electricity consumption that would occur over the study period in the absence of new utility-based CDM initiatives. The forecast data provided were based on a set of assumptions that include future rate changes. The Reference Case includes the same assumption and it becomes part of the environment in which conservation potential will be evaluated. The Reference Case, therefore, provides the point of comparison for the calculation of electricity-savings opportunities associated with each of the scenarios that are assessed within this study.

The Reference Case discussion is presented within the following sub sections:

- Estimation of Net Space Heating Loads—New Dwellings
- "Natural" Changes to Space Heating Loads—Existing Dwellings
- "Natural" Changes to Electric Appliance UECs
- Appliance Saturation Trends
- Stock Growth
- Fuel Shares
- Summary of Model Results.

## 3.2 ESTIMATION OF NET SPACE HEATING LOADS—NEW DWELLINGS

The first task in building the Reference Case involved the development of estimates of the net space heating loads for new dwellings to be built over the study period. As was the case with the existing building stock, the study relied on several sources to prepare these estimates, including:

- Estimated household electricity consumption levels contained in the NLH Long Term Planning Review Forecast, Summer/Fall 2006
- Consultation with housing experts in Newfoundland and Labrador
- Review of experience in other jurisdictions.

Based on consideration of the best available data from the above sources, this study assumes that the net space heating loads in new dwellings remain the same as for the existing dwellings. This conclusion recognizes that while thermal efficiencies are improving in new dwellings, they are being partially, or wholly, offset by changing construction practices.

Examples of these off-setting trends include:

- Overall, window, wall and roofing thermal efficiency levels have increased in new residential buildings and air leakage rates have been reduced by more than 40% compared to typical existing dwellings.

- The amount of window area in new houses has increased by up to 20% compared to typical existing homes.

- The new stock tends to have floor areas that are 15%-20% larger, on average.
- Buildings also feature an increase in exterior wall surface area of between 5%-20%. This reflects both the increased floor area and a tendency for homes to include architectural features with more corners and details that diverge from the standard rectangular shapes.

Exhibit 3.1 summarizes the resulting new net space heating loads.

**Exhibit 3.1: New Residential Units—Net Space Heating Loads[19] by Dwelling Type and Service Region, (kWh/yr.)[20]**

| Dwelling Type | Island and Isolated | Labrador Interconnected |
|---|---|---|
| Single Family Detached, Electric Heat | 12,554 | 29,966 |
| Single Family Detached, Non-Electric Heat | 16,700 | 39,863 |
| Attached, Electric Heat | 11,377 | 27,840 |
| Attached, Non-Electric Heat | 15,134 | 37,035 |
| Apartment, Electric Heat | 5,742 | 8,920 |
| Apartment, Non-Electric Heat | 5,742 | 8,920 |
| Isolated | 12,293 | N/A |
| Other | 10,036 | 5,630 |

### 3.2.1 Development of Thermal Archetypes – New Stock

Although the study assumes that the net space heating loads remain approximately the same for both new and existing dwellings, the physical and thermal specifications of the new dwellings differ from the existing dwellings. Thus, as in the Base Year discussion, a thermal archetype for each of the major new dwelling types was developed using HOT2000.

For the new housing stock, archetypes were created for the two primary dwelling types in each service region: single-family detached and attached. A brief description of each housing archetype is provided below.

**❑ Single-family Dwellings**

For the Island and Isolated service region, a “typical” existing, single-detached dwelling can be defined as a single-story bungalow of approximately 110 $m^2$ (1184 $ft^2$) with an unheated basement. This home has 9.6 $m^2$ (103 ft2) of windows, defined as double-glazed, mostly with vinyl frames. Walls are represented by RSI-3.0 (R-17) insulation values, ceilings RSI-5.5 (R-31) and no basement insulation. The houses are reasonably

[19] Net space heating load is the space heating load of a building that must be met by the space heating system over a full year. This is equal to the total heat loss through the building envelope minus solar and internal gains. Values shown for non-electrically heated dwellings are shown in kilowatt hours for format consistency.
[20] Vacant and partially-occupied dwelling units are not shown in this exhibit.

airtight with about 2.87 air changes per hour (ac/h) at 50 Pascal (Pa) depressurization. Typically, there is no central ventilation system.

For the Labrador Interconnected service region, a "typical" existing, single-detached dwelling can be defined as a single-story bungalow of approximately 110 $m^2$ (1184 $ft^2$) with a heated basement. This home has 9.6 $m^2$ (103 $ft^2$) of windows, defined as double-glazed, mostly with wood or vinyl frames. Walls are represented by RSI-3.0 (R-17) insulation values, ceilings RSI-5.5 (R-31) and there is no insulation in the basement. The houses are typically not very airtight with about 4.55 air changes per hour (ac/h) at 50 Pascal (Pa) depressurization. Typically, there is no central ventilation system.

- ❑ **Attached Dwellings**

For the Island and Isolated service region, a "typical" existing attached dwelling can be defined as a two-story home of approximately 130 $m^2$ (1400 $ft^2$) with an unheated basement. This home has 9.6 $m^2$ (103 $ft^2$) of windows, defined as double-glazed, mostly with vinyl frames. Walls are represented by RSI-3.0 (R-17) insulation values, ceilings RSI-5.5 (R-31) and there is no basement insulation. The houses are average in terms of air tightness with about 3.57 air changes per hour (ac/h) at 50 Pascal (Pa) depressurization. Typically, there is no central ventilation system.

For the Labrador Interconnected service region, a "typical" existing single-detached dwelling can be defined as a single-story bungalow of approximately 130 $m^2$ (1400 $ft^2$) with a heated basement. This home has 9.6 $m^2$ (103 $ft^2$) of windows, defined as double-glazed, mostly with wood or vinyl frames. Walls are represented by RSI-2.5 (R-14) insulation values, ceilings RSI-5.0 (R-28) and there is no insulation in the basement. The houses are typically not very airtight with about 4.55 air changes per hour (ac/h) at 50 Pascal (Pa) depressurization. Typically, there is no central ventilation system.

## 3.3 "NATURAL" CHANGES TO SPACE HEATING LOADS – EXISTING DWELLINGS

In addition to new dwellings, space heating loads in existing dwellings are also expected to change over the study period. However, no specific data are available and, as outlined in the preceding discussion of new dwellings, contrary trends[21] are occurring. Consequently, this analysis assumes that net space heating loads in existing buildings remain unchanged in the reference case.

Examples of trends that tend to decrease the net space heating loads include:

- Insulation and other improvements that occur when renovation projects are undertaken
- Replacement of old windows with new models that provide comfort and aesthetic benefits as well as improved energy efficiency
- Installation of more efficient thermostatic controls.

[21] Replacement of the heating equipment itself is not one of these factors, first, because it does not actually change the net heating load and second, because electric space heating in Newfoundland and Labrador is mainly done with baseboard strip, already at 100% efficiency.

Examples of trends that tend to increase net space heating loads include:

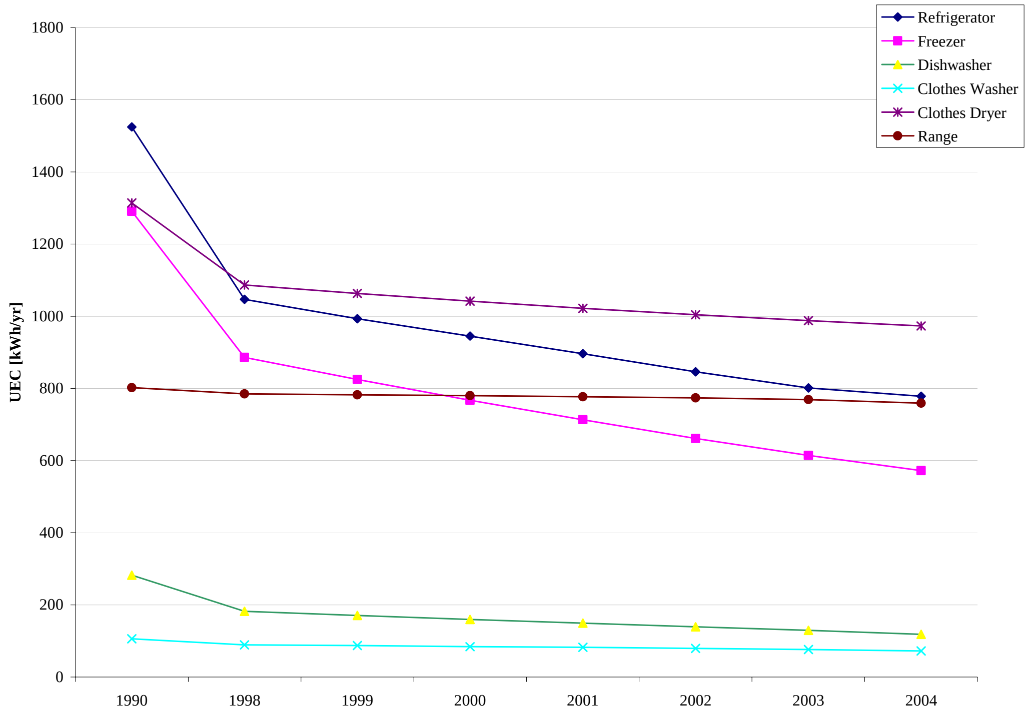
- Enlargement of houses with additions
- Reductions in internal gains due to more efficient appliances and lights.

## 3.4 "NATURAL" CHANGES TO ELECTRIC APPLIANCE UECS

This section identifies the annual unit electricity consumption (UEC) for the major household appliances and equipment for both "stock in place" and new sales for the period 2006 to 2026.

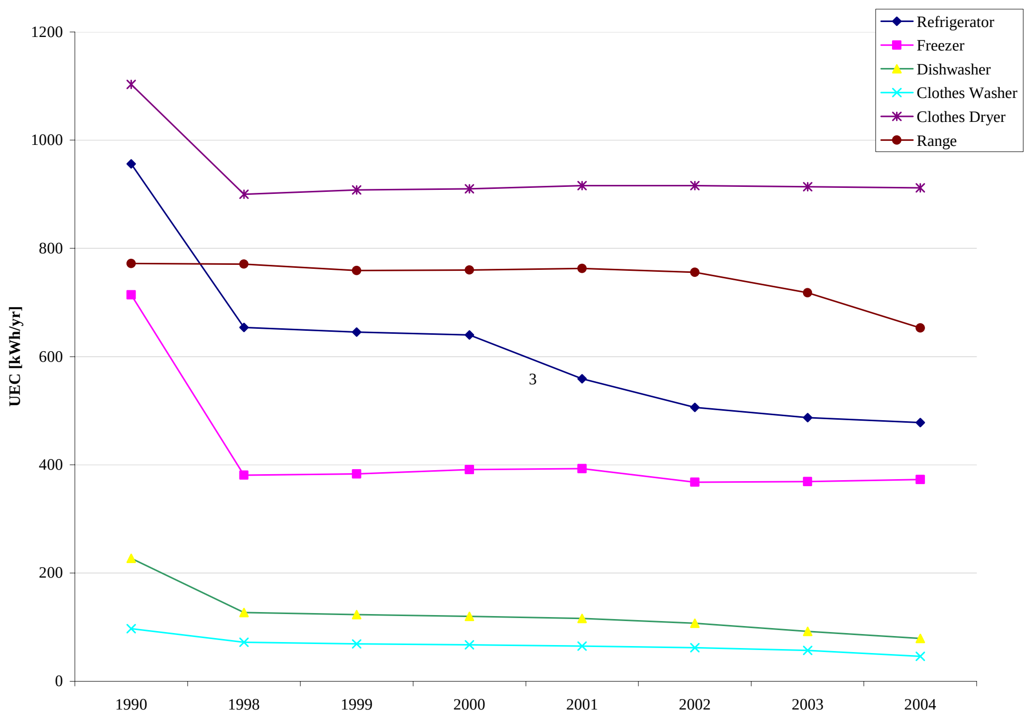
Exhibits 3.2 and 3.3 show Canadian trend information for both the existing stock and new sales of white goods for the period 1990 to 2004.

**Exhibit 3.2: Canadian White Goods UECs for Existing Stock**




*Source: NRCan, Energy Efficiency Trends in Canada 1990 and 1998–2004, August 2006.*

**Exhibit 3.3: Canadian White Goods UECs for New Sales**




*Source: NRCan, Energy Efficiency Trends in Canada 1990 and 1998–2004, August 2006.*

As shown in Exhibit 3.2, the annual UEC for major household white good type appliances in existing stock declined steadily between 1990 and 2000, due to stock turnover and to continuing improvements in new stock. However, as shown in Exhibit 3.3, the majority of efficiency improvements to large electrical appliances took place in the early to mid 1990s with the trend line levelling off after that for most appliances (except refrigerators and ranges, which show further improvement post 2000). In the future, federal energy-efficiency regulations will continue to regulate additional appliances and to revise existing regulations, suggesting that additional minor improvements in the UECs for new white goods will take place.

Further discussion of the modelled assumptions applied to each of the major appliances follows.

*Note: Assumptions for cooking appliances, refrigerators, freezers, dishwashers, clothes washers and clothes dryers are based on appliance energy use trend data compiled by Natural Resources Canada and reported in Energy Efficiency Trends in Canada 1990 and 1998–2004 (NRCan, August 2006) and Marbek's Appliance Replacement Model.*

- **Cooking**

A UEC, which includes both ranges and microwave ovens, of 770 kWh/yr. is assumed in the Base Year, adjusted for occupancy and region declining to 730 kWh/yr. in the final milestone year. In new stock, the UEC was assumed to decrease from 750 kWh/yr. to 700 kWh/yr.

- **Refrigerator**

A UEC of 830 kWh/yr. is assumed in the Base Year, adjusted for occupancy and service region declining to 510 kWh/yr. in the final milestone year. In new stock, the UEC was assumed to decrease from 680 kWh/yr. to 450 kWh/yr.

- **Freezer**

A UEC of 650 kWh/yr. is assumed in the Base Year, adjusted for occupancy and service region declining to 480 kWh/yr. in the final milestone year. In new stock, the UEC was assumed to decrease from 560 kWh/yr. to 420 kWh/yr.

- **Dishwasher**

A UEC of 92 kWh/yr. is assumed in the Base Year, adjusted for occupancy and region declining to 83 kWh/yr. in the final milestone year. In new stock, the UEC was assumed to decrease from 88 kWh/yr. to 81 kWh/yr.

The values shown are for mechanical energy only; hot water use is included with the DHW UEC.

- **Clothes Washer**

A UEC of 78 kWh/yr. is assumed in the Base Year, adjusted for occupancy and region declining to 71 kWh/yr. in the final milestone year. In new stock, the UEC was assumed to decrease from 75 kWh/yr. to 68kWh/yr.

The values shown are for mechanical energy only; hot water use is included with the DHW UEC.

- **Clothes Dryer**

A UEC of 1,000 kWh/yr. is assumed in the Base Year, adjusted for occupancy and region declining to 850 kWh/yr. in the final milestone year. In new stock, the UEC was assumed to decrease from 940 kWh/yr. to 800 kWh/yr.

- **Ventilation**

Ventilation energy in existing stock is assumed to remain constant. This assumption recognizes that there are a number of competing trends that remain unresolved at this time. On the one hand, there is a trend towards manufacturers' use of larger fan motors (1/2-HP versus 1/3-HP) in new oil and propane furnaces. This means that furnaces replaced in the study period may have a larger furnace fan motor. However, the trend towards larger fan motors is at least partially offset by efficiency improvements. For example, an earlier study for the Canadian Electricity Association (CEA) noted that improved fan design, combined with the use of permanent split capacitor fan motors, had improved furnace fan efficiency by between 13% and 19%.[22]

In new stock, average ventilation energy was assumed to increase to around 450 kWh/yr. from the current average of approximately 340 kWh/yr. This value was based on the HOT2000 modelled results and assumes compliance with municipal building codes. Building codes in Newfoundland and Labrador are based on the National Building Code (for example, the St. John's building bylaw references the 2005 edition of the National Building Code).

- **Domestic Hot Water**

Exhibit 3.4 summarizes DHW UECs by end use for new dwellings. A comparison with the values presented previously for existing dwellings (see Section 2) shows significant reductions for hot water use in dishwashing and clothes washing; however, slightly more modest changes have been assumed for personal consumption.

DHW electricity for new and existing appliances is obtained from NRCan (NRCan, 2005), augmented by results from conditional demand analysis and customer survey work done by both NP and NLH in the 1990s. For existing and retrofitted buildings, the DHW UEC is assumed to

[22] Phillips, B. Blower. *Efficiency in Domestic Heating Systems*, CEA Report No. 9202-U-921, 1995 and *Optimizing Heat and Air Distribution Systems when Retrofitting Houses with Energy Efficient Equipment*, Canada Mortgage and Housing Corporation, 2002. Ventilation UECs will be higher in dwellings that have air conditioning and/or continuous ventilation.

decrease by 0.2% per year based on data from NRCan.[23] The UEC for DHW in new buildings is assumed to be constant.

**Exhibit 3.4: Distribution of DHW Electricity Use by End Use in New Stock, (kWh/yr.)**

| End Use | Sample Electricity Use Single Family Detached (kWh/yr.) | % |
|---|---|---|
| Personal Use | 1,075 | 38 |
| Dishwashing | 600 | 21 |
| Clothes Washing | 750 | 26 |
| Standby Losses | 425 | 15 |
| Total | 2,850 | 100 |

### ❑ Lighting

The lighting UEC was assumed to decrease at a rate of 0.2% per year. This value is based on the results of analysis undertaken by Natural Resources Canada and reported in their *Energy End Use Data Handbook* (NRCan, June 2005).

### ❑ Televisions

The North American television industry has announced its commitment to convert all analog television to digital broadcasting within the next five years. These broadcast changes are occurring at a time when television technology and programming options are also rapidly changing. Some television technology changes, such as the introduction of liquid crystal display (LCD) and plasma models, may also have significant impacts on household electricity consumption. It is also possible that these changes will result in an increased rate of turnover in the current stock of televisions to models that are better able to take advantage of the high definition (HD) digital signal.

LCD is expected to become the dominant television technology by 2010, capturing approximately 57% of sales in that year. Although LCD screens typically use less electricity on a per inch basis, consumers typically choose screens that are larger when purchasing an LCD screen compared to cathode ray tube screens (CRTs). The most popular television on the market today is the 27” CRT but this is expected to shift within the next five years to the 32” LCD television. This trend has the effect of reducing the electricity advantage that would be gained from a direct switch to the new LCD technology.

In addition to the increase in screen size, HD television models typically consume more power than equivalent standard definition televisions for all technology types. Since the trend with televisions is towards HD sets with greater resolution, television unit electricity use is expected to increase in the future.

[23] Natural Resources Canada. *Energy Efficiency Trends in Canada*, 1990–2000, June 2002.

The growing popularity of larger and higher resolution screens means that, by 2010, national television electricity consumption is expected to grow by 40% to 45%.

In light of these changes, UECs for televisions are assumed to increase from 178 kWh/yr. to 250 kWh/yr. over the study period. These assumptions are based on market and energy use data collected as part of a 2006 study *Technology and Market Profile: Consumer Electronics.*[24]

- **Television Peripherals**

One implication of the pending changes towards digital television broadcasting is that new signal adaptors, commonly referred to as set-top boxes (STBs), will need to be added to nearly two-thirds of Canadian households to receive a television signal.

Industry representatives estimate that each Canadian subscriber household has, on average, 1.5 set-top boxes.[25] They also note that the trend is towards a greater number of STBs per household and, by 2010, the industry estimates that the average will have increased to approximately two STBs per subscriber household.

When complete, the switch to digital broadcasting is expected to increase national STB electricity consumption by up to four times its current level due to the added requirement for STBs among those televisions currently operating on analog cable or over-the-air broadcast signals. Moreover, within these STBs, the most significant trend is towards greater functionality, which is directly associated with further increases in unit electricity consumption.

In light of these changes, UECs for television peripherals are assumed to increase from 220 kWh/yr. to 310 kWh/yr. over the study period.[26]

- **Computers and Peripherals**

Electricity consumption for personal computers is expected to increase despite the move to more energy-efficient flat screen technology. This is due in part to the growing preference for larger screens but mainly due to a trend towards longer operating hours both in full operating mode and in idle mode. There is also a move towards increasing numbers and functionality of computer peripherals, further increasing consumption.

UECs for personal computers and their peripherals are assumed to increase from 390 kWh/yr. to 560 kWh/yr. over the study period.

- **Other Electronics**

As functionality increases, other entertainment devices, such as computer games and music systems are becoming more powerful. For example, the new PlayStation 3 games console uses 360 Watts compared to its predecessor, which uses only 45 Watts. One of the selling features of

[24] Marbek Resource Consultants. *Technology and Market Profile: Consumer Electronics*, September 2006.
[25] Ibid.
[26] Ibid.

the Nintendo Wii and other next generation products is that they can be left on-line for 24 hours a day.

UECs for other electronics are assumed to increase from 160 kWh/yr. to 190 kWh/yr. over the study period.

- **Small Appliances and Other**

The UECs for the small appliances and other categories increase over the study period in anticipation of new end uses, but there is considerable uncertainty in the amount of this increase.

Based on the changes observed in previous studies, new end uses are constantly emerging, some of which are substantial consumers of electricity. One example is electric vehicle charging. Electric cars and plug-in hybrids could achieve substantial penetration by the end of the study period; charging of a typical electric vehicle would require approximately 7,000 kWh/yr.[27]

## 3.5 APPLIANCE SATURATION TRENDS

To develop estimates of the future saturation of residential equipment, references from NLH were reviewed along with data on trends in the increasing use of entertainment-based electronics.

The saturation of most end-use appliances has remained relatively constant in recent years, suggesting that further changes to saturations are unlikely within the study period. There are two main exceptions:[28] computers and television peripherals. Based on current trends and industry data,[29] the following assumptions have been incorporated into the Reference Case.

- Computer saturation levels increase by approximately 60% over the study period
- Television peripherals saturation levels increase by more than 100%.

## 3.6 STOCK GROWTH

The next step in developing the Reference Case involved the development and application of estimated levels of growth in each dwelling type and service region over the study period. The number of dwelling units, by type and service region were provided by NLH and match exactly those contained in NLH Long Term Planning (PLF) Review Forecast, Summer/Fall 2006.

Exhibit 3.5 presents a summary of the resulting percentage stock growth, by year and dwelling type in each service region.

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[27] California EPA, Air Resources Board. *Fact Sheet: Battery Electric Vehicles*, Sacramento, CA, 2003, http://www.arb.ca.gov/msprog/zevprog/factsheets/evinformation.pdf.

[28] Some increase in space cooling saturation levels may also occur over the 20-year period and it may become material by the end of the period; however, based on client discussions it was agreed that residential space cooling consumption would experience minimal predicted growth with considerable uncertainty in that growth, and therefore it has not been addressed separately.

[29] Op. cit. *Technology and Market Profile: Consumer Electronics.*

**Exhibit 3.5: Residential Stock Growth Rates by Service Region, 2011 to 2026,**

| Region and Period | Electric Accounts | | | | | Non-Electric Accounts | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Single Family | Attached | Apart ment | Isolated | Other | Single Family | Attached | Apart ment | Isolated | Other |
| **Island and Isolated** | | | | | | | | | | |
| 2006-2011 | 1.5% | 1.5% | 1.5% | 0.6% | 0.4% | 0.1% | 0.1% | 0.1% | 0.6% | 0.4% |
| 2011-2016 | 1.2% | 1.2% | 1.2% | 0.5% | 0.3% | 0.1% | 0.1% | 0.1% | 0.5% | 0.3% |
| 2016-2021 | 1.1% | 1.1% | 1.1% | 0.5% | 0.2% | -0.1% | -0.1% | -0.1% | 0.5% | 0.2% |
| 2021-2026 | 1.1% | 1.1% | 1.1% | 0.5% | 0.1% | -0.2% | -0.2% | -0.2% | 0.5% | 0.1% |
| **Labrador Interconnected** | | | | | | | | | | |
| 2006-2011 | 0.7% | 0.7% | 0.7% | N/A | 0.7% | 0.0% | 0.0% | 0.0% | N/A | 0.0% |
| 2011-2016 | 0.5% | 0.5% | 0.5% | N/A | 0.5% | 0.0% | 0.0% | 0.0% | N/A | 0.0% |
| 2016-2021 | 0.5% | 0.5% | 0.5% | N/A | 0.5% | 0.6% | 0.6% | 0.0% | N/A | 0.0% |
| 2021-2026 | 0.5% | 0.5% | 0.5% | N/A | 0.5% | 0.6% | 0.6% | 0.0% | N/A | 0.0% |

## 3.7 FUEL SHARES

The only change in fuel shares assumed in the study period is the relative growth in electrically heated versus non-electrically heated dwellings. No changes are assumed in the fuel shares for any of the other end uses.

## 3.8 SUMMARY OF MODEL RESULTS

This section presents the results of the model runs for the entire study period. The results are measured at the customer's point-of-use and do not include line losses. They are presented in two exhibits:

- Exhibits 3.6 and 3.7 present the model results for the Island and Isolated service region. The results are broken out by dwelling type, end use and milestone year.

- Exhibits 3.8 and 3.9 present the model results for the Labrador Interconnected service region. The results are broken out by dwelling type, end use and milestone year.

Selected highlights of electricity use in 2026 are provided below.

❑ **By Dwelling Type**

Single-family detached dwellings continue to account for the overwhelming majority of total residential electricity consumption in both the Island and Isolated (79%) and the Labrador Interconnected (74%) service regions.

❑ **By End Use**

Space heating continues to account for the largest share of residential electricity use in both service regions (41% in Island and Isolated and 71% in Labrador Interconnected), followed by DHW (15% in Island and Isolated and 9% in Labrador Interconnected).

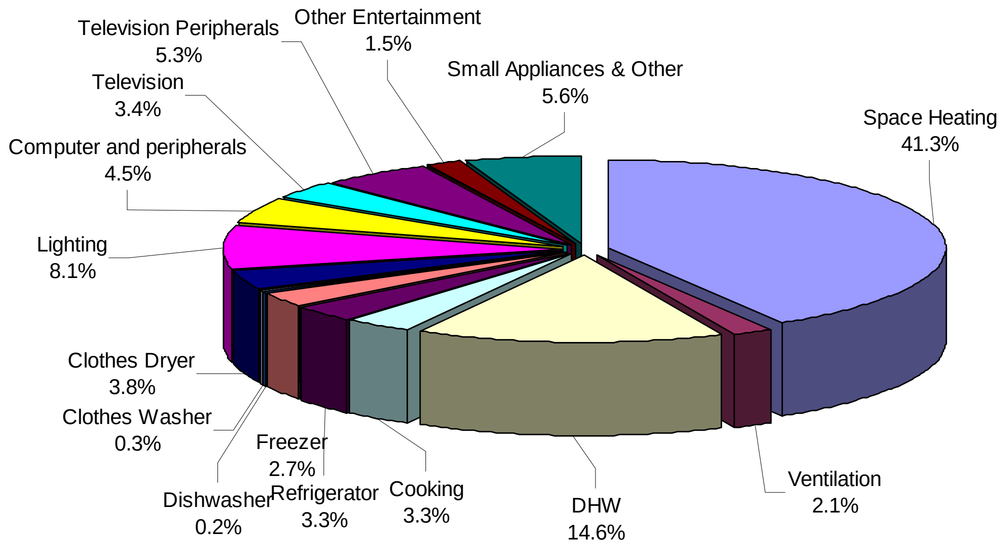
The most notable increase in electricity consumption occurs in the group of electronic end uses represented by televisions, television peripherals, computers and other entertainment. By 2026, these combined end uses are expected to account for approximately 15% of residential electricity use in the Island and Isolated service region and 6% in the Labrador Interconnected service region.

**Exhibit 3.6: Reference Case Electricity Consumption for the Island and Isolated Service Region, Modelled by End Use, Dwelling Type and Milestone Year (GWh/yr.)**

| Dwelling Type | Milestone Year | Residential | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Total | Space Heating | Ventilation | DHW | Cooking | Refrigerator | Freezer | Dishwasher | Clothes Washer | Clothes Dryer | Lighting | Computer and peripherals | Television | Television Peripherals | Other Entertainment | Small Appliances & Other |
| Single Family | 2006 | 2,569 | 1,006 | 69 | 420 | 97 | 152 | 109 | 6 | 10 | 122 | 234 | 47 | 67 | 55 | 36 | 139 |
| | 2011 | 2,757 | 1,076 | 70 | 431 | 99 | 136 | 104 | 6 | 10 | 123 | 241 | 69 | 87 | 112 | 39 | 152 |
| | 2016 | 2,873 | 1,139 | 72 | 439 | 101 | 125 | 100 | 6 | 10 | 125 | 247 | 91 | 94 | 119 | 42 | 166 |
| | 2021 | 3,016 | 1,211 | 72 | 446 | 103 | 114 | 95 | 6 | 10 | 125 | 252 | 114 | 100 | 144 | 45 | 179 |
| | 2026 | 3,125 | 1,264 | 73 | 452 | 104 | 103 | 90 | 6 | 10 | 126 | 256 | 141 | 108 | 152 | 48 | 193 |
| Attached | 2006 | 340 | 168 | 5 | 49 | 11 | 20 | 10 | 0 | 1 | 11 | 28 | 7 | 8 | 7 | 5 | 9 |
| | 2011 | 377 | 180 | 6 | 52 | 11 | 18 | 10 | 0 | 1 | 12 | 29 | 10 | 11 | 23 | 5 | 10 |
| | 2016 | 398 | 191 | 6 | 53 | 12 | 17 | 9 | 0 | 1 | 12 | 30 | 13 | 12 | 25 | 6 | 11 |
| | 2021 | 420 | 201 | 6 | 55 | 12 | 16 | 9 | 1 | 1 | 12 | 31 | 17 | 13 | 28 | 6 | 12 |
| | 2026 | 441 | 212 | 6 | 57 | 12 | 15 | 9 | 1 | 1 | 12 | 32 | 21 | 15 | 30 | 7 | 13 |
| Apartment | 2006 | 193 | 90 | 2 | 40 | 7 | 11 | 4 | 0 | 0 | 5 | 13 | 4 | 6 | 5 | 3 | 3 |
| | 2011 | 218 | 97 | 2 | 42 | 8 | 11 | 4 | 0 | 0 | 5 | 14 | 6 | 8 | 15 | 3 | 3 |
| | 2016 | 233 | 103 | 2 | 43 | 8 | 11 | 4 | 0 | 0 | 5 | 15 | 9 | 8 | 18 | 4 | 3 |
| | 2021 | 250 | 109 | 2 | 45 | 8 | 11 | 4 | 0 | 0 | 6 | 15 | 11 | 9 | 22 | 4 | 4 |
| | 2026 | 264 | 115 | 2 | 46 | 8 | 11 | 3 | 0 | 0 | 6 | 16 | 14 | 10 | 24 | 4 | 4 |
| Isolated | 2006 | 34 | 2 | 0 | 10 | 3 | 2 | 3 | 0 | 0 | 2 | 5 | 0 | 1 | 1 | 1 | 3 |
| | 2011 | 35 | 2 | 0 | 10 | 3 | 2 | 3 | 0 | 0 | 2 | 5 | 1 | 1 | 2 | 1 | 3 |
| | 2016 | 36 | 2 | 0 | 10 | 3 | 2 | 3 | 0 | 0 | 2 | 5 | 1 | 1 | 2 | 1 | 4 |
| | 2021 | 37 | 2 | 0 | 10 | 3 | 1 | 3 | 0 | 0 | 2 | 5 | 1 | 1 | 2 | 1 | 4 |
| | 2026 | 38 | 2 | 0 | 10 | 3 | 1 | 3 | 0 | 0 | 2 | 6 | 1 | 2 | 2 | 1 | 4 |
| Other | 2006 | 31 | 15 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 0 | 0 | 0 | 0 | 10 |
| | 2011 | 32 | 15 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 0 | 0 | 0 | 0 | 11 |
| | 2016 | 33 | 15 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 0 | 0 | 0 | 0 | 12 |
| | 2021 | 34 | 15 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 0 | 0 | 0 | 0 | 12 |
| | 2026 | 34 | 16 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 0 | 0 | 0 | 0 | 13 |
| TOTAL | 2006 | 3,228 | 1,298 | 77 | 530 | 120 | 189 | 128 | 6 | 12 | 144 | 291 | 60 | 83 | 69 | 45 | 175 |
| | 2011 | 3,483 | 1,388 | 79 | 545 | 124 | 170 | 123 | 6 | 12 | 146 | 300 | 87 | 109 | 154 | 49 | 191 |
| | 2016 | 3,637 | 1,467 | 80 | 556 | 126 | 157 | 118 | 7 | 12 | 147 | 307 | 115 | 118 | 167 | 53 | 207 |
| | 2021 | 3,821 | 1,557 | 81 | 566 | 128 | 144 | 112 | 7 | 12 | 149 | 314 | 146 | 126 | 200 | 57 | 224 |
| | 2026 | 3,968 | 1,626 | 82 | 575 | 130 | 132 | 107 | 7 | 12 | 149 | 320 | 180 | 136 | 211 | 61 | 241 |

*Notes: 1) Results are measured at the customer's point-of-use and do not include line losses. 2) Any differences in totals are due to rounding. 3) Rounding reduces many non-zero values in this table to apparent zeroes.*

**Exhibit 3.7: Distribution of Electricity Consumption, by End Use in 2026 for the Island and Isolated Service Region**



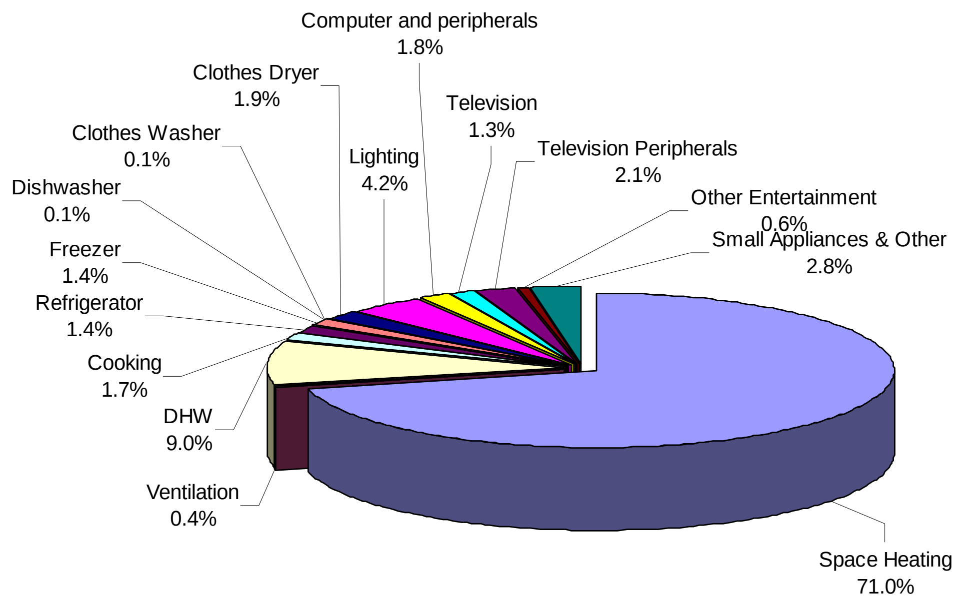

*Totals may not add to 100% due to rounding.*

## Exhibit 3.8: Reference Case Electricity Consumption for the Labrador Interconnected Service Region, Modelled by End Use, Dwelling Type and Milestone Year (GWh/yr.)

| Dwelling Type | Milestone Year | Residential | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Total | Space Heating | Ventilation | DHW | Cooking | Refrigerator | Freezer | Dishwasher | Clothes Washer | Clothes Dryer | Lighting | Computer and peripherals | Television | Television Peripherals | Other Entertainment | Small Appliances & Other |
| Single Family | 2006 | 195 | 139 | 1 | 20 | 3 | 4 | 3 | 0 | 0 | 4 | 9 | 1 | 2 | 1 | 1 | 5 |
| | 2011 | 205 | 147 | 1 | 21 | 3 | 4 | 3 | 0 | 0 | 4 | 10 | 2 | 2 | 3 | 1 | 5 |
| | 2016 | 210 | 150 | 1 | 21 | 3 | 3 | 3 | 0 | 0 | 4 | 10 | 2 | 2 | 3 | 1 | 5 |
| | 2021 | 215 | 154 | 1 | 21 | 3 | 3 | 3 | 0 | 0 | 4 | 10 | 3 | 2 | 3 | 1 | 6 |
| | 2026 | 220 | 158 | 1 | 21 | 3 | 3 | 3 | 0 | 0 | 4 | 10 | 4 | 3 | 4 | 1 | 6 |
| | | | | | | | | | | | | | | | | | |
| Attached | 2006 | 59 | 43 | 0 | 6 | 1 | 1 | 1 | 0 | 0 | 1 | 3 | 0 | 1 | 0 | 0 | 1 |
| | 2011 | 62 | 45 | 0 | 6 | 1 | 1 | 1 | 0 | 0 | 1 | 3 | 1 | 1 | 1 | 0 | 1 |
| | 2016 | 64 | 46 | 0 | 6 | 1 | 1 | 1 | 0 | 0 | 1 | 3 | 1 | 1 | 1 | 0 | 1 |
| | 2021 | 65 | 47 | 0 | 6 | 1 | 1 | 1 | 0 | 0 | 1 | 3 | 1 | 1 | 2 | 0 | 1 |
| | 2026 | 67 | 49 | 0 | 6 | 1 | 1 | 1 | 0 | 0 | 1 | 3 | 1 | 1 | 2 | 0 | 1 |
| | | | | | | | | | | | | | | | | | |
| Apartment | 2006 | 6 | 4 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 2011 | 7 | 4 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 2016 | 7 | 4 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 2021 | 7 | 4 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 2026 | 8 | 4 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | | | | | | | | | | | | | | | | |
| Other | 2006 | 4 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 2011 | 4 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 2016 | 4 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| | 2021 | 5 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| | 2026 | 5 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| | | | | | | | | | | | | | | | | | |
| TOTAL | 2006 | 264 | 189 | 1 | 28 | 4 | 6 | 5 | 0 | 0 | 5 | 13 | 2 | 2 | 2 | 1 | 6 |
| | 2011 | 279 | 199 | 1 | 28 | 4 | 5 | 4 | 0 | 0 | 5 | 13 | 2 | 3 | 4 | 1 | 6 |
| | 2016 | 285 | 204 | 1 | 28 | 4 | 5 | 4 | 0 | 0 | 5 | 13 | 3 | 3 | 5 | 1 | 7 |
| | 2021 | 292 | 209 | 1 | 28 | 4 | 4 | 4 | 0 | 0 | 5 | 13 | 4 | 3 | 5 | 1 | 7 |
| | 2026 | 300 | 215 | 1 | 29 | 4 | 4 | 4 | 0 | 0 | 5 | 14 | 5 | 4 | 6 | 2 | 8 |
| | | | | | | | | | | | | | | | | | |

*Notes: 1) Results are measured at the customer's point-of-use and do not include line losses. 2) Any differences in totals are due to rounding. 3) Rounding reduces many non-zero values in this table to apparent zeroes.*

**Exhibit 3.9: Distribution of Electricity Consumption, by End Use in 2026 for the Labrador Interconnected Service Region**




*Totals may not add to 100% due to rounding.*

# 4. CONSERVATION & DEMAND MANAGEMENT (CDM) MEASURES

## 4.1 INTRODUCTION

This section identifies and assesses selected energy-efficiency, fuel switching and peak load reduction measures for the Residential sector. The discussion is organized and presented as follows:

- Methodology for Assessment of Energy-efficiency Measures
- Description of Energy-efficiency Technologies
- Summary of Energy-efficiency Results
- Peak Load Reduction Measures.

## 4.2 METHODOLOGY FOR ASSESSMENT OF ENERGY-EFFICIENCY MEASURES

The following steps were employed to assess the energy-efficiency measures:

- Select candidate energy-efficiency measures
- Establish technical performance for each option within a range of applicable load sizes and/or service region conditions (e.g., degree days)
- Establish the capital, installation and operating costs for each option
- Calculate the cost of conserved energy (CCE) for each technology and O&M measure.

***Step 1 Select Candidate Measures***

The candidate measures were selected in collaboration with the Utilities and from a literature review and previous study team experience. The selected measures are all considered to be technically proven and commercially available, even if only at an early stage of market entry. Technology costs, which will be addressed in this section, were not a factor in the initial selection of candidate technologies.

***Step 2 Establish Technical Performance***

Information on the performance improvements provided by each measure was compiled from available secondary sources, including the experience and on-going research work of study team members.

***Step 3 Establish Capital, Installation and Operating Costs for Each Measure***

Information on the cost of implementing each measure was also compiled from secondary sources, including the experience and on-going research work of study team members.

The incremental cost is applicable when a measure is installed in a new facility, or at the end of its useful life in an existing facility; in this case, incremental cost is defined as the cost difference for the energy-efficiency measure relative to the “baseline” technology. The full cost is applicable when an operating piece of equipment is replaced with a more efficient model prior to the end of its useful life.

In both cases, the costs and savings are annualized, based on the number of years of equipment life and the discount rate, and the costs incorporate applicable changes in annual O&M costs. All costs are expressed in constant (2007) dollars.

***Step 4 Calculate CCE for Each Measure***

One of the important sets of information provided in this section is the CCE associated with each energy-efficiency measure. The CCE for an energy-efficient measure is defined as the annualized incremental cost of the upgrade measure divided by the annual energy savings achieved, excluding any administrative or program costs required to achieve full use of the technology or measure. All cost information presented in this section and in the accompanying tables (see Appendix A) are expressed in constant (2007) dollars.

The CCE provides a basis for the subsequent selection of measures to be included in the Economic Potential Forecast. The CCE is calculated according to the following formula:

$$\frac{C_A + M}{S}$$

Where:

$C_A$ is the annualized installed cost
$M$ is the incremental annual cost of O&M
$S$ is the annual kWh energy savings.

And $A$ is the annualization factor.

Where: $A = \frac{i(1+i)^n}{(1+i)^n - 1}$ $i$ is the discount rate
$n$ is the life of the measure.

The detailed CCE tables (see Appendix A) show both "incremental" and "full" installed costs for the energy-efficiency measures, as applicable. If the measure or technology is installed in a new facility or at the point of natural replacement in an existing facility, then the "incremental" cost of the measure versus the cost of the baseline technology is used. If, prior to the end of its life, an operating piece of equipment is replaced with a more efficient model, then the "full" cost of the efficient measure is used.

The annual saving associated with the efficiency measure is the difference in annual electricity consumption with and without the measure.

The CCE calculation is sensitive to the chosen discount rate. In the CCE calculations that accompany this document, three discount rates are shown: 4%, 6% and 8%. The 6% real discount rate was used for the primary CCE calculation. The CCE was also calculated using the 4% and 8% real discount rates to provide sensitivity analysis.

Selection of the appropriate discount rate to be used in this analysis was guided by the intended use of the study results. This study seeks to identify the economic potential for DSM in Newfoundland and Labrador from a provincial perspective. Therefore, the appropriate discount rate is the social opportunity cost of capital, which is the estimated average pre-tax rate of return on public and private investments in the provincial economy.[30]

## 4.3 DESCRIPTION OF ENERGY-EFFICIENCY TECHNOLOGIES

This subsection provides a brief description of each of the energy-efficiency technologies and measures that are included in this study, as listed in Exhibit 4.1.

**Exhibit 4.1: Energy-efficiency Technologies and Measures - Residential Sector**

**Existing Building Envelope**
- High- & super high-performance windows
- Air leakage Sealing
- Attic insulation
- Wall insulation
- Foundation insulation
- Crawl space insulation

**New Building Design**
- R-2000 Home
- EnerGuide for Housing 80
- Energy-efficient new apartment building construction

**Space Heating and Ventilation Equipment**
- Programmable thermostat
- Electronic and high-efficiency thermostats
- Air source heat pump for homes
- Ground source heat pump for homes
- Low-temperature heat pump for apartments
- Ground source heat pump for apartments
- Integrated heating and DHW heat pumps
- High-efficiency heat recovery ventilator
- Electronically commutated permanent magnet (ECPM) motors for furnace fans
- Premium motors for apartment building ventilation systems
- Building recommissioning – apartment buildings
- Oil-fired central forced air heating system

**Domestic Hot Water**
- Low-flow shower heads and faucets
- Water tank insulation
- Pipe insulation

**Major Appliances**
- Microwave/convection oven
- ENERGY STAR refrigerator
- ENERGY STAR freezer
- ENERGY STAR dishwasher
- ENERGY STAR front loading clothes washer
- ENERGY STAR top loading clothes washer

**Household Electronics**
- Reduction in standby losses
- ENERGY STAR compliant computer
- ENERGY STAR television
- LCD television

**Lighting**
- CFLs
- Replacement of T12s with T8s
- LED holiday Lighting
- Lighting timers
- Motion sensors

[30] This discount rate allows for analytic consistency with the earlier NERA Marginal Cost Study, which used a nominal discount rate of 8.4% (approximately 6% real, i.e. net of inflation). NLH lowered its nominal discount rate in the summer of 2007 to 7.75%; however, this change has no material impact on the results of this study.

The discussion is organized by major end use and is presented in the following subsections:

- Existing building envelope
- New building design
- Space heating and ventilation equipment
- Domestic hot water
- Major appliances
- Household electronics
- Lighting.

Each energy-efficiency improvement opportunity is discussed below, with a brief description of the technology, savings relative to the baseline with respect to detached homes in the Island and Isolated service region (with savings ranges provided for other dwelling types and climate regions), typical installed costs, applicability and co-benefits.[31]

### 4.3.1 Existing Building Envelope

Building envelope measures improve the thermal performance of the building's walls, roof and/or windows. These measures also provide significant co-benefits, such as increased occupant comfort, improved resale value, etc. Ten energy-efficiency upgrade options were identified and assessed for this end use. They are:

- High-performance (ENERGY STAR) windows
- Super high-performance windows
- Air leakage sealing
- Attic insulation
- Wall insulation
- Foundation insulation
- Crawl space insulation
- High-performance glazing systems for apartment buildings
- Upgrade wall insulation for apartment buildings
- Upgrade roof insulation for apartment buildings.

❑ **High-Performance (ENERGY STAR) Windows**

| Measure Profile | |
|---|---|
| Applicable Dwelling Type(s) | Single detached and attached |
| Vintage | Existing and new |
| Costs | $4 per square foot incremental cost in existing<br>$2 per square foot incremental cost in new |
| Savings | 3%-7% HVAC energy, depending on dwelling type, vintage, and region |
| Useful Life | 25 years |

[31] Measure inputs not otherwise sourced are based on the consultants' recent work with BC Hydro and other utility clients.

High-performance windows are double glazed with a ½-inch air space; they incorporate a number of additional energy-saving features including low-e (soft coating), insulating spacers, argon fill and low conductivity frames (a mix of sliders, hinged and picture). The more efficient windows reduce heat loss through the window by 20% or more, compared to the average low- or mid-efficiency replacement window depending on dwelling type and region. High-performance windows have an RSI value of 0.5 (R-2.8) or higher, compared to standard double glazed windows, which are clear with no gas filling and typically have an RSI value of 0.34 (R-1.9) or less. High-performance windows also provide occupant co-benefits, such as reduced interior noise, reduced air leakage, greater thermal comfort and fewer condensation problems.

This analysis employs an incremental cost of $4 per square foot[32] to renovate an attached or detached dwelling to high-performance windows as opposed to standard windows; the corresponding savings are approximately 3%-7% of space heating, depending on housing type and climate.

If the upgrade is chosen as part of a new construction, the incremental cost is $2 per square foot[33] and the potential savings are higher because new homes tend to have more and larger windows. They are also a larger proportion of the heating energy consumption; because the other building shell components are better in a new home, windows account for a larger fraction of the heat loss than they do in an older home. The product lifetime for windows is approximately 25 years.[34]

- **Super High-Performance Windows**

| Measure Profile | |
|---|---|
| Applicable Dwelling Type(s) | Single detached and attached |
| Vintage | Existing and new |
| Costs | $8 per square foot |
| Savings | 5%-11% HVAC energy, depending on dwelling type, vintage and region |
| Useful Life | 25 years |

Super high-performance windows incorporate additional features such as triple glazing, transparent insulating films or fibreglass frames as well as the low-e coating, argon fill and insulating spacers, giving them an equivalent R-value of up to R-11. These windows are approximately twice the cost of the high-performance windows; incremental costs would be approximately $8 per square foot and the corresponding savings are approximately 5%-11% of space heating, depending on housing type and climate. Triple glazed units are considerably heavier and present fastening issues for existing vinyl window frame extrusions.

[32] Cost data from product review undertaken for Terasen Gas, 2006.
[33] Incremental costs are generally lower for windows installed in new homes, because tract builders are able to purchase windows in the wholesale market where the incremental cost of efficient windows is usually smaller than it is in the retail marketplace.
[34] BC Hydro Power Smart. *QA STANDARD Technology: Effective Measure Life*. September 11, 2006.

### ❑ Air Leakage Sealing

| Measure Profile | |
|---|---|
| Applicable Dwelling Type(s) | Single detached and attached |
| Vintage | Existing and new |
| Costs | $900 incremental cost in existing<br>$600 incremental cost in new |
| Savings | 8%-26% HVAC energy, depending on dwelling type, vintage and region |
| Useful Life | 25 years |

Air sealing of building envelopes includes completion of a blower door test to quantify leakage levels and to identify the location of air leaks. Generally, major leakage occurs at window-to-wall interfaces, around doors, through electrical and plumbing penetrations, at the top of foundation walls and around chimneys and fireplaces.[35] Installation of sealant and gaskets are generally accepted methods for reducing air leakage in buildings.

Air sealing also provides important co-benefits, including reduced drafts, increased occupant comfort and greater control over ventilation capability. In addition, reduced air leakage around windows and attic penetrations eliminates one of the key contributors to water ingress into exterior envelope assemblies.

HOT2000 simulations for Newfoundland showed significant HVAC savings in the range of 8% to 26% due to air leakage sealing, depending on housing type and climate. Electricity savings from ventilation fans, if applicable, would be approximately the same percentage. The cost of leakage control is approximately $900 per existing single-family dwelling if undertaken by an air sealing contractor who can perform an air test as part of the work. If homeowners undertake the air sealing work, significant cost savings can be achieved, but the resulting energy savings would be substantially reduced as well.

The incremental cost of improved air sealing in a new construction project used in this analysis is $600. The life of this measure is approximately 25 years; however, some elements of air leakage sealing, such as weather stripping, will require more frequent replacement and an annual O&M cost of $50 has been added in to account for this.[36]

[35] Fireplaces are particularly challenging to seal around, because of the difficulty of obtaining high-temperature sealants. Selection of fireplaces and woodstoves with outside air intake and proper air sealing built into them avoids this problem.

[36] Energy impacts are from HOT2000 simulations; cost data are based on discussions with installation contractors.

### ❑ Attic Insulation

| **Measure Profile** | |
|---|---|
| Applicable Dwelling Type(s) | Single detached and attached |
| Vintage | Existing and new |
| Costs | $600 incremental cost |
| Savings | 2%-6% HVAC energy, depending on dwelling type, vintage and region |
| Useful Life | 25 years |

Insulation levels can be increased in attics by blowing insulation into the attic spaces to fill and cover the space within the roof frame. One technique is to make sure loose-fill or batt insulation fills the attic floor joists fully, then add an additional layer of unfaced fibreglass batt insulation across the joists. This analysis assumed attic insulation is improved to RSI-7.0.

This analysis estimates the incremental cost of this measure to be about $600, with a resulting savings of approximately 2%-6% of the space heating costs depending on housing type and climate. Electricity savings from ventilation fans, if applicable, would be approximately the same percentage. The life of this measure is estimated at 25 years.[37]

### ❑ Wall Insulation

| **Measure Profile** | |
|---|---|
| Applicable Dwelling Type(s) | Single detached and attached |
| Vintage | Existing and new |
| Costs | $750-$2,400 |
| Savings | 3%-11% HVAC energy, depending on dwelling type, vintage and region |
| Useful Life | 25 years |

Wall insulation is usually challenging to retrofit in an existing house because the inside surfaces of the exterior walls are already finished and in place. Adding insulation is only possible by blowing insulating materials into the wall cavity, if sufficient space exists, or by adding insulation to the exterior of the building under the siding. Insulation levels are assumed to increase to RSI-3.5.

The incremental cost of adding the exterior insulation (as not all walls have sufficient space for blown-in insulation) used in this analysis is $750-$2,400 depending on dwelling vintage.[38] Savings are estimated to be 3%-11% of space heating costs depending on housing type and climate. Electricity savings from ventilation fans, if applicable, would

[37] Energy impacts are from HOT2000 simulations; cost data are based on discussions with retailers and installation contractors.

[38] Cost does not include siding. If insulation cannot be blown in, the rigid foam is assumed to be added in conjunction with an already-planned project to replace the siding. The insulation cost is incremental to the siding job.

be approximately the same percentage. The life of this measure is approximately 25 years.[39]

### ❑ Foundation Insulation

| Measure Profile | |
|---|---|
| Applicable Dwelling Type(s) | Single detached and attached |
| Vintage | Existing and new |
| Costs | $40 per square meter |
| Savings | 18%-43% HVAC energy, depending on dwelling type, vintage and region |
| Useful Life | 25 years |

In older homes the basement is often under insulated or even left uninsulated. Increasing the insulation level in basements can be achieved in a number of ways including: constructing a new insulated frame wall or moving the existing frame wall to increase the insulation level, adding extra insulation to the existing frame wall, adding rigid board insulation to the exterior of the foundation or using a combination of interior and exterior rigid board insulation. For the purposes of this report, increased basement insulation was assumed to be either moving an existing frame wall or constructing a new frame wall with an upgrade to RSI-4 insulation. The cost of adding insulation to the foundation, including labour and finishing, is approximately $40 per square meter ($3.70 per square foot) of basement wall area.[40]

HOT2000 simulations for Newfoundland showed significant HVAC savings in the range of 18% to 43% depending on housing type and climate. Electricity savings from ventilation fans, if applicable, would be approximately the same percentage. This measure has a life of approximately 25 years.[41]

### ❑ Crawl Space Insulation

| Measure Profile | |
|---|---|
| Applicable Dwelling Type(s) | Single detached and attached |
| Vintage | Existing |
| Costs | $1,000 incremental cost in existing |
| Savings | 10%-25% HVAC energy, depending on dwelling type, vintage and region |
| Useful Life | 25 years |

Insulation levels may be inadequate in some homes that include a crawl space as part of the basement design. Co-benefits of improved crawl space insulation include improved thermal comfort, fewer drafts and less condensation.

[39] Op. cit., footnote 36.
[40] Cost does not include adding or rebuilding the basement interior walls. The insulation is assumed to be added in conjunction with an already planned basement renovation. The insulation cost is incremental to the renovation cost.
[41] Op. cit., footnote 36.

The addition of crawl space insulation in existing houses to bring the thermal resistance values up to existing code levels of RSI-2.1 provides annual energy savings of approximately 10%-25% of HVAC energy use. Electricity savings from furnace fans, if applicable, would be approximately the same percentage. This measure has a life of approximately 25 years.[42] Typical installed costs are approximately $1,000.

- **High-performance Glazing Systems for Apartment Buildings**

| **Measure Profile** | |
|---|---|
| Applicable Building Types | All |
| Vintage | Existing and new |
| Costs | $2.00/ft$^2$ (floor area) incremental cost |
| Savings | 28% to 34% of heating and cooling energy |
| Useful Life | 20 years |

High-performance glazing systems consist of low-e coated films suspended inside an insulating glass unit. These units can be incorporated into both window and curtain wall systems. In addition to superior insulating performance and lower energy costs, the co-benefits include enhanced comfort, noise reduction, the elimination of perimeter heating and reduced HVAC equipment costs.

Visionwall window and curtain wall systems manufactured by Visionwall Corporation[43] have thermal resistance R-values ranging from 3 to 7 hr.ft$^2$.$^o$F/Btu, low shading coefficients and high visible light transmission. The highest performing product on the market is Superglass Quad (R-value 12.5 hr.ft$^2$.$^o$F/Btu) manufactured by Southwall Technologies.[44] It features two films suspended inside an insulating glass unit creating three krypton-filled air spaces. A tape system is used for gas retention and a thermally broken insolating spacer stops the conduction through the edge of the glass.

This upgrade is a high-performance glazing system with an overall U-value of 0.25 Btu/hr.ft$^2$.$^o$F (R-4). It is applicable to both existing buildings (at end of window life cycle) and new construction. The baseline is an electrically heated commercial building with standard double-glazed windows with an overall U-value of 0.45 Btu/hr.ft$^2$.$^o$F (R-2.2). The incremental cost is $2.00 per square foot of floor area, the savings range from 28% to 34% of the heating and cooling energy and the service life is 20 years.

- **Upgrade Wall Insulation for Apartment Buildings**

| **Measure Profile** | |
|---|---|
| Applicable Building Types | All |
| Vintage | Existing and new |
| Costs | $1.38/ft$^2$ (floor area) incremental cost |
| Savings | 18% of heating energy |
| Useful Life | 25 years |

[42] Op. cit., footnote 36.
[43] http://www.visionwall.com.
[44] http://www.southwall.com.

Various insulating materials and methods can be used to upgrade wall insulation including applying rigid polystyrene board to the exterior of a building or installing fibreglass batts between interior wall studs.

This measure involves upgrading wall insulation to R-24. It is applicable to both existing buildings (at time of recladding) and new construction. The baseline is an electrically heated commercial building with R-12 wall insulation. The incremental cost is $1.38 per square foot of floor area, the savings are 18% of heating energy and the service life is 25 years.

❑ **Upgrade Roof Insulation for Apartment Buildings**

| **Measure Profile** | |
|---|---|
| Applicable Building Types | All |
| Vintage | Existing and new |
| Costs | $1.00/ft$^2$ (floor area) incremental cost |
| Savings | 13% of heating energy |
| Useful Life | 25 years |

Upgrading insulation on a built-up roofing system typically involves adding additional layers of rigid insulation at the time of re-roofing.

This measure involves upgrading roof insulation to R-30. It is applicable to both existing buildings (at time of re-roofing) and new construction. The baseline is an electrically heated commercial building with R-20 roof insulation. The incremental cost is $1.00 per square foot of floor area, the savings are 13% of heating energy and the service life is 25 years.

### 4.3.2 New Building Design

New building design integrates advances in both building envelope and space/water conditioning technologies. Three energy-efficiency upgrades were addressed:

- R-2000 Home
- Construction of new homes to achieve an EnerGuide rating of 80 (EG80)
- Energy-efficient new apartment construction.

❑ **R-2000 Home**

| **Measure Profile** | |
|---|---|
| Applicable Dwelling Type(s) | Single detached and attached |
| Vintage | New |
| Costs | $7,500 incremental cost for bungalow<br>$9,000 incremental cost for 2-story |
| Savings | 30% to 50% of HVAC |
| Useful Life | 30 years |

R-2000 homes are required to achieve a stringent energy budget that is determined by a combination of factors related to heating fuel, house size and climatic data. In addition, R-2000 homes are required to achieve an air tightness level of 1.5 ac/h at 50 Pa. A number of co-benefits are associated with R-2000 construction, such as improved occupant comfort, improved air quality due to the mandatory use of heat recovery ventilators, higher resale value and reduced environmental impact.

This analysis estimates that annual space heating savings are 30%[45] relative to standard, electrically heated new houses. Actual performance verification performed by an R-2000 builder in Newfoundland showed energy savings of between 30% and 50%[46] relative to standard practice. Fuel savings for non-electrically heated homes would be approximately the same percentage. Typical incremental construction costs for an R-2000 home are assumed to be $7,500 to $9,000.[47]

- **EnerGuide 80 Home**

| **Measure Profile** | |
|---|---|
| Applicable Dwelling Type(s) | Single detached and attached |
| Vintage | New |
| Costs | $7,500 incremental cost for bungalow<br>$9,000 incremental cost for 2-story |
| Savings | 30% to 50% of space heating energy |
| Useful Life | 30 years |

An EnerGuide for Houses rating is a standard measure of a home's energy performance, calculated by a professional EnerGuide for Houses advisor. The rating is based on information on the construction of the home and the results of a blower door test performed once the house has been built. A blower door test measures air leakage when the air pressure within the house is lowered a specified amount below the air pressure outside. EnerGuide ratings for new houses fall within the following ranges:

- Typical new houses: 72 to 74
- Energy-efficient new houses: 77 to 82
- R-2000 houses: 80 minimum
- Highly energy-efficient new houses: 80 to 90
- Advanced houses using little or no purchased energy: 91 to 100.

The key difference between the R-2000 standard and the more flexible requirement to meet the EG80 rating is that builders do not need to install a heat recovery ventilator to achieve a rating of EG80, nor meet other environmental requirements of the R-2000 program. This substantially reduces the cost of the measure. However, in St. John's where electric heating is in the majority of homes, heat recovery ventilation is standard

[45] Energy impacts are from HOT2000 simulations; cost data are based on information from a paper by Anil Parekh of NRCan, *Cost Impact of the New R-2000 Technical Standard – Summary Report*, March 2000. Supplemented by discussions with installation contractors.
[46] Discussion with Greg Hussey of Karwood Contracting, an R-2000 builder in Newfoundland, August, 2007.
[47] Ibid.

practice,[48] meaning there will be no cost difference between a home achieving EG80 and an R-2000 home.

This analysis estimates that annual space heating savings are 30% to 50% relative to standard electrically heated new houses. Fuel savings in non-electrically heated homes would be approximately the same percentage. Typical incremental construction costs for an EG80 home are assumed to be $7,500 to $9,000.[49]

❑ **Energy-efficient New Apartment Construction**

New construction refers to new high-efficiency buildings designed using the integrated design process that achieve substantial improvements over conventional new buildings through the application and integration of energy-efficiency technologies and design approaches.

Baseline new construction is assumed to follow the MNECB and ASHRAE 90.1 - 1999 standards.

Two energy-efficiency upgrade options were evaluated for new construction:

- New apartment building - 25% more efficient than current standards
- New apartment building - 40% more efficient than current standards.

❑ **New Apartment Building - 25% More Efficient Than Current Standards**

| **Measure Profile** | |
|---|---|
| Applicable Dwelling Type(s) | Apartment buildings |
| Vintage | New |
| Costs | $1.00/ft$^2$ incremental cost |
| Savings | 25% |
| Useful Life | 30 years |

The integrated design approach (IDA) to new building design is predicated on a systematic application of energy measures to all end uses at the design stage. This includes targeting the building envelope, lighting, HVAC equipment (fans and pumps) and, finally, the heating and cooling plants. Savings of 25% are achievable at an average incremental cost of $1/ft$^2$. The 25% measure is a subset of the 40% measure and is, therefore, not considered separately in cases where the 40% measure passes the CCE test. If the 40% measure fails the CCE test for a particular region or dwelling type, the analysis falls back to the 25% improvement. If the latter passes the CCE test, it would be included in the potential.

[48] Ibid.
[49] Cost is based on R-2000 incremental cost, less the cost of installing an HRV.

❑ **New Apartment Building - 40% More Efficient Than Current Standards**

| **Measure Profile** | |
|---|---|
| Applicable Dwelling Type(s) | Apartment buildings |
| Vintage | New |
| Costs | $4.50/ft$^2$ incremental cost |
| Savings | 40% |
| Useful Life | 30 years |

A new apartment building that is 40% more efficient than current design practice will require a very high-performance design, equivalent to C-2000 levels. This requires a full IDA that takes advantage of costs trade-offs from equipment downsizing. The design will require the most energy-efficient technologies, extremely efficient lighting designs and heating/cooling plants with very high part-load efficiencies. Savings of 40% are achievable at an average incremental cost of $4.50/ft$^2$.

### 4.3.3 Space Heating and Ventilation Equipment

Space heating and ventilation equipment refers to the equipment and controls used to heat and ventilate residential dwellings. The following energy-efficiency upgrade options were identified and assessed for this end use.[50]

- Programmable thermostat
- High-efficiency thermostat
- Low-temperature air source heat pumps for new homes
- Ground source heat pump for new homes
- Low-temperature heat pumps for apartments
- Ground source heat pump for apartments
- Integrated heating and DHW heat pumps
- High-efficiency heat recovery ventilator
- Electronically commutated permanent magnet (ECPM) motors for furnace fans
- Oil-fired central forced air heating system.
- Premium motors for apartment building ventilation systems
- Building recommissioning—apartment buildings.

[50] Duct sealing is not included due to the negligible number of homes with ducted electric heating systems in Newfoundland and Labrador. It should be noted that 27% of the electrically heated homes in the Labrador Interconnected service region do have ducts. Including both detached and attached dwellings, this would total approximately 1,800 dwellings. In a dwelling where the ducts run within the conditioned space (as is typical of Canadian homes), duct sealing saves approximately 5%. It costs approximately $1,000 per home, mostly in labour, and would not pass the CCE test in Labrador.

### ❑ Programmable Thermostat

| Measure Profile | |
|---|---|
| Applicable Dwelling Type(s) | Single detached and attached |
| Vintage | New and existing |
| Costs | $70 incremental cost |
| Savings | 6% of HVAC energy |
| Useful Life | 18 years |

Digital programmable thermostats provide improved temperature setting accuracy and are capable of multiple time settings. When combined with an assumed 4ºC temperature setback during night and unoccupied periods, typical space heat savings are in the range of 10% to 15%[51] relative to the baseline, depending on the dwelling's vintage and type of dwelling. Other utility studies[52] have indicated that a lower savings percentage should be used, to reflect the fact that the thermostat's setback capabilities do not completely reflect how they are used, e.g., some home occupants reliably set back manual thermostats, and some home occupants do not use the setback features on their electronic thermostats. Accordingly a value of 6% savings has been used in this study.

These thermostats can be installed in both new and existing dwellings. The typical incremental installed cost for a programmable versus non-programmable thermostat is about $70[53] per thermostat and the units have an expected life of 15-20[54] years.

### ❑ High-efficiency Thermostat

| Measure Profile | |
|---|---|
| Applicable Dwelling Type(s) | Single detached and attached |
| Vintage | New and existing |
| Costs | $30 incremental cost |
| Savings | 3% of HVAC energy |
| Useful Life | 18 years |

Digital programmable thermostats are, in general known for their increased accuracy and energy savings potential due to setback features. Recently, less expensive thermostats with the same accuracy, but without the programming functions, have become available. These improved electronic thermostats help reduce temperature fluctuations to less than 0.5-1$^{o}$C, whereas fluctuations usually range on an average from 1.5-2$^{o}$C. This increased sensitivity helps to ensure that electric furnaces or baseboard heaters start up as close as possible to the desired temperature set point. One model used with baseboard electric heaters will switch the heater on and off to maintain an ambient temperature within +/-

[51] Canadian ENERGY STAR Calculator.
[52] Enbridge Gas Distribution, Inc., consumer awareness campaign literature, supported by unpublished internal studies.
[53] From retail outlets e.g., Home Hardware and Canadian Tire.
[54] Canadian ENERGY STAR Calculator.

0.5°C of the set point. It could save around 3%[55] of energy use while improving comfort considerably. This model, however, is not recommended for fuel fired furnaces or wherever short cycling is not desirable.

It should be noted that increased temperature sensing precision may not have any significant impact on energy savings since the temperature setting in a home is generally linked to homeowner comfort and preference, not to the number displayed on the thermostat. The assumption would also need to be made that the less precise thermostat allows homes to overheat by 1 degree, not be under heated by 1 degree. Based on the NRCan 3% savings information, the assumption used in the analysis will be that this type of thermostat saves 3% compared to a regular thermostat. It is assumed to cost approximately $30.

- ❑ **Low-temperature Air Source Heat Pumps for New Homes**

| **Measure Profile** | |
|---|---|
| Applicable Dwelling Type(s) | Single detached and attached |
| Vintage | New |
| Costs | $8,000 incremental cost |
| Savings | 50% of space heating energy in Island houses<br>43% of space heating energy in Labrador houses |
| Useful Life | 20 years |

When outdoor air temperatures drop below freezing, standard air source heat pump (ASHPs) systems switch to auxiliary electric resistance heaters to meet the space heating requirements. This limitation has served to minimize the penetration of ASHPs in cold climates. However, a low-temperature air source heat pump (LTHP) developed by Hallowell International[56] is capable of operating at 0°F with a coefficient of performance (COP) of greater than two. At this temperature, standard ASHPs operate less efficiently, produce less than half their rated capacity, and rely primarily on backup electric resistance heaters to maintain comfort.

The LTHP features a two-speed, two-cylinder compressor for efficient operation, a back-up booster compressor that allows the system to operate efficiently down to 15ºF and a plate heat exchanger called an "economizer" that further extends the performance of the heat pump to well below 0ºF.

LTHPs were considered as an alternative for new dwellings only.[57] In new dwellings, LTHPs can provide increased efficiency compared to the more common electric baseboard heaters.[58] Energy savings in the Island and Isolated service region were

[55] NRCan Office of Energy Efficiency, *Heating with Electricity*, March 2003, http://oee.nrcan.gc.ca/publications/infosource/pub/home/Heating_With_Electricity_Chapter2.cfm?attr=4.
[56] www.gotohallowell.com
[57] In existing homes, it would be practical to install an ASHP only in electrically heated homes that already have ducts. The number of such homes in Newfoundland and Labrador is so small that the potential from this measure in existing homes was deemed negligible.
[58] It is assumed that the additional duct work required to install an ASHP in an existing home with electric baseboard heaters is prohibitive.

estimated to be 50% relative to baseboard heaters. In the Labrador Interconnected region, the more severe winters reduced the savings estimate to 43% relative to baseboard heaters. LTHPs can also provide space cooling in summer months at no incremental capital cost, which can improve the CCE slightly.

Typical installed costs in new dwellings are approximately $8,000 to $12,000, including duct work (the lower number has been used in the model, as more representative of a mature market price), and units can last from 15-25 years.[59]

- **Ground Source Heat Pumps for New Homes**

| **Measure Profile** | |
|---|---|
| Applicable Dwelling Type(s) | Single detached |
| Vintage | New |
| Costs | $18,200 incremental cost |
| Savings | 65% of space heating energy in Island houses<br>62% of space heating energy in Labrador houses |
| Useful Life | 20 years |

Ground source heat pumps (GSHP) utilize the relatively constant temperature properties of the earth or ground water to provide heating and cooling to homes. Although they offer further savings relative to other heat pump types, they are expensive and cannot be used in many urban applications.[60]

Typical HSPF values for regions in Canada experiencing a winter similar to St John’s are 8.9-10.6, which equates to energy savings of 65% relative to baseboard heaters in new homes. Typical HSPF values for regions in Canada experiencing a more severe winter such as in Labrador are 8-10, which equates to energy savings of 62% relative to baseboard heaters.[61] In both regions GSHP save approximately 30% to 45% compared to ASHP in new buildings.

Installed costs are approximately $20,000 for a closed loop system in a typical dwelling, or $18,200 more than a conventional system.[62]

Again, the addition of cooling at no incremental cost can improve the savings relative to the baseline.

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[59] Heating seasonal performance factors (HSPF), savings, costs and lifetimes from NRCan Office of Energy Efficiency, *Heating and Cooling with a Heat Pump*. Data checked with manufacturers and contractors.
[60] In most urban locations, there is insufficient room for trenching to install horizontal ground loops for GSHPs. At best, there may be room to drill the vertical holes for vertical ground loops. In many locations, there is no space even for that. In some cases where there is room, it is impossible to gain access with the drilling rig because of surrounding structures.
[61] Ibid.
[62] Earth Energy Society of Canada. http://www.earthenergy.ca/saving.html.

### ❑ Low-temperature Air Source Heat Pumps for Apartments

| Measure Profile | |
|---|---|
| Applicable Dwelling Type(s) | Apartments |
| Vintage | Existing and new |
| Costs | $1.80 to $2.50/ft$^2$ incremental cost |
| Savings | 56% to 59% of space heating and cooling energy |
| Useful Life | 15 years |

When outdoor air temperatures drop below freezing, standard air source heat pump systems switch to auxiliary electric resistance heaters to meet the space heating requirements. This limitation has served to minimize the penetration of air source heat pumps in cold climates. However, as indicated earlier, Hallowell International's low-temperature air source heat pump is capable of operating at 0°F with a COP of greater than two. At this temperature, standard air source heat pumps operate less efficiently, produce less than half their rated capacity and rely primarily on backup electric resistance heaters to maintain comfort.

The LTHP features a two-speed, two-cylinder compressor for efficient operation, a backup booster compressor that allows the system to operate efficiently down to 15ºF and a plate heat exchanger called an "economizer" that further extends the performance of the heat pump to well below 0ºF.

This measure involves upgrading a standard HVAC system with an equivalent LTHP system. This could include, for example, replacing a standard ASHP system with a LTHP system. The target market is both residential and small commercial buildings and the baseline is electric resistance heating and direct expansion cooling. This technology is applicable to existing buildings (at the end of HVAC life cycle) and new construction. The incremental cost ranges between $1.80 and $2.50 per square foot, the savings range between 56% and 59% of space heating and cooling energy and the service life is 15 years.

Currently, the LTHP is available only as a 3.0 and 3.5 ton split system, however Hallowell International expects to launch an expanded product line targeting the commercial market including a packaged rooftop heat pump and a packaged terminal heat pump (PTHP) as early as 2008.[63]

[63] Conversation with James Bryant of Hallowell International, [September, 2007]

## ❑ Ground Source Heat Pumps for Apartments

| Measure Profile | |
|---|---|
| Applicable Dwelling Type(s) | All |
| Vintage | Existing & new |
| Costs | $4.90/ft$^2$ incremental cost |
| Savings | 61% to 64% of space heating & cooling energy |
| Useful Life | 20 years |

Ground source heat pump (GSHP) systems are more efficient than conventional heat pump systems, with higher COPs and energy-efficiency ratios (EERs). GSHPs also replace the need for a boiler in winter by utilizing heat stored in the ground; this heat is upgraded by a vapour-compressor refrigeration cycle. In summer, heat from a building is rejected to the ground, eliminating the need for a cooling tower or a heat rejector. They also lower operating costs because the ground is cooler than the outdoor air.

Water-to-air heat pumps are typically installed throughout a building with duct work serving only the immediate zone; a two-pipe water distribution system conveys water to and from the ground source heat exchanger. The heat exchanger field consists of a grid of vertical boreholes with plastic u-tube heat exchangers connected in parallel.

This measure involves upgrading a standard HVAC system with a GSHP system and is applicable to existing building (at the end of HVAC life cycle) and new construction. The baseline is a commercial building with standard electric resistance heating and direct expansion cooling. The incremental cost is $4.90 per square foot, the savings range between 61% and 64% of heating and cooling energy and the service life is 20 years.

## ❑ Integrated Heating and Hot Water (Heat Pump)

| Measure Profile | |
|---|---|
| Applicable Dwelling Type(s) | Single detached |
| Vintage | New and existing |
| Costs | $1,000 incremental on top of GSHP costs |
| Savings | 35% DHW plus heating savings as above |
| Useful Life | 20 years |

GSHP can also reduce DHW energy consumption through the addition of a desuperheater. A desuperheater is a small, refrigerant/water heat exchanger that transfers superheated gases from the heat pump’s compressor to a water pipe that runs to a home’s hot water storage tank. In the cooling season, the desuperheater uses excess heat extracted from the home and in the heating season it uses any excess heat that is not needed for space heating. At peak heating times a conventional water heater can meet additional needs.

A desuperheater can purportedly result in DHW energy savings of 25%-50%[64] (35% has been used in the model, as an approximate midpoint) and costs approximately $1,000.[65]

- ❑ **High-efficiency Heat Recovery Ventilators (HRV)**

| **Measure Profile** | |
|---|---|
| Applicable Dwelling Type(s) | Single detached and attached |
| Vintage | New |
| Costs | $650 incremental cost |
| Savings | 7% of HVAC energy |
| Useful Life | 15 years |

Heat recovery ventilators (HRV) are installed to recover wasted heat energy from centralized exhausts. Such units typically result in a 13% reduction in space heating costs.[66] New, high-efficiency HRV units recover approximately 50% more of the energy escaping in ventilation air, resulting in an additional 7%[67] reduction in space heating costs.

This analysis assumes that a high-efficiency HRV costs approximately $3,150[68] compared to a standard unit, which costs $2,500. The technology has an estimated life of 15 years. New HRV also have an energy-efficiency option, utilizing a variable speed DC motor instead of the less efficient PSC motor, cutting consumption from 150 Watts to less than 50 Watts on low speed.

- ❑ **Electronically Commutated Permanent Magnet (ECPM) Furnace Fan Motor**

| **Measure Profile** | |
|---|---|
| Applicable Dwelling Type(s) | Single detached and attached |
| Vintage | New and existing |
| Costs | $140 incremental cost |
| Savings | 40% of ventilation energy |
| Useful Life | 20 years |

Furnace fan motors are typically designed with permanent split capacitors (PSC) and achieve efficiencies in the range of 50%-60%. In contrast, ECPM motors have operating efficiencies in the range of 80%. Furnace fan motors are used in houses with central,

[64] NRCan Office of Energy Efficiency, *Heating and Cooling with a Heat Pump*.
[65] Earth Energy Society of Canada http://www.earthenergy.ca/saving.html.
[66] The standard HRV is not a separate measure in this analysis. Based on discussions with local contractors, installing HRVs is becoming standard practice in electrically heated new homes in Newfoundland and Labrador. It should be noted, however, that, for the existing vintage, with an installed cost of $2,500 (nearly four times the incremental cost of the above measure) and savings of 13% (only double the savings of the above measure), the standard HRV would not pass the CCE test.
[67] E Source Heating Technology Atlas.
[68] Cost based on discussions with contractors.

forced air heating systems. When operated exclusively in space heating mode, ECPM motors reduce fan motor electricity use[69] by approximately 40%.[70]

Typical installed costs are approximately $140[71] more than for a standard fan motor. ECPM motors also reduce fan noise.

- **Oil-fired Forced Air Heating System for New Homes[72]**

| Measure Profile | |
|---|---|
| Target Segments | All |
| Vintage | New |
| Costs | $4,300 incremental cost |
| Electricity Savings | Approximately 95%[73] |
| Useful Life | 15 years |

Space heating in new homes can be provided by an ENERGY STAR (83% efficiency) oil-fired furnace instead of electric baseboard heating. The installed cost of a direct vent forced air furnace with oil tank and duct work in a new single family home is in the range of $6,500 to $7,000. This compares with an estimated installed cost of up to $2,700 for electric baseboard heating, which includes the cost of a larger electrical panel, wiring, heaters and thermostats. The oil-fired system also uses approximately 420 kWh of fan electricity (in this analysis, assumed to be powered by an ECPM motor).

- **Premium Motors for Apartment Building Ventilation systems**

| Measure Profile | |
|---|---|
| Applicable Dwelling Type(s) | Apartment buildings |
| Vintage | Existing & new |
| Costs | 20% incremental cost |
| Savings | 1.4% of ventilation energy |
| Useful Life | 10 years |

Premium efficiency motors typically have reduced losses of 10%-40%, thereby increasing motor efficiency by 1%-10%.[74] In a retrofit situation it is considered best

[69] As noted in earlier sections, this end use is currently the focus of extensive research efforts. Recent end-use metering results suggest that, in heating mode, ECPM motor savings are fully offset by increased space heating fuel consumption. This is because waste heat generated by the fan motor is captured in the distributed hot air. Therefore, if the fan motor's waste heat is reduced due to increased efficiency, the primary heating fuel must make up the difference. If used to distribute cooled air, the increased fan motor efficiency (i.e., reduced waste heat) would reduce both motor consumption and the total cooling load.
[70] Canadian Centre For Housing Technology, *Effects of ECM Furnace Motors on Electricity and Gas Use*.
[71] Canadian Centre for Housing Technology, *Effects of ECM Furnace Motors on Electricity and Gas Use*, and discussion with retailers.
[72] This measure has been included as it may offer a net benefit to the NLH system. This is because a portion of the electricity generated will be from thermal sources if the Island and Isolated service region remains an isolated grid.
[73] Electricity savings require use of another fuel, assumed to be oil in this case; residual electricity use is for circulation fan operation.
[74] BC Hydro. *Power Smart Tips & Practices*.

practice to replace failed motors with new premium efficiency motors rather than rewind them since motor rewinding often degrades motor efficiency by 1%-3%.

This measure involves upgrading an induction motor with an equivalent premium efficiency motor. It is applicable to both existing buildings (at end of motor life cycle) and new construction. The baseline is a standard efficiency induction motor. The incremental cost is estimated to be 20% relative to a standard efficiency motor, the savings are 1.4% and the service life is 10 years.

- **Building Recommissioning – Apartment Buildings**

| **Measure Profile** | |
|---|---|
| Applicable Dwelling Type(s) | Apartment buildings |
| Vintage | Existing |
| Costs | $0.60 per ft$^2$ |
| Savings | 20% of HVAC energy use |
| Useful Life | 5 years |

Recommissioning is a quality assurance process for ensuring that a building's complex array of mechanical and electrical systems is operated to perform according to the design intent and current operational needs of the building. The process generally involves monitoring and simulation of building systems to gain a thorough understanding of current operation and possibilities for optimization. Energy savings generally result from equipment repairs, air and water rebalancing and control optimization.

Recommissioning is applicable to existing buildings only. The baseline is a typical office building with an electricity intensity of 26 kWh/ft$^2$yr. The full cost is estimated to be $0.60/ft$^2$, the savings are 20% of HVAC energy use and the service life is 5 years.

### 4.3.4 Domestic Hot Water

Domestic hot water (DHW) refers to the heated water used for showers, baths, hand washing and clothes and dishwashing (DHW savings for clothes and dishwashers are treated separately in Section 4.3.5). Four[75] energy-efficiency upgrade options were identified and assessed for this end use, of which three are discussed below:

- Low-flow shower heads and faucets
- Water tank insulation
- Pipe insulation.

[75] The potential for heat traps was deemed negligible in the context of this study due to the relatively high replacement rate of DHW tanks in the Newfoundland residential marketplace (often after 6 years). The discussion was removed accordingly.

### ❑ Low-flow Showers and Faucets

| Measure Profile | |
|---|---|
| Applicable Dwelling Type(s) | Single detached and attached |
| Vintage | Existing |
| Costs | $25 incremental cost |
| Savings | 11% of DHW energy in existing |
| Useful Life | 12 years |

Energy-efficient showers and faucets have aerators and flow restrictors to reduce water use. DHW used for general use (including showers and faucets) is assumed to account for approximately 35% of total DHW energy.

This analysis estimates that reductions in hot water usage are in the range of 30% relative to traditional models, or 11% of total DHW use. Installed costs are approximately $25 for a single-family dwelling. This measure has an expected life of 12 years.[76]

### ❑ Hot Water Tank Insulation

| Measure Profile | |
|---|---|
| Applicable Dwelling Type(s) | Single detached and attached |
| Vintage | Existing |
| Costs | $30 full cost |
| Savings | 6% of DHW energy |
| Useful Life | 10 years |

Very energy-efficient water heater storage tanks will have an insulation value of at least RSI-4.2. Adding insulation to an existing hot water tank, purchased before 2004, can reduce standby heat losses resulting in energy savings of 4%–9% (6% has been used in the model as an approximately midpoint).[77]

Pre-cut tank jackets (blankets) are readily available and cost around $15-20[78] in central Canada but are more expensive in Newfoundland and Labrador (approximately $30). They last for 10-15 years. Space limitations restrict the applicability of this measure in some cases. The potential is rapidly eroding as tanks are replaced.

[76] Data used in the BC Hydro 2007 Conservation Potential Review, and in the 2006 Terasen Gas CPR Study. Similar assumptions are used in the American Council for an Energy-Efficient Economy (ACEEE) and Energy Efficiency and Renewable Energy (EERE) *Consumer Tip Sheets* and have been confirmed for 2007.
[77] U.S. Department of Energy. http://www.eere.energy.gov/consumer/your_home/water_heating/index.cfm/mytopic=13070.
[78] From Canadian retailers.

❑ **Hot Water Pipe Insulation**

| Measure Profile | |
|---|---|
| Applicable Dwelling Type(s) | Single detached and attached |
| Vintage | Existing |
| Costs | $4 incremental cost |
| Savings | 3% of DHW energy |
| Useful Life | 6 years |

Hot water pipe insulation reduces the distribution losses for DHW, which account for approximately 5%-10% of the total water heater electricity consumption.

This analysis estimates that hot water pipe insulation reduces total DHW energy consumption by 3%. The materials cost an average of $4 per house and are assumed to be installed by the homeowner. The measure has an expected life of 6 years.[79]

### 4.3.5 Major Appliances

- Microwave/convection oven
- ENERGY STAR refrigerator
- High-efficiency freezer
- ENERGY STAR dishwasher
- ENERGY STAR front loading clothes washer
- ENERGY STAR top loading clothes washer
- Switch to propane gas for cooking.

❑ **Microwave/Convection Oven**

| Measure Profile | |
|---|---|
| Applicable Dwelling Type(s) | All |
| Vintage | New and existing |
| Costs | $1,400 incremental |
| Savings | 25% |
| Useful Life | 20 years |

New stove models combine conventional, microwave and convection ovens into a single appliance. Relative to a conventional oven, these designs provide electricity savings of about 25% and faster cooking times. Typical incremental costs are about $1,400 relative to conventional models and the units have a life of approximately 20 years.

[79] Savings data based on earlier analysis conducted for Terasen Gas. Cost data gathered from retailer scan.

### ❑ ENERGY STAR Refrigerator

| Measure Profile | |
|---|---|
| Applicable Dwelling Type(s) | All |
| Vintage | New and existing |
| Costs | Incremental cost $50-$100 |
| Savings | 15% -20% |
| Useful Life | 17 years |

ENERGY STAR refrigerators achieve substantial savings in electricity consumption through improved insulation and compressor efficiency, as well as better quality door seals and load sensors.[80] ENERGY STAR refrigerators must use 15% less energy than current standards dictate for an upright model, and 20% less energy for a compact design. Incremental cost for an ENERGY STAR fridge is $50-$100.[81]

### ❑ ENERGY STAR Freezer

| Measure Profile | |
|---|---|
| Applicable Dwelling Type(s) | All |
| Vintage | New and existing |
| Costs | Incremental cost $50-$100 |
| Savings | 10% |
| Useful Life | 17 years |

The performance efficiency of freezers has increased significantly over the last 10 years through improved insulation and compressor efficiency. ENERGY STAR freezers must use 10% less energy than current standards dictate. Incremental cost for an ENERGY STAR freezer is $50-$100.[82]

### ❑ Manual Defrost Freezer

| Measure Profile | |
|---|---|
| Applicable Dwelling Type(s) | All |
| Vintage | New and existing |
| Costs | Incremental cost $0 |
| Savings | 30% |
| Useful Life | 17 years |

Freezers without an automatic defrost cycle use approximately 30%[83] less electricity than comparable freezers with the defrost cycle; they also cost the same or less. Chest freezers

[80] A potential pitfall with refrigerator replacement initiatives is that some customers will retain the old refrigerator. For example, it may get moved to the basement and used as a beer fridge. This phenomenon may also affect freezer initiatives. Other utilities have addressed this issue through programs that offer a "bounty" to customers who surrender old second refrigerators and freezers.
[81] Based on scan of retailers.
[82] Based on scan of retailers.
[83] Canadian ENERGY STAR Calculator.

experience only limited amount of frost build up over time and rarely require defrosting and, therefore, for the purposes of this study, the level of service provided is assumed to remain virtually unchanged.

- ❑ **ENERGY STAR Dishwasher**

| **Measure Profile** | |
|---|---|
| Applicable Dwelling Type(s) | Single detached and attached |
| Vintage | Existing and new |
| Costs | Incremental cost $50 |
| Savings | 41% of DHW and mechanical dishwasher energy |
| Useful Life | 10 years |

ENERGY STAR dishwashers save energy by using improved technology for the primary wash cycle and by using less hot water to clean. Construction includes more effective washing action, energy-efficient motors and other advanced technologies, such as sensors, that determine the length of the wash cycle and the temperature of the water necessary to clean the dishes. In addition, some advanced dishwashers can sense and adjust for the amount of soil on dishes, using only as much water as necessary.

As of January 1, 2007 the ENERGY STAR level for dishwashers was changed with a corresponding increase in energy efficiency from 26% better than standard to 41% better. These savings affect both the mechanical energy of the dishwasher and the energy used for heating the water. The incremental cost of a unit meeting these new criteria is assumed to be $50.[84] The estimated life of a dishwasher is 10 years.[85]

- ❑ **ENERGY STAR Front Loading Clothes Washer**

| **Measure Profile** | |
|---|---|
| Applicable Dwelling Type(s) | Single detached and attached |
| Vintage | Existing and new |
| Costs | Incremental cost $550 |
| Savings | 70% of DHW used for clothes washing<br>50% of mechanical energy<br>35% of dryer energy |
| Useful Life | 15 years |

Compared to standard models, front loading (horizontal axis) washing machines reduce hot water use by 60%-80% (70% has been used in the model, as an approximate midpoint). Mechanical energy use is also reduced by about 50% and, due to their faster spin speed, they also reduce dryer energy by about 35%.[86]

This analysis assumes the energy savings outlined above. Incremental costs are assumed to be about $550 more than a standard vertical axis machine, although some high-end

[84] Based on discussion with retailers.
[85] Canadian ENERGY STAR Calculator.
[86] Savings data based on earlier analysis conducted for Terasen Gas.

models have incremental costs of about $1,000.[87] They are assumed to have a life of 15 years.

- **ENERGY STAR Top Loading Clothes Washer**

| Measure Profile | |
|---|---|
| Applicable Dwelling Type(s) | Single detached and attached |
| Vintage | Existing and new |
| Costs | Incremental cost $250 |
| Savings | 60% of DHW used for clothes washing<br>50% of mechanical energy<br>35% of dryer energy |
| Useful Life | 15 years |

ENERGY STAR clothes washers use approximately 60%[88] less hot water and 50% less mechanical energy per load than standard models. Because ENERGY STAR clothes washers spin faster, there are additional savings in dryer energy of approximately 35%. In January 2007, the ENERGY STAR standard for clothes washers was increased. However, the base regulation was also increased and the savings above the baseline, therefore, remain the same.

The change in standards has, however, resulted in a reduction of the number of qualifying models to only top of the range units and the incremental cost has therefore increased to about $250.[89] The estimated life of a clothes washer is 15 years.

- **Switch to Propane Gas for Cooking**[90]

| Measure Profile | |
|---|---|
| Target Segments | All |
| Vintage | New |
| Costs | $245 installed cost for a tank plus $105/yr. rental<br>$400 installed cost for piping |
| Electricity Savings | 100% of on-site cooking electricity [91] |
| Useful Life | 15 years |

Propane cooking stoves offer the same perceived advantages in cooking convenience offered by natural gas stoves. Typical installed cost is $645 more than an electric stove due to piping costs (typically $400-500) and the cost of installing a propane tank ($245). The propane tank is typically a rental, costing an additional $105 per year.

[87] Cost data based on retailer scan.
[88] Canadian and U.S. ENERGY STAR Calculator.
[89] From retailer scan.
[90] This measure is not an efficiency measure but has been included for the same reasons as outlined previously in footnote 72, Section 4.3.3, for oil-fired space heating.
[91] Electricity savings require use of another fuel, assumed to be propane in this case.

### 4.3.6 Household Electronics

Improvements to household electronics enhance the efficacy of entertainment items such as TVs and computers, while maintaining service levels. Four[92] energy-efficiency upgrade options were identified and assessed for this end use as follows:

- Reduction in standby losses
- ENERGY STAR compliant computer
- ENERGY STAR television
- LCD television.

❑ **Standby Losses**

| Measure Profile | |
|---|---|
| Applicable Dwelling Type(s) | All |
| Vintage | New and existing |
| Costs | $40 per dwelling |
| Savings | 16% for computers, 8% for TVs and other electronics, 73% for TV peripherals |
| Useful Life | 10 years |

Standby losses, consumed by electrical appliances when they are turned off or not in use, represent a significant component of residential electricity consumption. They account for 16% of computer energy use, 8% of the electricity used by TV and other electronics such as games consoles, and 73% of the electricity use of TV peripherals such as set-top boxes.[93] Technically, these standby losses can be reduced to zero by use of a power bar to completely remove power to the appliance.

In practice, the interaction between the power bar and the electronic device will often need to be more sophisticated than a simple shut-off. Some TVs need fan runtime after the screen is shut off, to avoid heat damage. Some set-top boxes require time to boot up and reconnect to their network before use, suggesting that to avoid user inconvenience they should be turned on in advance of prime viewing hours with a timer. Smart power bars with these capabilities are now making inroads in the marketplace. Over the study period, technical advances will improve these features and, in some cases, may move them from the power bar into the electronic appliance itself.

[92] LCD monitors have become the standard technology and the measure was dropped accordingly.
[93] Alan Fung, Adam Aulenback, Alex Ferguson and V Ismet Ugurssal. *Standby Power Requirements of Household Appliances in Canada*, April 2002.

### ❑ ENERGY STAR Compliant Computer

| Measure Profile | |
|---|---|
| Applicable Dwelling Type(s) | All |
| Vintage | New and existing |
| Costs | Incremental cost negligible |
| Savings | 60% |
| Useful Life | 8 years |

The ENERGY STAR specification for computers was revised in October 2006 and came into effect in July 2007. The previous specification only addressed energy use during a computer's sleep mode and was not demanding even in this respect with approximately 98% of available computers carrying the ENERGY STAR label. The energy savings were also dependent on the operating mode set by the user. The requirements have been seriously revised in an attempt to offer greater differentiation for innovative, truly energy-efficient models and now address all modes of operation in order to have automatic savings that are not dependent on user behaviour. It is estimated that the new specification will mean that ENERGY STAR computers and computer peripherals use, on average, 60% less energy than conventional models.[94] This premium performance comes at a price that remains comparable to conventional computer models.

### ❑ ENERGY STAR Television

| Measure Profile | |
|---|---|
| Applicable Dwelling Type(s) | All |
| Vintage | New and existing |
| Costs | Incremental cost $50 |
| Savings | 30% |
| Useful Life | 20 years |

ENERGY STAR qualified televisions must use one Watt or less in standby mode, which equates to approximately 30% less energy use annually[95] than a non-qualifying product. An ENERGY STAR TV may be CRT, LCD or plasma technology. The incremental cost of a 32" LCD ENERGY STAR qualified TV compared to its standard counterpart was found to be $20-$100 ($50 has been used in the model, as an approximate midpoint).[96]

[94] ENERGY STAR Press Release, 2006.
[95] Canadian and U.S. ENERGY STAR Calculator.
[96] From retailer scan.

- ❑ **LCD Television**

| Measure Profile | |
|---|---|
| Applicable Dwelling Type(s) | All |
| Vintage | New and existing |
| Costs | $400 incremental cost |
| Savings | 40% |
| Useful Life | 20 years |

Like LCD computer monitors, LCD TVs typically use less energy than CRTs, both when running and when in standby mode. A 27” LCD TV uses approximately 80-100 Watts[97] of power in “on” mode compared to an equivalent CRT monitor, which uses 150 Watts. Energy savings are thus in the order of 40%. LCD TVs are $300-$500[98] more expensive than the CRT equivalents ($400 has been used, as an approximate midpoint). One aspect of consumer behaviour that may complicate analysis of this measure is that people tend to buy larger LCD TVs than CRTs, potentially reducing the savings. We have not included this effect at this stage of the analysis.

### 4.3.7 Lighting

Lighting improvements enhance the efficacy of lighting fixtures, while maintaining service levels. Seven energy-efficiency upgrade options were identified and assessed for this end use as follows:

- Replacement of incandescent lamps with compact fluorescent lights (CFLs)
- White LED lamp
- Replacement of T12s with T8s (mainly in apartment building common areas)
- Redesign with high-performance T8 lighting systems
- LED holiday lighting
- Lighting timers
- Motion sensors.

- ❑ **Replacement of Incandescent Lamps with Compact Fluorescent Lights[99]**

| Measure Profile | |
|---|---|
| Applicable Dwelling Type(s) | All |
| Vintage | New and existing |
| Costs | Incremental cost $3 |
| Savings | 75% |
| Useful Life | 9 years |

[97] Marbek Resources Consultants Ltd. *Consumer Electronics Report*.
[98] From review of retailers.
[99] This measure is the replacement of incandescent lamps in standard applications with relatively long hours of use and no requirement for special shapes or dimming capability. A second compact fluorescent measure was added to the model, to address specialty applications where the lamp is more expensive or the hours of use are shorter. Incremental cost for the specialty CFL measure is $9. All other profile assumptions remain the same.

Compact fluorescent lights (CFLs) can be used to replace incandescent bulbs in most applications. A 13-Watt CFL provides a light output similar to that of a 60-Watt incandescent lamp and consumes approximately 75% less electricity. CFLs have come down a lot in price in recent years with the top end of the price range now being about \$3-\$10[100] for one CFL compared to no more than \$1 for an incandescent bulb (\$3 has been used as an incremental cost in the model, as representative of the majority of standard, low-cost applications). A CFL lasts approximately eight to ten times longer.

- **White LED Lamp**

| **Measure Profile** | |
|---|---|
| Applicable Building Types | All |
| Vintage | Existing and new |
| Costs | Full \$43/lamp; incremental \$38/lamp |
| Savings | 75% of lighting energy |
| Useful Life | 12 years |

This upgrade is a white light-emitting diode (LED) array that displays 800 lumens at 50 lumens per Watt and has a full cost of \$43. Relamping a 65-Watt incandescent reflector lamp with this upgrade results in savings of 75% while producing an equivalent amount of light. In addition, white LEDs currently have a life of 35,000 hours compared to the shorter life of incandescent lamps; this provides additional benefits in the form of lower maintenance and lamp replacement costs. However, this technology is in the early stages of market entry and therefore improvements to the technology in terms of cost and efficacy should be expected in the coming years.

- **Replacement of Existing T12 Lamps and Magnetic Ballasts with T8 Fluorescent Lamps and Electronic Ballasts**

| **Measure Profile** | |
|---|---|
| Applicable Dwelling Type(s) | Detached, attached and apartment |
| Vintage | New and existing |
| Costs | Standard: Full \$41/fixture; incremental \$0<br>High-performance: Full \$50/fixture; incremental \$9/fixture |
| Savings | Standard T8 lamp and ballast: 26%<br>High-performance T8 lamp and ballast: 39% |
| Useful Life | 16 years |

T12 fluorescent lamps and magnetic ballasts can be replaced with standard 32-Watt T8 fluorescent lamps and electronic ballasts or the newer so called “high-performance” T8 lamps and ballasts. T12s still remain in limited applications in detached and attached homes, and in apartment building lobbies and corridors. Standard T8 lighting systems provide savings of approximately 26% relative to the conventional T12 systems in existing buildings. High-performance systems have even greater savings (39%) resulting

[100] From a retailer scan. \$10 is now quite expensive for a singe CFL and might be paid only for a “daylight” model. Lowest prices were in the range of \$3 for one lamp.

from a possible reduction in the number of lamps used due to the superior lumen output of this lighting. In new apartment buildings and other residential applications, the choice of high-performance T8s over standard T8s can save up to 17%.

Typical installed cost can be as little as nothing, when considering the incremental cost of a standard T8 system compared to a T12 system, or $41 per fixture if considering the full cost of a standard T8 system. Typical installed cost can be as little as $9 per fixture when considering the incremental cost of a high-performance T8 system compared to a T12 system, or $50 per fixture if considering the full cost of a high-performance T8 system.

- ❑ **Redesign with High-performance T8 Lighting Systems**

| Measure Profile | |
|---|---|
| Applicable Building Types | All |
| Vintage | Existing |
| Costs | Full $1.72/ft^2; incremental $0.48/ft^2 |
| Savings | 62% of lighting energy |
| Useful Life | 16 years |

The combination of lighting redesign to lower light levels and next generation T8 lighting systems results in savings of 62% and a lower incremental cost (due to fewer fixtures) relative to baseline T12 systems.

| Measure Profile | |
|---|---|
| Applicable Building Types | All |
| Vintage | New |
| Costs | Full $1.72/ft^2; incremental $0.01/ft^2 |
| Savings | 48% of lighting energy |
| Useful Life | 16 years |

This technology upgrade is the same as previously described in the T12 upgrades discussion above. However, in this case the savings are 48% relative to the baseline standard T8 systems.

- ❑ **Replacement of Incandescent Holiday Lights with LED Holiday Lights**

| Measure Profile | |
|---|---|
| Applicable Dwelling Type(s) | All |
| Vintage | New and existing |
| Costs | $2 incremental cost |
| Savings | 91% |
| Useful Life | 20 years |

LED seasonal decorative lights (including Christmas lights) can replace existing incandescent light strings. A string of LED holiday lights uses 14 Watts on average compared to a string of incandescent lights, which uses 150 Watts on average. LED strings thus consume less than 10% of the electricity used by a comparable string of incandescent holiday lights.

LED holiday lights are now available in most hardware stores at an incremental cost of about $1 to $3 ($2 has been used in the model, as an approximate midpoint). LED holiday lights can also last up to 10 times longer than incandescent holiday lights.

### ❑ Lighting Timers

| Measure Profile | |
|---|---|
| Applicable Dwelling Type(s) | All |
| Vintage | New and existing |
| Costs | Full cost $20 |
| Savings | 60% |
| Useful Life | 10 years |

Outdoor security lights or aesthetic lights are often fitted with a photo-sensor to run from dusk until dawn. However, if exterior lighting is only required until a certain hour (e.g., 11 pm), a timer can be installed to turn the light off automatically.

This analysis assumes that in the base case an outdoor light operates from dusk to dawn (on average 10 hours a night over the course of the year[101]) and a timer reduces this to an average of 4 hours a night. Energy savings are, therefore, in the range of 60%. Outdoor light timers cost approximately $20.[102]

### ❑ Motion Sensors

| Measure Profile | |
|---|---|
| Applicable Dwelling Type(s) | All |
| Vintage | New and existing |
| Costs | Full cost $50 |
| Savings | 95% |
| Useful Life | 10 years |

Motion sensors for residential security lighting are designed to switch on the light only if there is movement. This reduces the time that the light is actually on to 30-60 minutes per night on average and results in energy savings of approximately 95%. Motion sensors cost approximately $50.[103]

[101] Marbek Resource Consultants Ltd., *Dusk to Dawn Luminaires*.
[102] From retailer scan.
[103] From retailer scan.

## 4.4 SUMMARY OF ENERGY-EFFICIENCY RESULTS

The energy-efficiency measures and associated CCEs are summarized in Exhibit 4.2. Note that the negative values shown for selected lighting upgrades indicate that the annualized capital cost of the energy-efficiency measure is less expensive than the baseline technology.

The building-level measures for apartment buildings and their associated CCEs were derived from the results found for the Commercial sector. These are presented in Exhibit 4.3 (numbered Exhibit 4.2 in the Commercial sector report). Note that some measures in this table are not applicable to residential buildings. Measures that apply within the apartment suites are included in Exhibit 4.2 below.

## Exhibit 4.2: Residential Energy-efficiency Technologies and Measures – Cost of Conserved Energy

**Summary of CCE's - Residential Sector**

| End Use | | Technology | Dwelling Type | Vintage | Sp heating fuel | CCEs (¢/kWh) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 4.0% DR | | 6.0% DR | | 8.0% DR | |
| | | | | | | Full | Incr. | Full | Incr. | Full | Incr. |
| Lighting | Upgrade 1 | Replace incandescent with CFL | All Detachments | New & Exist. | Elec. & Non-elec. | 0.7 | -2.3 | 0.8 | -2.3 | 0.9 | -2.3 |
| | Upgrade 2 | Replace incandescent with CFL - Specialized applications | All Detachments | New & Exist. | Elec. & Non-elec. | 6.3 | -3.8 | 6.9 | -3.3 | 7.5 | -2.9 |
| | Upgrade 3 | Replace incandescent with white LED | All Detachments | New & Exist. | Elec. & Non-elec. | 16.6 | 16.5 | 19.0 | 18.8 | 21.5 | 21.2 |
| | Upgrade 4 | Replace T12 with T8 | Detached/Attached | New & Exist. | Elec. & Non-elec. | 4.2 | | 4.8 | | 5.5 | |
| | Upgrade 5 | Replace T12 with T8 | Apartment | New & Exist. | Elec. & Non-elec. | 0.6 | | 0.7 | | 0.8 | |
| | Upgrade 6 | Replace porchlight with CFL | Detached/Attached | New & Exist. | Elec. & Non-elec. | 0.2 | -0.7 | 0.2 | -0.7 | 0.3 | -0.7 |
| | Upgrade 7 | Replace porchlight with white LED | Detached/Attached | New & Exist. | Elec. & Non-elec. | 5.0 | 4.9 | 5.7 | 5.6 | 6.5 | 6.4 |
| | Upgrade 8 | Exterior and holiday lights | All Detachments | New & Exist. | Elec. & Non-elec. | 5.6 | -9.7 | 6.6 | -9.1 | 7.7 | -8.5 |
| | Upgrade 9 | Motion Sensor | All Detachments | New & Exist. | Elec. & Non-elec. | 3.0 | | 3.3 | | 3.6 | |
| | Upgrade 10 | Lighting Timer | All Detachments | New & Exist. | Elec. & Non-elec. | 1.9 | | 2.1 | | 2.3 | |
| Existing Building Envelope - Island & Isolated | Upgrade 1 | High-performance glazings | Detached | New | Elec | | 4.2 | | 5.2 | | 6.2 |
| | Upgrade 1 | High-performance glazings | Row | New | Elec | | 3.7 | | 4.5 | | 5.4 |
| | Upgrade 1 | High-performance glazings | Detached | Exist. | Elec | | 3.4 | | 4.2 | | 5.0 |
| | Upgrade 1 | High-performance glazings | Row | Exist. | Elec | | 3.9 | | 4.7 | | 5.7 |
| | Upgrade 2 | ENERGYSTAR glazings | Detached | New | Elec | | 1.6 | | 2.0 | | 2.3 |
| | Upgrade 2 | ENERGYSTAR glazings | Row | New | Elec | | 1.5 | | 1.8 | | 2.1 |
| | Upgrade 2 | ENERGYSTAR glazings | Detached | Exist. | Elec | | 2.4 | | 3.0 | | 3.6 |
| | Upgrade 2 | ENERGYSTAR glazings | Row | Exist. | Elec | | 2.9 | | 3.6 | | 4.3 |
| | Upgrade 3 | Wall Insulation | Detached | New | Elec | | 14.7 | | 18.0 | | 21.5 |
| | Upgrade 3 | Wall Insulation | Row | New | Elec | | 16.1 | | 19.6 | | 23.5 |
| | Upgrade 3 | Wall Insulation | Detached | Exist. | Elec | | 11.7 | | 14.2 | | 17.1 |
| | Upgrade 3 | Wall Insulation | Row | Exist. | Elec | | 15.3 | | 18.8 | | 22.5 |
| | Upgrade 4 | Attic Insulation | Detached | New | Elec | | 10.2 | | 12.5 | | 14.9 |
| | Upgrade 4 | Attic Insulation | Row | New | Elec | | 11.7 | | 14.3 | | 17.2 |
| | Upgrade 4 | Attic Insulation | Detached | Exist. | Elec | | 5.7 | | 6.9 | | 8.3 |
| | Upgrade 4 | Attic Insulation | Row | Exist. | Elec | | 7.6 | | 9.3 | | 11.1 |
| | Upgrade 5 | Foundation Insulation | Detached | New | Elec | | 5.9 | | 7.2 | | 8.6 |
| | Upgrade 5 | Foundation Insulation | Row | New | Elec | | 3.7 | | 4.5 | | 5.4 |
| | Upgrade 5 | Foundation Insulation | Detached | Exist. | Elec | | 6.9 | | 8.4 | | 10.1 |
| | Upgrade 5 | Foundation Insulation | Row | Exist. | Elec | | 4.7 | | 5.7 | | 6.8 |
| | Upgrade 5 | Crawlspace Insulation | Detached | New | Elec | | 2.0 | | 2.5 | | 3.0 |
| | Upgrade 5 | Crawlspace Insulation | Row | New | Elec | | 3.5 | | 4.3 | | 5.1 |
| | Upgrade 5 | Crawlspace Insulation | Detached | Exist. | Elec | | 2.2 | | 2.7 | | 3.2 |
| | Upgrade 5 | Crawlspace Insulation | Row | Exist. | Elec | | 4.0 | | 4.9 | | 5.9 |
| | Upgrade 6 | Air leakage sealing | Detached | New | Elec | | 8.9 | | 9.8 | | 10.7 |
| | Upgrade 6 | Air leakage sealing | Row | New | Elec | | 9.8 | | 10.8 | | 11.8 |
| | Upgrade 6 | Air leakage sealing | Detached | Exist. | Elec | | 9.1 | | 10.2 | | 11.4 |
| | Upgrade 6 | Air leakage sealing | Row | Exist. | Elec | | 10.1 | | 11.3 | | 12.6 |

**Exhibit 4.2: Residential Energy-efficiency Technologies and Measures – Cost of Conserved Energy (cont'd)**

| End Use | | Technology | Dwelling Type | Vintage | Sp heating fuel | CCEs (¢/kWh) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 4.0% DR | | 6.0% DR | | 8.0% DR | |
| | | | | | | Full | Incr. | Full | Incr. | Full | Incr. |
| Existing Building Envelope - Labrador Interconnected | Upgrade 1 | High-performance glazings | Detached | New | Elec | | 2.6 | | 3.2 | | 3.8 |
| | Upgrade 1 | High-performance glazings | Row | New | Elec | | 2.4 | | 2.9 | | 3.5 |
| | Upgrade 1 | High-performance glazings | Detached | Exist. | Elec | | 2.5 | | 3.1 | | 3.7 |
| | Upgrade 1 | High-performance glazings | Row | Exist. | Elec | | 2.4 | | 3.0 | | 3.5 |
| | Upgrade 2 | ENERGYSTAR glazings | Detached | New | Elec | | 1.0 | | 1.2 | | 1.4 |
| | Upgrade 2 | ENERGYSTAR glazings | Row | New | Elec | | 0.9 | | 1.1 | | 1.4 |
| | Upgrade 2 | ENERGYSTAR glazings | Detached | Exist. | Elec | | 1.7 | | 2.1 | | 2.5 |
| | Upgrade 2 | ENERGYSTAR glazings | Row | Exist. | Elec | | 1.9 | | 2.3 | | 2.7 |
| | Upgrade 3 | Wall Insulation | Detached | New | Elec | | 12.8 | | 15.7 | | 18.8 |
| | Upgrade 3 | Wall Insulation | Row | New | Elec | | 9.2 | | 11.2 | | 13.5 |
| | Upgrade 3 | Wall Insulation | Detached | Exist. | Elec | | 4.4 | | 5.3 | | 6.4 |
| | Upgrade 3 | Wall Insulation | Row | Exist. | Elec | | 5.5 | | 6.7 | | 8.1 |
| | Upgrade 4 | Attic Insulation | Detached | New | Elec | | 6.8 | | 8.3 | | 9.9 |
| | Upgrade 4 | Attic Insulation | Row | New | Elec | | 6.0 | | 7.3 | | 8.8 |
| | Upgrade 4 | Attic Insulation | Detached | Exist. | Elec | | 2.5 | | 3.1 | | 3.7 |
| | Upgrade 4 | Attic Insulation | Row | Exist. | Elec | | 3.1 | | 3.8 | | 4.6 |
| | Upgrade 5 | Foundation Insulation | Detached | New | Elec | | 1.6 | | 2.0 | | 2.3 |
| | Upgrade 5 | Foundation Insulation | Row | New | Elec | | 1.0 | | 1.2 | | 1.4 |
| | Upgrade 5 | Foundation Insulation | Detached | Exist. | Elec | | 2.0 | | 2.4 | | 2.9 |
| | Upgrade 5 | Foundation Insulation | Row | Exist. | Elec | | 1.5 | | 1.9 | | 2.2 |
| | Upgrade 5 | Crawlspace Insulation | Detached | New | Elec | | 1.0 | | 1.2 | | 1.4 |
| | Upgrade 5 | Crawlspace Insulation | Row | New | Elec | | 1.8 | | 2.2 | | 2.6 |
| | Upgrade 5 | Crawlspace Insulation | Detached | Exist. | Elec | | 1.3 | | 1.6 | | 1.9 |
| | Upgrade 5 | Crawlspace Insulation | Row | Exist. | Elec | | 2.3 | | 2.9 | | 3.4 |
| | Upgrade 6 | Air leakage sealing | Detached | New | Elec | | 3.0 | | 3.2 | | 3.5 |
| | Upgrade 6 | Air leakage sealing | Row | New | Elec | | 3.2 | | 3.5 | | 3.8 |
| | Upgrade 6 | Air leakage sealing | Detached | Exist. | Elec | | 3.7 | | 4.1 | | 4.6 |
| | Upgrade 6 | Air leakage sealing | Row | Exist. | Elec | | 3.9 | | 4.4 | | 4.9 |
| Space Heating and Ventilation Equipment | Upgrade 1 | Prog. Tstat - High Cons. | All Detachments | New & Exist. | Elec | 0.5 | | 0.6 | | 0.6 | |
| | Upgrade 1 | Prog. Tstat - Med Cons. | All Detachments | New & Exist. | Elec | 1.0 | | 1.2 | | 1.3 | |
| | Upgrade 1 | Prog. Tstat - Low Cons. | All Detachments | New & Exist. | Elec | 1.6 | | 1.7 | | 1.9 | |
| | Upgrade 1 | Eff. Tstat - High Cons. | All Detachments | New & Exist. | Elec | 0.4 | | 0.5 | | 0.5 | |
| | Upgrade 1 | Eff. Tstat - Med Cons. | All Detachments | New & Exist. | Elec | 0.9 | | 1.0 | | 1.1 | |
| | Upgrade 1 | Eff. Tstat - Low Cons. | All Detachments | New & Exist. | Elec | 1.3 | | 1.5 | | 1.7 | |
| | Upgrade 1 | Air source heat pump | All Detachments - Island | New | Elec | 11.7 | 9.6 | 13.9 | 11.4 | 16.2 | 13.3 |
| | Upgrade 2 | Air source heat pump | All Detachments - Lab | New | Elec | 4.7 | 3.9 | 5.6 | 4.6 | 6.6 | 5.4 |
| | Upgrade 3 | Ground source heat pump | All Detachments - Island | New | Elec | 18.0 | 16.4 | 21.4 | 19.4 | 25.0 | 22.7 |
| | Upgrade 1 | Ground source heat pump | All Detachments - Lab | New | Elec | 7.3 | 6.6 | 8.6 | 7.9 | 10.1 | 9.2 |
| | Upgrade 3 | Integrated Space/DHW heating | All Detachments - Island | New | Elec | 15.7 | 14.4 | 18.6 | 17.0 | 21.8 | 19.9 |
| | Upgrade 1 | Integrated Space/DHW heating | All Detachments - Lab | New | Elec | 7.1 | 6.5 | 8.4 | 7.7 | 9.8 | 9.0 |

**Exhibit 4.2: Residential Energy-efficiency Technologies and Measures – Cost of Conserved Energy (cont'd)**

| End Use | | Technology | Dwelling Type | Vintage | Sp heating fuel | CCEs (¢/kWh) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 4.0% DR | | 6.0% DR | | 8.0% DR | |
| | | | | | | Full | Incr. | Full | Incr. | Full | Incr. |
| Space Heating and Ventilation Equipment | Upgrade1 | Electronically commutated permanent magnet motors (ECPM) - High Cons | Detached/Attached | New/Existing | Elec. & Non-elec. | | 3.7 | | 4.4 | | 5.1 |
| | Upgrade1 | Electronically commutated permanent magnet motors (ECPM) - Low Cons | Detached/Attached | New/Existing | Elec. & Non-elec. | | 7.4 | | 8.7 | | 10.2 |
| | Upgrade1 | Electronically commutated permanent magnet motors (ECPM) - Continuous | Detached/Attached | New/Existing | Elec. & Non-elec. | | 0.9 | | 1.1 | | 1.3 |
| | Upgrade2 | Heat Recovery Ventilator - High Cons | Detached/Attached | New & Exist. | Elec. & Non-elec. | 15.2 | 3.1 | 17.4 | 3.6 | 19.7 | 4.1 |
| | Upgrade2 | Heat Recovery Ventilator - Med Cons | Detached/Attached | New & Exist. | Elec. & Non-elec. | 35.1 | 7.2 | 40.2 | 8.3 | 45.6 | 9.4 |
| | Upgrade2 | Heat Recovery Ventilator - Low Cons | Detached/Attached | New & Exist. | Elec. & Non-elec. | 39.7 | 8.2 | 45.4 | 9.4 | 51.5 | 10.6 |
| Domestic Hot Water | Upgrade1 | Efficient shower/faucet | All Detachments | Exist. | Elec DHW | 0.9 | | 1.0 | | 1.1 | |
| | Upgrade2 | DHW tank insulation | Detached | New & Exist. | Elec DHW | 1.9 | 1.9 | 2.1 | 2.1 | 2.3 | 2.3 |
| | Upgrade2 | DHW tank insulation | Attached | New & Exist. | Elec DHW | 4.1 | 4.1 | 4.5 | 4.5 | 5.0 | 5.0 |
| | Upgrade 3 | Heat trap | All Detachments | New & Exist. | Elec DHW | 18.4 | 18.4 | 19.2 | 19.2 | 20.1 | 20.1 |
| | Upgrade 4 | Pipe Insulation | Detached/Attached | New & Exist. | Elec DHW | 0.4 | 0.4 | 0.4 | 0.4 | 0.5 | 0.5 |
| Major Appliances | Upgrade 1 | Energy Star top-loading clothes washer + Dryer energy | All Detachments | New & Exist. | Elec DHW | | 7.5 | | 8.6 | | 9.8 |
| | Upgrade 2 | Horizontal axis clothes washer + Dryer Energy | All Detachments | New & Exist. | Elec DHW | | 16.6 | | 19.0 | | 21.5 |
| | Upgrade 3 | New Energy Star dishwasher | All Detachments | New & Exist. | Elec DHW | | 17.4 | | 19.6 | | 21.9 |
| | Upgrade 4 | Highest efficiency dishwasher | All Detachments | New & Exist. | Elec DHW | | 1.5 | | 1.7 | | 1.9 |
| | Upgrade 5 | Energy Star 18 Cu Ft New | Detached/Attached | New & Exist. | Elec. & Non-elec. | | 4.5 | | 5.2 | | 6.1 |
| | Upgrade 6 | Highest efficiency refrigerator | Detached/Attached | New & Exist. | Elec. & Non-elec. | | 74.1 | | 88.1 | | 103.2 |
| | Upgrade 7 | Energy Star compact | Apartment | New & Exist. | Elec. & Non-elec. | | 4.3 | | 5.1 | | 5.9 |
| | Upgrade 8 | High efficiency freezer | Detached/Attached | New & Exist. | Elec. & Non-elec. | | 7.6 | | 8.9 | | 10.3 |
| | Upgrade 9 | High efficiency freezer | Apartment | New & Exist. | Elec. & Non-elec. | | 12.5 | | 14.6 | | 16.9 |
| | Upgrade 10 | Microwave/convection oven | All Detachments | | | | 50.6 | | 59.9 | | 70.0 |
| Household Electronics | Upgrade 1 | ENERGY STAR Computer | All Detachments | New & Exist. | Elec. & Non-elec. | | 0.0 | | 0.0 | | 0.0 |
| | Upgrade 2 | LCD monitors | All Detachments | New & Exist. | Elec. & Non-elec. | | -0.8 | | 0.1 | | 1.0 |
| | Upgrade 3 | ENERGY STAR television | All Detachments | New & Exist. | Elec. | | 4.9 | | 5.8 | | 6.8 |
| | Upgrade 3 | LCD Television | All Detachments | New & Exist. | Elec. | | 29.0 | | 34.3 | | 40.1 |
| | Upgrade 4 | Miscellaneous reduced standby | All Detachments | New & Exist. | Elec. & Non-elec. | | 1.4 | | 1.6 | | 1.9 |
| New Building Design | Upgrade 1 | R2000 housing | Detached | New | Elec. | 252.4 | 6.8 | 317.1 | 8.5 | 387.8 | 10.4 |
| | Upgrade 2 | EGH 80 | Detached | New | Elec. | 249.4 | 3.7 | 313.3 | 4.6 | 383.0 | 5.7 |
| Fuel Switching | Upgrade 1 | Oil Furnace, New Island Detached | Detached | New | Elec. | | 13.6 | | 14.1 | | 14.6 |
| | Upgrade 1 | Oil Furnace, New Labrador Detached | Detached | New | Elec. | | 10.8 | | 11.0 | | 11.2 |
| | Upgrade 1 | Oil Furnace, New Island Attached | Attached | New | Elec. | | 12.8 | | 13.2 | | 13.7 |
| | Upgrade 1 | Oil Furnace, New Labrador Attached | Attached | New | Elec. | | 10.2 | | 10.4 | | 10.6 |
| | Upgrade 2 | Propane Cooking Range | All Detachments | New & Exist. | Elec. | | 49.0 | | 50.3 | | 51.8 |

## Exhibit 4.3: Commercial (Apartment Buildings) Energy-efficiency Technologies and Measures – Cost of Conserved Energy[104]

| Measure/Technology | | | Vintage | CCEs (¢/kWh) | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | 4.0% DR | | 6.0% DR | | 8.0% DR | |
| | | | | Full | Incr. | Full | Incr. | Full | Incr. |
| Lighting | T12 | Standard T8s | Existing | 5.4 | 0.0 | 6.3 | 0.0 | 7.2 | 0.0 |
| | | Low BF T8s | Existing | 3.9 | 0.0 | 4.6 | 0.0 | 5.2 | 0.0 |
| | | High-performance T8s | Existing | 4.2 | 0.5 | 4.9 | 0.7 | 5.7 | 0.8 |
| | | Redesign with standard T8s | Existing | 5.1 | -2.0 | 5.9 | -2.3 | 6.8 | -2.6 |
| | | Redesign with high-performance T8s | Existing | 4.9 | -1.3 | 5.6 | -1.6 | 6.4 | -1.8 |
| | T8 | High-performance T8s | Existing & New | 13.1 | 1.7 | 15.3 | 2.1 | 17.6 | 2.5 |
| | | Redesign with high-performance T8s | Existing & New | 8.4 | 0.0 | 9.8 | 0.0 | 11.2 | 0.0 |
| | | Fully integrated lighting and controls | Existing & New | 29.6 | 22.0 | 34.3 | 25.4 | 39.3 | 29.2 |
| | | Occupancy sensors | Existing & New | 6.0 | 4.3 | 6.6 | 4.7 | 7.2 | 5.1 |
| | Inc | Compact fluorescent lamps | Existing & New | 2.7 | -1.1 | 2.9 | -1.0 | 3.2 | -0.8 |
| | | Induction lighting | Existing & New | 4.5 | 0.4 | 4.9 | 0.7 | 5.4 | 1.1 |
| | | White LEDs | Existing & New | 0.1 | -3.5 | 0.4 | -3.2 | 0.8 | -2.8 |
| | | Halogen IR | Existing & New | 10.1 | -4.8 | 10.5 | -4.7 | 10.8 | -4.6 |
| | | Ceramic metal halide | Existing & New | 4.7 | -4.6 | 5.1 | -4.4 | 5.6 | -4.1 |
| | | LED exit signs | Existing | 1.7 | na | 2.0 | na | 2.4 | na |
| | HID | Pulse-start metal halide | Existing & New | 9.5 | 0.3 | 10.9 | 0.3 | 12.5 | 0.4 |
| | | High intensity fluorescents | Existing & New | 4.1 | 0.4 | 4.8 | 0.5 | 5.4 | 0.5 |
| HVAC | | Low temperature heat pumps - Island | Existing & New | na | 5.5 | na | 6.0 | na | 6.6 |
| | | Low temperature heat pumps - Labrador | Existing & New | na | 4.8 | na | 5.3 | na | 5.8 |
| | | Ground source heat pumps - Island | Existing & New | na | 6.2 | na | 7.3 | na | 8.6 |
| | | Ground source heat pumps - Labrador | Existing & New | na | 4.5 | na | 5.4 | na | 6.3 |
| | | Infrared heaters - Island | Existing & New | 6.7 | 6.7 | 7.4 | 7.4 | 8.1 | 8.1 |
| | | Infrared heaters - Labrador | Existing & New | 4.8 | 4.8 | 5.3 | 5.3 | 5.8 | 5.8 |
| | | High-efficiency chillers - Island | Existing & New | na | 6.1 | na | 7.4 | na | 8.9 |
| | | High-efficiency chillers - Labrador | Existing & New | na | 8.1 | na | 9.9 | na | 11.8 |
| | | High-efficiency AC units - Island | Existing & New | na | 11.3 | na | 12.9 | na | 14.7 |
| | | High-efficiency AC units - Labrador | Existing & New | na | 18.7 | na | 21.5 | na | 24.3 |
| | | Adjustable speed drives | Existing & New | 5.0 | 5.0 | 5.6 | 5.6 | 6.1 | 6.1 |
| | | Premium efficiency motors | Existing & New | 19.5 | 2.9 | 21.5 | 3.2 | 23.5 | 3.6 |
| | | Building recommissioning | Existing | 4.0 | na | 4.3 | na | 4.5 | na |
| | | Advanced BAS | Existing & New | 4.3 | na | 4.7 | na | 5.1 | na |
| | | Programmable thermostats - Island | Existing & New | 1.8 | 0.9 | 2.0 | 1.0 | 2.2 | 1.1 |
| | | Programmable thermostats - Labrador | Existing & New | 1.6 | 0.8 | 1.8 | 0.9 | 1.9 | 1.0 |
| DHW | | Low-flow aerators & shower heads | Existing & New | 2.6 | na | 2.8 | na | 2.9 | na |
| | | Tankless water heaters | Existing & New | na | 37.4 | na | 41.2 | na | 45.2 |
| Building Envelope | | High-performance glazings - Island | Existing & New | na | 5.5 | na | 6.5 | na | 7.5 |
| | | High-performance glazings - Labrador | Existing & New | na | 3.3 | na | 4.0 | na | 4.6 |
| | | Wall insulation - Island | Existing & New | na | 6.0 | na | 7.4 | na | 8.8 |
| | | Wall insulation - Labrador | Existing & New | na | 4.2 | na | 5.1 | na | 6.1 |
| | | Roof insulation - Island | Existing & New | na | 6.9 | na | 8.5 | na | 10.1 |
| | | Roof insulation - Labrador | Existing & New | na | 4.4 | na | 5.3 | na | 6.4 |
| | | Air curtains - Island | Existing & New | 5.1 | 5.1 | 5.8 | 5.8 | 6.6 | 6.6 |
| | | Air curtains - Labrador | Existing & New | 3.3 | 3.3 | 3.8 | 3.8 | 4.3 | 4.3 |
| New Construction | | New buildings - 25% more efficient | New | na | 0.9 | na | 1.1 | na | 1.4 |
| | | New buildings - 40% more efficient | New | na | 2.5 | na | 3.1 | na | 3.8 |

[104] This exhibit is produced from the measure summary in the Commercial report.

## 4.5 PEAK LOAD REDUCTION MEASURES

### 4.5.1 Overview

Electric utilities are typically interested in peak load reduction measures as a means to avoid or defer the costs of capacity expansion. Capacity costs refer to a wide range of capital-based investments, including generating stations (new and upgraded), transmission lines, distribution lines, substations, transformers and other infrastructure required to deliver power.

From the customer's perspective, adoption of peak load reduction measures is typically dependent on the overall benefits to them, such as direct incentive payments or rate benefits. Under most current rate structures, residential customers are billed only for electricity (kWh) regardless of when it is used, and not for "demand." Consequently, in the absence of specific peak-based rate structures, peak load reduction measures that do not also reduce overall energy consumption do not provide financial benefits to customers.

The current trend throughout much of the North American utility industry is towards more specific pricing, such as time-of-use and even hourly pricing, or peak incentives that pass along some of the utility benefits to customers on a performance basis. These new pricing structures provide incentive for even residential customers to implement measures or to participate in utility peak load reduction programs, as long as the differential between peak and off-peak prices is sufficient to provide a noticeable financial benefit to the customer. To date, effective implementation of many of the potential peak load reduction options has been limited by the availability and cost of suitable metering and data communications technology.

Currently, several Canadian jurisdictions[105] are in the early stages of implementing pilot Residential sector load reduction initiatives. These initiatives are designed to test:

- New metering technologies, such as advanced meters (also referred to as "smart meters")
- New rate structures, such as real-time feedback, pay-as-you-go billing and critical peak pricing
- Direct load control.

Most conventional meters monitor electricity consumption (kWh) but do not track *when* the electricity is used. Instead, conventional meters are occasionally read and reported to electric utilities, which then bill customers every one or two months. As a result, customers only find out their electricity usage after the fact.

In contrast, advanced meters (known in some industry circles as "smart meters") record how much electricity is used and when. Advanced meters, through their interval metering

[105] Marbek Resource Consultants; *Technology & Market Assessment of Residential Electricity Advanced Metering In Canada. P*repared for Natural Resources Canada, November 2006.

and two-way communications, allow the implementation of numerous utility programs and services that encourage customers to reduce or shift (i.e., change the time of) their electricity consumption, particularly away from peak times when the cost of supply is becoming increasingly more expensive.

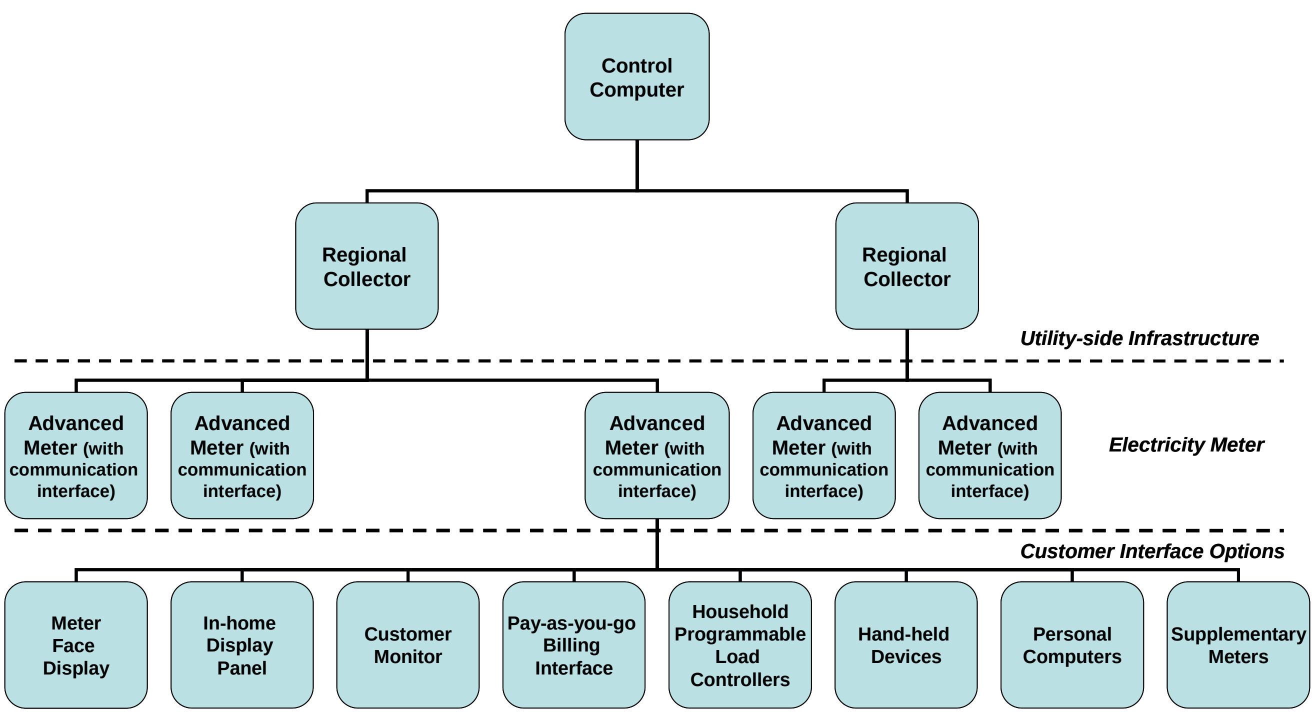
Exhibit 4.4 presents an illustrative schematic of an advanced metering system. As illustrated, there are three major levels of system components:

- **Customer Interface Options** — The hardware interfaces that can be used for the advanced meter to communicate with the customer and, to a certain extent, any applicable electrical load controllers in the customer's household.

- **Electricity Meter** — The advanced meter itself, equipped with a communication interface to facilitate communication to other devices and the utility.

- **Utility-side Infrastructure** — The infrastructure required for two-way communication between the utility and the advanced meter.[106]

**Exhibit 4.4: Illustrative Schematic of an Advanced Metering System**




[106] Ibid, *Technology & Market Assessment of Residential Electricity Advanced Metering In Canada*. page 4

As illustrated in Exhibit 4.4, there is wide range of technical options available at each level in a typical advanced metering system. This is particularly the case at the customer interface level where there is a growing number of devices that can be used to provide real-time feedback to customers in a convenient and understandable manner. Typically, these devices provide a numerical or graphical display that is either wired into the same room as the meter, wired next to the main thermostat, or is a wireless panel that can be placed anywhere in the home. Alone, none of these devices save energy per se, though the information provided may enable consumer behaviour change.

In summary, new electric metering and customer interface technologies, when combined with the applicable utility infrastructure, have the potential to support a wide range of utility-sponsored peak load reduction and load shifting initiatives via pricing and promotional initiatives. Within the agreed study scope, it is not feasible to provide further specific rate design or system infrastructure specifications. However, further information is provided below on selected direct load control options.

### 4.5.2 Peak Load Reduction Measures – Direct Load Control

Consistent with the agreed study scope, the information provided below is based on existing secondary data sources and does not include a detailed analysis of specific peak load conditions of the Utilities. Much of the information provided draws from work that the consultant team recently completed for BC Hydro.[107] To that end, the material presented is intended to be indicative of general trends and costs but would also need to be adjusted for specific application to NLH/NP peak load conditions.[108]

The remainder of this subsection provides an overview of the following Residential sector peak load reduction measures:

- Utility control of space heating equipment using remote thermostat or switch
- Utility control of DHW heater using remote switch.

#### ❑ Utility-Based Control of Space Heating Equipment

Utility-based control of space heating equipment can be thermostat-based or switch-based. Thermostat-based control typically applies to those applications where there is one thermostat that controls a central furnace (or air conditioner) that provides space conditioning for the entire home. Switch-based control, on the other hand, applies to those applications where space heating is provided by baseboard heaters with individual (or multiple) thermostats. As virtually all of the residential electric space heating in Newfoundland and Labrador is baseboard heating, the remainder of this discussion focuses on switch-based space heating load control.

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[107] Marbek Resource Consultants and Applied Energy Group. *BC Hydro Conservation Potential Review – 2007*. Prepared for BC Hydro, 2007.

[108] As both BC Hydro and NLH/NP are winter peaking utilities and both are hydro-based with fossil fuel plants serving peak load conditions, the information provided is expected to be generally applicable to the NLH/NP context.

Switch-based space heating load control is accomplished by the installation of a remote control switch on either the heating unit itself or on the circuits controlling the heating unit. This measure primarily addresses units where temperature control is on each room unit, without a central thermostat capability. Typically this would include baseboard units with individual controls or where one or more units are controlled from an electrical circuit. Typically, units are not shut off for the entire control period but rather "cycled" to limit the on time to a predetermined number of minutes per control cycle. Installations are also equipped with an owner-operated override to ensure that the customer's comfort is not adversely impacted.

The control technology is commercially available and has been implemented in millions of sites in the U.S. However, in the overwhelming majority of applications, this control technology has been applied to air conditioning loads, not space heating loads.

The research conducted for the BC Hydro study[109] noted that switches cost approximately $285 ($170 device plus $115 installation), plus 10% annual equipment maintenance ($12/year). The installation cost is higher for the switch because it involves a high voltage connection and would thus require a higher skilled installer (in many locales this would be a licensed electrician). Installation costs are the same in both new and existing homes.

Actual peak load reduction is difficult to predict due to the impacts of customer override to mitigate adverse comfort impacts, which depend heavily on the degree of over- or under-sizing of the units as well as the overall thermal characteristics of the home. Override control is critical to ensure that customers with undersized systems, poor insulation or low tolerance for cold would not be too adversely affected.

On a household basis, the BC Hydro study concluded that the potential peak load reduction (during the 8 am to 1 pm period on a typical winter peak day) would be in the range of 0.74-0.92 kW per single-family dwelling (annual space heat load of about 13,000 kWh), assuming a comparable level of overrides and system failures to current thermostat programs. Previous experience has also shown that reductions may erode over time due to a number of factors, including signal strength losses and customer overrides.

Based on a one-time cost of approximately $285 ($170 device plus $115 installation), plus 10% annual equipment maintenance ($12/year), and estimated annual impacts of 0.74-0.92 kW per household, the BC Hydro study estimated that the cost would be in the range of about $30-$40[110] per kW/year when applied to single-family dwellings with 100% electric fuel use. Utility infrastructure costs as well as program promotion or incentive costs are in addition.

***Caveat***

The experience in this technology has primarily been for central air conditioning and water heater load control. As there are no customer benefits inherent in the technology, a

[109] Op. cit., BC Hydro Conservation Potential Review – 2007, p. 140.
[110] Assumes 15-year life, 6% discount rate.

cash incentive would typically be expected for each season that the measure was needed, payable either by season or by event (or both).

- **Utility Control of Domestic Hot Water Heater Using Remote Switch**

Switch-based water heater load control is accomplished by the installation of a remote control switch on either the water heater itself or on the circuits controlling the water heater. In older systems, this type of control has been accomplished via radio frequency (RF) control, which allows remote shut off of the water heater under specific capacity-constrained conditions during a limited number of pre-specified hours during winter peak months. In the systems that are currently offered, pager-based communications is used. An even more economic solution is to piggyback off an existing communications system. For example, if space heat control already exists, water heat control can be added via a hard-wired or wireless connection. This can reduce the total cost of the water heater control by up to 40%.

Depending upon the length of the control and the size of the water heater tank, units can be shut off for the entire control period or "cycled" to limit the on time to a predetermined number of minutes per control cycle. Water heat control is commercially available and implemented in hundreds of thousands of sites in the U.S.

Applicable dwelling types should have a water heater that has at least a 40-gallon tank. The size of the tank is important because it provides hot water during times when the control is in effect. The larger the water heater tank, the longer the control can be in place without disrupting the customer's comfort.

Switches cost about $100 per unit, plus $150 for installation, plus maintenance. Costs are reduced to $150 (i.e., $50 incremental installation) if the control switch can be added to an existing control system at the same time, including one-way/two-way thermostats and switches for space heating. Installation costs are the same in both new and existing homes.[111]

On a household basis, the BC Hydro study concluded that the potential peak load reduction (during the 8 am to 1 pm period on a typical winter peak day) would be about 0.66 kW. This assumes annual DHW electricity consumption of about 3,300 kWh/yr. per household.

Based on a one-time cost of approximately $250, ongoing maintenance of 5% (about $12/year) and estimated annual impacts of 0.63-0.70 kW, the BC Hydro study estimated that the cost would be in the range of about $49-$55[112] per kW/year when applied to single-family dwellings. As an incremental option to space heating load control, the installation costs would be reduced by $100 and the resulting cost of electric peak reduction (CEPR) would be $35-$39 per kW. Utility infrastructure costs as well as program promotion or incentive costs are in addition.

[111] Op. cit., BC Hydro Conservation Potential Review – 2007, p. 146.
[112] Assumes 15-year life, 6% discount rate.

Because there are no customer benefits inherent in the technology, a cash incentive would typically be expected for each season that the measure was needed, payable either by season or by event (or both). Additional work would be required to maintain, verify and evaluate the system performance to the same degree of accuracy as two-way thermostat systems due to the lack of confirmation and higher incidence of removals and failures.

***Caveat***

This water heater control measure would not provide customers with any ancillary benefits and thus the only incentive for their participation would be monetary, likely on a per annum or per control event basis.

# 5. ECONOMIC POTENTIAL ELECTRICITY FORECAST

## 5.1 INTRODUCTION

This section presents the Residential sector Economic Potential Forecast for the study period 2006 to 2026. The Economic Potential Forecast estimates the level of electricity consumption that would occur if all equipment and building envelopes were upgraded to the level that is cost effective against the long run avoided cost of electricity in the Newfoundland Labrador service area. In this study, "cost effective" means that the technology upgrade cost, referred to as the cost of conserved energy (CCE) in the preceding section, is equal to, or less than, the economic screen.[113]

The discussion in this section is organized according to the following sub sections:

- Avoided Cost Used for Screening
- Major Modelling Tasks
- Technologies Included in Economic Potential Forecast
- Summary of Results
- CDM Measure Supply Curves.

## 5.2 AVOIDED COST USED FOR SCREENING

NLH has determined that the primary avoided costs of new electricity supply to be used for this analysis are $0.0980/kWh for the Island and Isolated service region and $0.0432/kWh for the Labrador Interconnected service region. These avoided costs represent a future in which the Lower Churchill project is not built and there is no DC link from Labrador to the Island.[114]

Therefore, the Economic Potential Forecast incorporates all the CDM measures reviewed in Section 4 that have a CCE equal to or less than the avoided costs.

NLH is currently studying the Lower Churchill/DC Link project. However, a decision on whether to proceed is not expected until 2009 and, even if the project proceeds, the earliest completion date would be in late 2014. This means that, regardless of the decision, the avoided cost values shown above will be in effect until the approximate mid point of the study period.

If the Lower Churchill/DC Link project does proceed, the avoided costs presented above are expected to change. To provide insight into the potential impacts of the Lower Churchill/DC Link project on this study, it was agreed that the consultants would provide a high-level sensitivity analysis.

[113] Costs related to program design and implementation are not yet included.
[114] The avoided costs draw on the results of the earlier study conducted by NERA Economic Consulting, which is entitled: Newfoundland and Labrador Hydro. *Marginal Costs of Generation and Transmission*. May 2006. The avoided costs used in this study include generation, transmission and distribution.

## 5.3 MAJOR MODELLING TASKS

By comparing the results of the Residential sector Economic Potential Electricity Forecast with the Reference Case, it is possible to determine the aggregate level of potential electricity savings within the Residential sector, as well as identify which specific dwelling and end uses provide the most significant opportunities for savings.

To develop the Residential sector Economic Potential Forecast, the following tasks were completed:

- The CCE for each of the energy-efficient upgrades presented in Exhibits 4.2 and 4.3 were reviewed, using the 6% (real) discount rate. [115]

- Technology upgrades that had a CCE equal to, or less than, the avoided cost threshold were selected for inclusion in the economic potential scenario, either on a "full cost" or "incremental" basis. It is assumed that technical upgrades having a "full cost" CCE that met the cost threshold were implemented in the first forecast year. It is assumed that those upgrades that only met the cost threshold on an "incremental" basis are being introduced more slowly as the existing stock reaches the end of its useful life.

- Electricity use within each of the dwelling types was modelled with the same energy models used to generate the Reference Case. However, for this forecast, the remaining "baseline" technologies included in the Reference Case forecast were replaced with the most efficient "technology upgrade option" and associated performance efficiency that met the cost threshold of $0.0980/kWh for the Island and Isolated service region and $0.0432/kWh for the Labrador Interconnected service region.

- When more than one upgrade option was applied to a given end use, the first measure selected was the one that reduced the electrical load. For example, measures to reduce the overall DHW load (e.g., low-flow showerheads and more efficient dishwashers) were applied before the heat pump water heater. Similarly, the cost effectiveness of the heat pump water heater was tested at the new, lower annual load and included only if it continued to meet the CCE threshold.

- The economic potential analysis includes full consideration of interaction between measures and interaction between end uses. Measures applied to the same end use are applied sequentially, so that there is no "double-counting" of savings. The second measure applied to an end use takes its savings from the energy consumption remaining after the first measure has been applied. Interaction between end uses affects space heating, because measures that reduce internal loads (lighting, appliances, electronics, etc.) tend to increase the space heating consumption. In extreme cases, where few space heating measures are applied and the savings in other end uses are large, the space heating may actually increase.

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[115] See Section 4.2.

- A sensitivity analysis was conducted using preliminary avoided cost values that assume development of the Lower Churchill/DC Link.

## 5.4 TECHNOLOGIES INCLUDED IN ECONOMIC POTENTIAL FORECAST

Exhibits 5.1 and 5.2 provide a listing of the technologies selected for inclusion in this forecast for, respectively, the Island and Isolated and Labrador Interconnected service regions. In each case, the exhibits show the following:

- End use affected
- Upgrade option(s) selected
- Dwelling types to which the upgrade options were applied
- Rate at which the upgrade options were introduced into the stock.

## Exhibit 5.1: Technologies Included in Economic Potential Forecast for the Island and Isolated Service Region

| End Use | Upgrade Option | Applicability of Upgrade Options by Dwelling Type | Rate of Stock Introduction |
|---|---|---|---|
| Existing Building Envelope | ENERGY STAR Windows | Detached and Attached | New construction, immediate<br>Existing homes, at rate of window replacement |
| | Super high-performance windows | Detached and Attached | New construction, immediate<br>Existing homes, at rate of window replacement |
| | Air leakage sealing | Detached and Attached | Immediate |
| | Attic insulation | Detached and Attached | Immediate |
| | Wall insulation | Detached and Attached | Immediate where insulation can be blown in; where rigid foam external insulation is needed, at rate of siding replacement |
| | Foundation insulation | Detached and Attached | At rate of installation or replacement of finished basement walls |
| New Building Design | New house designed to an EG80 rating | Detached and Attached | Immediate |
| | New apartment building designed to 40% better energy consumption than current standard | Apartment | Immediate |
| Space Heating and Ventilation Equipment | Efficient (programmable and highly accurate) thermostats | All Residential | Immediate |
| | High-efficiency HRV | Detached and Attached | New construction, immediate<br>Existing homes, at rate of unit replacement |
| | Cold climate heat pumps | Apartment | Immediate in new construction |
| Domestic Hot Water | DHW pipe wrap | Detached and Attached | Immediate |
| | Low-flow shower heads and faucets | All Residential | Immediate |
| Major Appliances | ENERGY STAR fridge | All Residential | At rate of unit replacement |
| | Energy-efficient freezer | All Residential | At rate of unit replacement |
| | ENERGY STAR top loading clothes washer | All Residential | At rate of unit replacement |
| Lighting | CFLs, including both standard and specialized | All Residential | Immediate |
| | LED holiday lights | All Residential | At rate of unit replacement |
| | Outdoor lighting timer | Detached and Attached | Immediate |
| | Motion sensor | Detached and Attached | Immediate |
| | T8 lighting in common areas | Apartment | New construction, immediate<br>Existing, at rate of renovation |
| Computers & Peripherals | ENERGY STAR computer | All Residential | At rate of unit replacement |
| | Reduce standby losses | All Residential | Immediate |
| Television | ENERGY STAR TV | All Residential | At rate of unit replacement |
| | Reduce standby losses | All Residential | Immediate |

| End Use | Upgrade Option | Applicability of Upgrade Options by Dwelling Type | Rate of Stock Introduction |
|---|---|---|---|
| Television Peripherals | Reduce standby losses | All Residential | Immediate |
| Other Electronics | Reduce standby losses | All Residential | Immediate |

### Exhibit 5.2: Technologies Included in Economic Potential Forecast for the Labrador Interconnected Service Region

| End Use | Upgrade Option | Applicability of Upgrade Options by Dwelling Type | Rate of Stock Introduction |
|---|---|---|---|
| Existing Building Envelope | ENERGY STAR Windows | Detached and Attached | New construction, immediate<br>Existing homes, at rate of window replacement |
| | Super high-performance windows | Detached and Attached | New construction, immediate<br>Existing homes, at rate of window replacement |
| | Air leakage sealing | Detached and Attached | Immediate |
| | Attic insulation | Detached and Attached | Immediate |
| | Wall insulation | Detached and Attached | Immediate where insulation can be blown in; where rigid foam external insulation is needed, at rate of siding replacement |
| | Foundation insulation | Detached and Attached | At rate of installation or replacement of finished basement walls |
| Space Heating and Ventilation Equipment | Efficient (programmable and highly accurate) thermostats | All Residential | Immediate |
| | Cold climate heat pumps | Apartment | Immediate in new construction |
| Domestic Hot Water | DHW pipe wrap | Detached and Attached | Immediate |
| | Low-flow shower heads and faucets | All Residential | Immediate |
| Lighting | CFLs, standard only | All Residential | Immediate |
| | Outdoor lighting timer | Detached and Attached | Immediate |
| | Motion sensor | Detached and Attached | Immediate |
| | T8 lighting in common areas | Apartment | New construction, immediate<br>Existing, at rate of renovation |
| Computers & Peripherals | ENERGY STAR computer | All Residential | At rate of unit replacement |
| | Reduce standby losses | All Residential | Immediate |
| Television | Reduce standby losses | All Residential | Immediate |
| Television Peripherals | Reduce standby losses | All Residential | Immediate |
| Other Electronics | Reduce standby losses | All Residential | Immediate |

## 5.5 SUMMARY OF RESULTS[116]

This section compares the Reference Case and Economic Potential Electricity Forecast levels of residential electricity consumption for the two service regions. In each case, the results are presented as electricity savings that would occur at the customer's point-of-use. The results are presented in the following exhibits:

- Exhibits 5.3 and 5.4 present the results by end use, dwelling type and milestone year for, respectively, the Island and Isolated and Labrador Interconnected service regions.

[116] All results are reported at the customer's point-of-use and do not include line losses.

## Exhibit 5.3: Total Potential Electricity Savings by End Use, Dwelling Type and Milestone Year for the Island and Isolated Service Region (GWh/yr.)

| Dwelling Type | Milestone Year | Residential | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Total | Space Heating | Ventilation | DHW | Cooking | Refrigerator | Freezer | Dishwasher | Clothes Washer | Clothes Dryer | Lighting | Computer and peripherals | Television | Television Peripherals | Other Electronics | Small Appliances & Other |
| Detached | 2011 | 330.28 | 48.79 | 2.50 | 35.97 | | 0.00 | 0.00 | | 0.00 | 0.00 | 138.91 | 23.97 | 4.93 | 73.00 | 2.22 | |
| | 2016 | 440.92 | 98.72 | 2.86 | 40.89 | | 3.23 | 1.70 | | 1.44 | 11.95 | 142.22 | 52.60 | 8.43 | 74.69 | 2.18 | |
| | 2021 | 568.49 | 159.79 | 3.21 | 53.98 | | 6.63 | 3.65 | | 2.90 | 24.04 | 145.00 | 65.73 | 14.34 | 87.11 | 2.11 | |
| | 2026 | 688.16 | 223.58 | 3.23 | 67.62 | | 9.39 | 5.39 | | 4.36 | 36.19 | 147.50 | 80.37 | 21.26 | 87.26 | 2.02 | |
| Attached | 2011 | 40.62 | 0.35 | 0.20 | 4.26 | | 0.00 | 0.00 | | 0.00 | 0.00 | 16.79 | 3.44 | 0.64 | 14.66 | 0.29 | |
| | 2016 | 54.57 | 5.40 | 0.23 | 4.91 | | 0.60 | 0.00 | | 0.14 | 1.16 | 17.41 | 7.65 | 1.11 | 15.69 | 0.28 | |
| | 2021 | 70.22 | 12.49 | 0.26 | 6.61 | | 1.25 | 0.00 | | 0.29 | 2.36 | 17.99 | 9.69 | 1.91 | 17.11 | 0.28 | |
| | 2026 | 86.25 | 20.63 | 0.27 | 8.44 | | 1.78 | 0.00 | | 0.44 | 3.59 | 18.55 | 12.01 | 2.87 | 17.39 | 0.27 | |
| Apartment | 2011 | 27.64 | 3.03 | 0.79 | 2.24 | | 0.00 | 0.00 | | 0.00 | 0.00 | 8.82 | 2.26 | 0.43 | 9.89 | 0.19 | |
| | 2016 | 38.48 | 5.88 | 0.80 | 3.98 | | 0.37 | 0.00 | | 0.07 | 0.52 | 9.26 | 5.04 | 0.75 | 11.62 | 0.19 | |
| | 2021 | 49.82 | 10.03 | 0.81 | 5.80 | | 0.84 | 0.00 | | 0.13 | 1.06 | 9.68 | 6.43 | 1.30 | 13.55 | 0.19 | |
| | 2026 | 58.07 | 12.25 | 0.82 | 7.68 | | 1.30 | 0.00 | | 0.21 | 1.62 | 10.17 | 8.01 | 1.97 | 13.85 | 0.19 | |
| Isolated | 2011 | 5.36 | 0.12 | 0.02 | 0.81 | | 0.00 | 0.00 | | 0.00 | 0.00 | 3.04 | 0.23 | 0.07 | 1.04 | 0.03 | |
| | 2016 | 6.31 | 0.22 | 0.02 | 0.91 | | 0.04 | 0.05 | | 0.03 | 0.24 | 3.09 | 0.51 | 0.12 | 1.05 | 0.03 | |
| | 2021 | 7.49 | 0.33 | 0.02 | 1.19 | | 0.08 | 0.11 | | 0.05 | 0.47 | 3.14 | 0.63 | 0.20 | 1.22 | 0.03 | |
| | 2026 | 8.52 | 0.44 | 0.02 | 1.48 | | 0.11 | 0.16 | | 0.08 | 0.71 | 3.19 | 0.77 | 0.30 | 1.22 | 0.03 | |
| Other | 2011 | 2.16 | -0.10 | 0.01 | 0.00 | | 0.00 | 0.00 | | 0.00 | 0.00 | 2.26 | 0.00 | 0.00 | 0.00 | 0.00 | |
| | 2016 | 2.18 | -0.10 | 0.01 | 0.00 | | 0.00 | 0.00 | | 0.00 | 0.00 | 2.27 | 0.00 | 0.00 | 0.00 | 0.00 | |
| | 2021 | 2.18 | -0.10 | 0.01 | 0.00 | | 0.00 | 0.00 | | 0.00 | 0.00 | 2.27 | 0.00 | 0.00 | 0.00 | 0.00 | |
| | 2026 | 2.18 | -0.09 | 0.01 | 0.00 | | 0.00 | 0.00 | | 0.00 | 0.00 | 2.26 | 0.00 | 0.00 | 0.00 | 0.00 | |
| Vacant and Partial | 2011 | 2.98 | -0.12 | 0.01 | 0.00 | | 0.00 | 0.00 | | 0.00 | 0.00 | 3.09 | 0.00 | 0.00 | 0.00 | 0.00 | |
| | 2016 | 2.96 | -0.11 | 0.01 | 0.00 | | 0.00 | 0.00 | | 0.00 | 0.00 | 3.06 | 0.00 | 0.00 | 0.00 | 0.00 | |
| | 2021 | 2.93 | -0.11 | 0.01 | 0.00 | | 0.00 | 0.00 | | 0.00 | 0.00 | 3.03 | 0.00 | 0.00 | 0.00 | 0.00 | |
| | 2026 | 2.91 | -0.10 | 0.01 | 0.00 | | 0.00 | 0.00 | | 0.00 | 0.00 | 3.00 | 0.00 | 0.00 | 0.00 | 0.00 | |
| TOTAL | 2011 | 409.05 | 52.07 | 3.51 | 43.28 | | 0.00 | 0.00 | | 0.00 | 0.00 | 172.91 | 29.89 | 6.07 | 98.59 | 2.73 | |
| | 2016 | 545.41 | 110.01 | 3.93 | 50.69 | | 4.25 | 1.76 | | 1.67 | 13.86 | 177.31 | 65.80 | 10.40 | 103.04 | 2.69 | |
| | 2021 | 701.13 | 182.43 | 4.32 | 67.57 | | 8.80 | 3.76 | | 3.37 | 27.93 | 181.11 | 82.48 | 17.76 | 118.99 | 2.61 | |
| | 2026 | 846.09 | 256.72 | 4.36 | 85.22 | | 12.58 | 5.55 | | 5.09 | 42.11 | 184.67 | 101.17 | 26.40 | 119.72 | 2.50 | |

*Notes: 1) Savings for dishwasher and clothes washer are for mechanical energy only; hot water savings are reported in DHW. All savings at customer's point-of-use. 2) Any differences in totals are due to rounding. 3) Negative values in the space heating end use for "Other" and "Vacant and Partial" dwellings are a result of interaction between end uses; the reduction in internal heat gains due to lighting measures is greater than the savings from space heating measures.*

## Exhibit 5.4: Total Potential Electricity Savings by End Use, Dwelling Type and Milestone Year for the Labrador Interconnected Service Region (GWh/yr.)

| Dwelling Type | Milestone Year | Residential | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Total | Space Heating | Ventilation | DHW | Cooking | Refrigerator | Freezer | Dishwasher | Clothes Washer | Clothes Dryer | Lighting | Computer and peripherals | Television | Television Peripherals | Other Electronics | Small Appliances & Other |
| Detached | 2011 | 33.69 | 24.78 | 0.02 | 1.73 | | | | | | | 4.62 | 0.61 | 0.12 | 1.76 | 0.05 | |
| | 2016 | 40.43 | 31.36 | 0.02 | 1.09 | | | | | | | 4.69 | 1.33 | 0.11 | 1.78 | 0.05 | |
| | 2021 | 47.92 | 38.46 | 0.02 | 0.81 | | | | | | | 4.76 | 1.65 | 0.11 | 2.06 | 0.05 | |
| | 2026 | 55.82 | 46.22 | 0.02 | 0.53 | | | | | | | 4.82 | 2.01 | 0.11 | 2.06 | 0.05 | |
| | | | | | | | | | | | | | | | | | |
| Attached | 2011 | 6.39 | 3.29 | 0.01 | 0.53 | | | | | | | 1.42 | 0.21 | 0.04 | 0.87 | 0.02 | |
| | 2016 | 8.05 | 4.84 | 0.01 | 0.33 | | | | | | | 1.44 | 0.47 | 0.04 | 0.91 | 0.02 | |
| | 2021 | 9.87 | 6.55 | 0.01 | 0.25 | | | | | | | 1.46 | 0.58 | 0.04 | 0.97 | 0.02 | |
| | 2026 | 11.80 | 8.42 | 0.01 | 0.16 | | | | | | | 1.48 | 0.71 | 0.03 | 0.97 | 0.02 | |
| | | | | | | | | | | | | | | | | | |
| Apartment | 2011 | 0.60 | 0.11 | 0.01 | 0.06 | | | | | | | 0.20 | 0.02 | 0.01 | 0.20 | 0.00 | |
| | 2016 | 0.72 | 0.19 | 0.01 | 0.05 | | | | | | | 0.20 | 0.03 | 0.01 | 0.23 | 0.00 | |
| | 2021 | 0.84 | 0.27 | 0.01 | 0.04 | | | | | | | 0.21 | 0.04 | 0.01 | 0.26 | 0.00 | |
| | 2026 | 0.93 | 0.36 | 0.01 | 0.03 | | | | | | | 0.22 | 0.05 | 0.01 | 0.26 | 0.00 | |
| | | | | | | | | | | | | | | | | | |
| Other | 2011 | 0.19 | 0.09 | 0.00 | 0.00 | | | | | | | 0.10 | 0.00 | 0.00 | 0.00 | 0.00 | |
| | 2016 | 0.19 | 0.09 | 0.00 | 0.00 | | | | | | | 0.10 | 0.00 | 0.00 | 0.00 | 0.00 | |
| | 2021 | 0.20 | 0.10 | 0.00 | 0.00 | | | | | | | 0.10 | 0.00 | 0.00 | 0.00 | 0.00 | |
| | 2026 | 0.20 | 0.10 | 0.00 | 0.00 | | | | | | | 0.10 | 0.00 | 0.00 | 0.00 | 0.00 | |
| | | | | | | | | | | | | | | | | | |
| TOTAL | 2011 | 40.87 | 28.27 | 0.04 | 2.32 | | | | | | | 6.33 | 0.84 | 0.17 | 2.83 | 0.07 | |
| | 2016 | 49.39 | 36.48 | 0.04 | 1.47 | | | | | | | 6.43 | 1.83 | 0.16 | 2.91 | 0.07 | |
| | 2021 | 58.82 | 45.37 | 0.04 | 1.10 | | | | | | | 6.52 | 2.27 | 0.15 | 3.29 | 0.07 | |
| | 2026 | 68.75 | 55.09 | 0.04 | 0.73 | | | | | | | 6.62 | 2.77 | 0.15 | 3.29 | 0.07 | |

*Notes: 1) Savings for dishwasher and clothes washer are for mechanical energy only; hot water savings are reported in DHW. All savings at customer's point-of-use. 2) Any differences in totals are due to rounding.*

### 5.5.1 Interpretation of Results

Highlights of the results presented in the preceding exhibits are summarized below.

❑ **Electricity Savings by Service Region**

The Island and Isolated service region accounts for 92% of the potential savings.

❑ **Electricity Savings by Milestone Year**

Approximately 48% of the savings are available by the first milestone year because some of the efficiency upgrades are economically attractive at full replacement cost. Under the economic scenario, therefore, they are implemented immediately.

❑ **Electricity Savings by Segment**

Single-family detached dwellings account for more than 80% of the potential savings, which reflects their dominant market share within the overall Residential sector and their generally higher electrical intensity per dwelling.

❑ **Electricity Savings by End Use – Island and Isolated Service Region**

- Space heating accounts for 30% of the total electricity savings in the Economic Potential Forecast. Of this, approximately 53% come from foundation insulation, 13% come from more efficient windows, 9% come from programmable thermostats and 8% come from improved new building design. It should be noted that space heating savings are substantially reduced by decreases in internal loads associated with savings to electronics, lighting and appliances within the home.

- The new buildings account for a larger fraction of space heating savings than of other end use savings. Savings in new buildings are 37% of space heating savings, whereas savings in new buildings are 21% of overall savings. This is because the new building design measures save a disproportionate amount of space heating energy.

- Four electronic end uses (computers, televisions, television peripherals and other electronics) account for 30% of the total electricity savings in the Economic Potential Forecast. Of this, reducing standby losses accounts for 58% of the savings and ENERGY STAR computers account for 34%.

- Savings from lighting account for 22% of the total electricity savings in the Economic Potential Forecast. Of this, compact fluorescent lamps (both standard and specialized) account for over 90% of the savings.

- DHW accounts for 10% of the total electricity savings in the Economic Potential Forecast. Of this, nearly 83% are from DHW savings associated with ENERGY STAR clothes washers.

- **Electricity Savings by End Use – Labrador Interconnected Service Region**

- Space heating accounts for 81% of the total electricity savings in the Economic Potential Forecast. Approximately 67% of space heating savings are from foundation insulation and approximately 23% are from air leakage sealing.

- Lighting and the four electronic end uses referred to above each account for approximately 9% of the savings in the Economic Potential Forecast.

- Appliance measures are not included in the economic potential results for the Labrador Interconnected Service Region. The lower electricity rates in that region caused those measures to fail the CCE test.

### 5.5.2 Caveats

A systems approach was used to model the energy impacts of the CDM measures presented in the preceding section. In the absence of a systems approach, there would be double counting of savings and an accurate assessment of the total contribution of the energy-efficient upgrades would not be possible. More specifically, there are two particularly important considerations:

- **More than one upgrade may affect a given end use**. For example, improved insulation reduces space heating electricity use, as does the installation of new energy-efficient windows. On its own, each measure will reduce overall space heating electricity use. However, the two savings are not additive. The order in which some upgrades are introduced is also important. In this study, the approach has been to select and model the impact of "bundles of measures" that reduce the load for a given end use (e.g., wall insulation and window upgrades that reduce the space heating load) and then to introduce measures that meet the remaining load more efficiently (e.g., a high-efficiency space heating system).

- **There are interactive effects among end uses**. For example, the electricity savings from more efficient appliances and lighting result in reduced waste heat. During the space heating season, this appliance and lighting waste heat contributes to the building's internal heat gains, which lower the amount of heat that must be provided by the space heating system.

- The magnitude of the interactive effects can be significant. Based on selected building energy use simulations, a 100 kWh savings in appliance or lighting electricity use could result in an increased space heating load of 50 to 70 kWh, depending on housing dwelling type and geographical location. This is higher than the ratio of approximately 0.5 more typical of other jurisdictions. It is credible that the fraction would be higher in Newfoundland and Labrador because it is dependent more on the length of the heating season than on its severity. Newfoundland and Labrador experience more months in which heating is required than most other jurisdictions in Canada. Nonetheless, given that some fraction of the heat energy from lighting and other end uses escapes to the outside, the simulation may somewhat overstate the interaction. A ratio of 0.6 has been incorporated into the model to account for this uncertainty.

### 5.5.3 Sensitivity Analysis – Alternative Avoided Costs

A sensitivity analysis was conducted using preliminary avoided cost values that assume development of the Lower Churchill/DC link. The sensitivity analysis reviewed the scope of measures that would pass or fail the economic screen under the changed avoided costs. Based on the preliminary avoided cost values assessed, the analysis concluded that any impacts would be modest.

## 5.6 CDM MEASURE SUPPLY CURVES

A supply curve was constructed for each of the two service regions based on the economic potential savings associated with the above measures. The following approach was followed:

- Measures are introduced in sequence to see incremental impact and cost
- Sequence is determined by principle of 1) reduce load 2) meeting residual load with most efficient technology
- Is organized by CCE levels.

Exhibits 5.5 and 5.6 show the supply curves for, respectively, the Island and Isolated and the Labrador Interconnected service regions. Exhibits 5.7 and 5.8 show the measures included in each of the supply curves.

Exhibits 5.5 and 5.6 both show measures with CCEs above the thresholds for the two regions. This is because the economic screening process did not consider either interaction between measures or interaction between end uses. All measures were included in the analysis if their CCE values were below the threshold, excluding interactive effects. In the economic potential analysis itself, however, these interactive effects are included in full. Measures that apply to the same end use are applied in sequence, as described above, substantially reducing the savings available to those applied later. Furthermore, measures that reduce the internal heat loads produced by lighting, electronics and appliances tend to increase the need for space heating. This space heating penalty is applied against the savings from those measures. For consistency with previous exhibits, the supply curve shows all the measures that were included in the economic potential analysis, including those that now exceed the economic threshold.

**Exhibit 5.5: Supply Curve for Residential Sector, Island and Isolated Service Region, 2026**

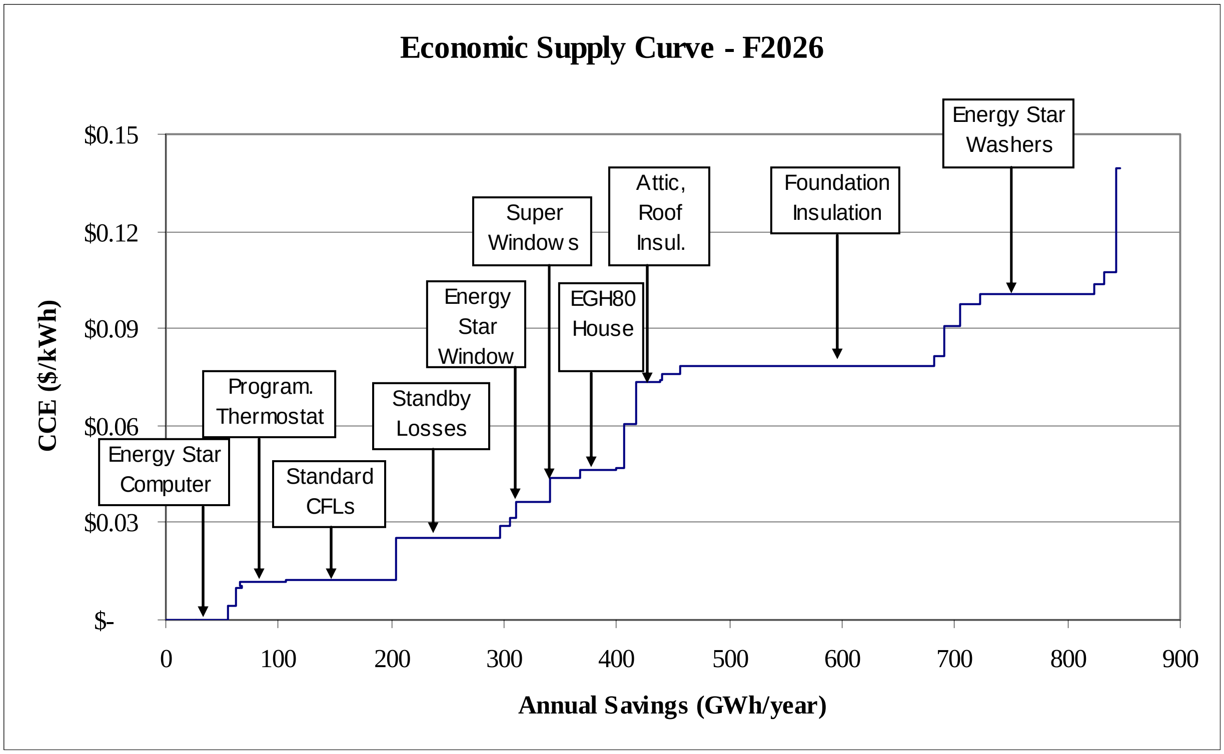
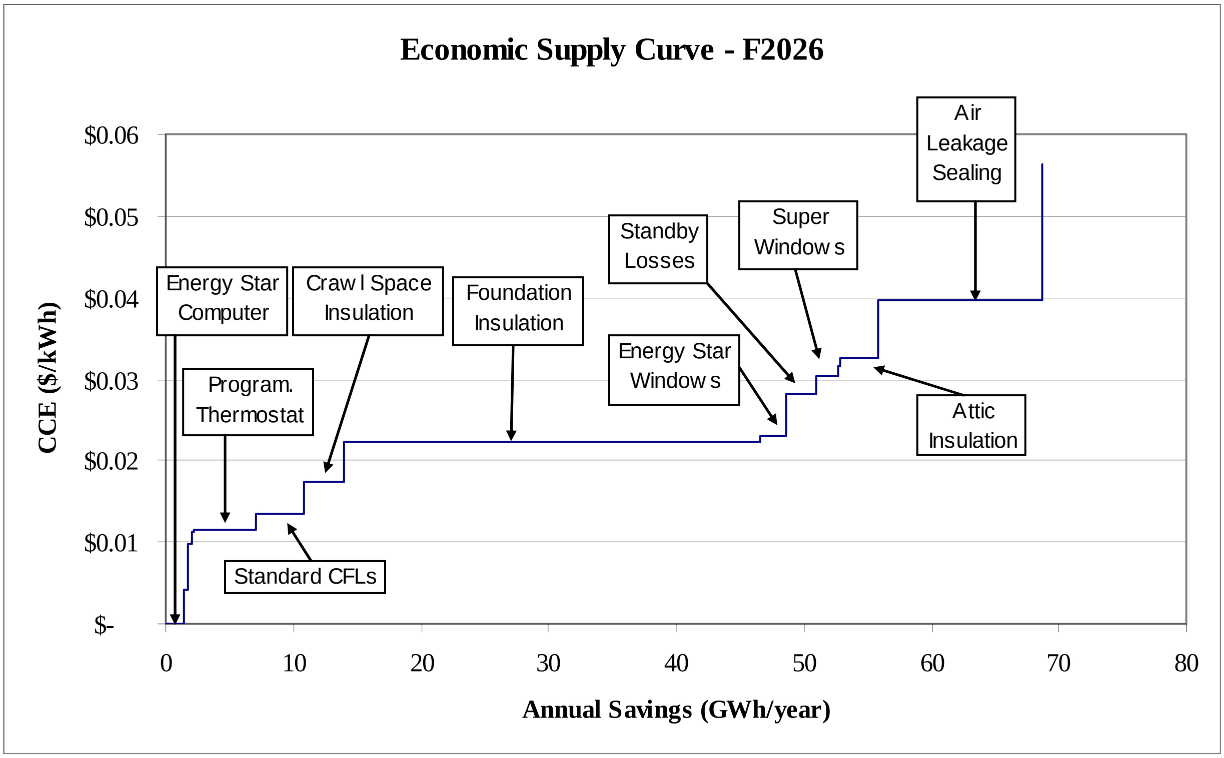



**Exhibit 5.6: Supply Curve for Residential Sector, Labrador Interconnected Service Region, 2026**



## Exhibit 5.7: Summary of Residential Sector Energy-efficiency Measures, Island and Isolated Service Region 2026[117]

| Measure | Average CCE ($/kWh) | Annual Savings (GWh/year) |
|---|---|---|
| Energy Star Computer | $0.00 | 55 |
| DHW Pipe Wrap | $0.00 | 7 |
| Low-Flow Showerheads and Faucets | $0.01 | 6 |
| Standard T8 Lighting - Common Areas | $0.01 | 0.1 |
| 25% Lower Energy Apartment Building | $0.01 | -1 |
| Programmable Thermostats | $0.01 | 40 |
| CFLs - Standard | $0.01 | 97 |
| Standby Losses | $0.03 | 92 |
| Crawl-space Insulation | $0.03 | 10 |
| 40% Lower Energy Apartment Building | $0.03 | 4 |
| Timer | $0.03 | 1 |
| Energy Star Windows , Advanced Glazing | $0.04 | 29 |
| Super High Performance Windows | $0.04 | 28 |
| New House Designed to an EGNH 80 Rating | $0.05 | 32 |
| Building recommissioning | $0.05 | 6 |
| Motion Sensor | $0.05 | 1 |
| Air Source Heat Pump | $0.06 | 11 |
| Ground Source Heat Pump | $0.07 | 0.4 |
| Attic Insulation, Roof Insulation | $0.07 | 21 |
| Wall Insulation | $0.07 | 1 |
| High Efficiency HRV | $0.08 | 16 |
| Foundation Insulation | $0.08 | 225 |
| Energy Star Fridge | $0.08 | 8 |
| Redesign with high performance T8s | $0.09 | 1 |
| Energy Star TV | $0.09 | 13 |
| Air Leakage Sealing | $0.10 | 19 |
| Energy Star Top Loading Clothes Washer | $0.10 | 102 |
| LED Holiday Lights | $0.10 | 9 |
| CFLs Specialised | $0.11 | 10 |
| Energy Efficient Freezer | $0.14 | 4 |

[117] The above exhibit includes measures with a CCE that exceeds the study's avoided cost threshold. The increased CCE is due to the impact of interactive effects. The measures are shown to maintain consistency with previous exhibits. The inclusion of interaction between measures has a particularly large effect on space heating savings. More efficient lighting and appliances contribute less waste heat to the home and therefore the space heating requirement is greater. In the 25% Lower Energy Apartment Building, for example, the savings in space heating energy are actually overwhelmed by the increased load because the lights and appliances are more efficient. This is less of an issue in Labrador, where fewer appliance measures pass the economic screen.

### Exhibit 5.8: Summary of Residential Sector Energy-efficiency Measures, Labrador Interconnected Service Region 2026[118]

| Measure | Average CCE ($/kWh) | Annual Savings (GWh/year) |
|---|---|---|
| Redesign with high performance T8s | -$0.03 | 0.004 |
| Energy Star Computer | $0.00 | 1 |
| DHW Pipe Wrap | $0.00 | 0.4 |
| Low-Flow Showerheads and Faucets | $0.01 | 0.3 |
| 25% Lower Energy Apartment Building | $0.01 | 0.1 |
| Standard T8 Lighting - Common Areas | $0.01 | 0.002 |
| Programmable Thermostats | $0.01 | 5 |
| CFLs - Standard | $0.01 | 4 |
| Crawl-space Insulation | $0.02 | 3 |
| Foundation Insulation | $0.02 | 33 |
| Energy Star Windows , Advanced Glazing | $0.02 | 2 |
| Standby Losses | $0.03 | 2 |
| Super High Performance Windows | $0.03 | 2 |
| 40% Lower Energy Apartment Building | $0.03 | 0.1 |
| Attic Insulation, Roof Insulation | $0.03 | 3 |
| Timer | $0.04 | 0.02 |
| Air Leakage Sealing | $0.04 | 13 |
| Building recommissioning | $0.04 | 0.1 |
| Motion Sensor | $0.06 | 0.03 |

[118] The above exhibit includes measures with a CCE that exceeds the study's avoided cost threshold. The increased CCE is due to the impact of interactive effects. The measures are shown to maintain consistency with previous exhibits. The measure for redesign with high-performance T8s has a negative CCE for the Labrador Interconnected service region because the only circumstance under which it passes for Labrador is when a renovation is planned that already involves lighting replacement. The advanced T8s with redesign would incorporate fewer fixtures than a standard lighting replacement and therefore capital cost would actually be lower. In the Island and Isolated service region, there would certainly be cases where the measure would be installed as part of an already planned renovation (and hence would have a negative incremental cost), but the measure passes at full cost as well, so the average CCE is $0.09/kWh.

# 6. ACHIEVABLE POTENTIAL

## 6.1 INTRODUCTION

This section presents the Residential sector Achievable Potential electricity savings for the study period (2006 to 2026). The Achievable Potential is defined as the proportion of the savings identified in the Economic Potential Forecast that could realistically be achieved within the study period.

The remainder of this discussion is organized into the following subsections:

- Description of Achievable Potential
- Approach to the Estimation of Achievable Potential
- Workshop Results
- Summary of Achievable Electricity Savings
- Peak Load Impacts.

## 6.2 DESCRIPTION OF ACHIEVABLE POTENTIAL

Achievable Potential recognizes that it is difficult to induce all customers to purchase and install all the electrical efficiency technologies that meet the criteria defined by the Economic Potential Forecast. For example, customer decisions to implement energy-efficient measures can be constrained by important factors such as:

- Higher first cost of efficient product(s)
- Need to recover investment costs in a short period (payback)
- Lack of product performance information
- Lack of product availability
- Consumer awareness.

The rate at which customers accept and purchase energy-efficient products can be influenced by a variety of factors including the level of financial incentives, information and other measures put in place by the Utilities, governments and the private sector to remove barriers such as those noted above.

Exhibit 6.1 presents the level of electricity consumption that is estimated in the Achievable Potential scenarios. As illustrated, the Achievable Potential scenarios are “banded” by the two forecasts presented in previous sections, namely, the Economic Potential Forecast and the Reference Case.

Electricity savings under Achievable Potential are typically less than in the Economic Potential Forecast. In the Economic Potential Forecast, efficient new technologies are assumed to fully penetrate the market as soon as it is financially attractive to do so. However, the Achievable Potential recognizes that under “real world” conditions, the rate at which customers are likely to implement new technologies will be influenced by additional practical considerations and will, therefore, occur more slowly than under the assumptions employed in the Economic Potential Forecast. Exhibit 6.1 also shows that future electricity consumption under the Reference Case is greater than in either of the two Achievable Potential forecasts. This is because the Reference Case represents a "worst case" situation in which there are no additional utility market interventions and hence no additional electricity savings beyond those that occur "naturally."

Exhibit 6.1 presents the achievable results as a band of possibilities, rather than a single line. This recognizes that any estimate of Achievable Potential over a 20-year period is necessarily subject to uncertainty and that there are different levels of potential CDM program intervention.

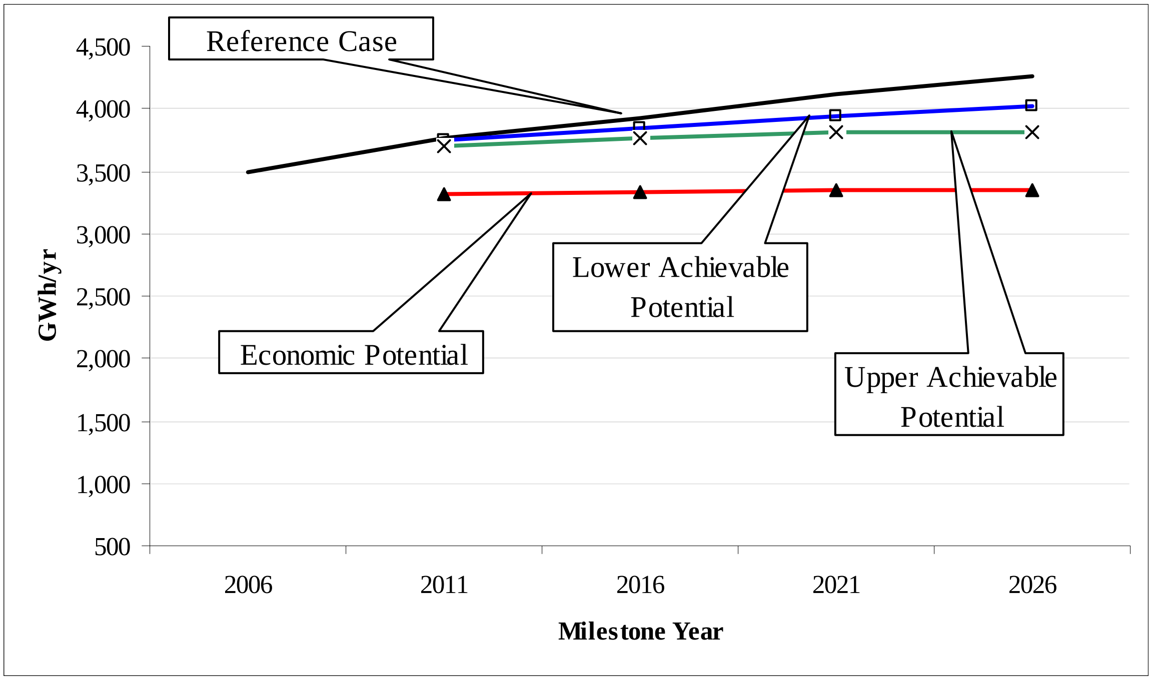
- **The Upper Achievable Potential** assumes both an aggressive program approach and a very supportive context, e.g., healthy economy, very strong public commitment to climate change mitigation, etc.

  However, the Upper Achievable Potential scenario also recognizes that there are limits to the scope of influence of any electric utility. It recognizes that some markets or submarkets may be so price sensitive or constrained by market barriers beyond the influence of CDM programs that they will only fully act if forced to by legal or other legislative means. It also recognizes that there are practical constraints related to the pace that existing inefficient equipment can be replaced by new, more efficient models or that existing building stock can be retrofitted to new energy performance levels

  For the purposes of this study, the Upper Achievable Potential can, informally, be described as: "*Economic Potential less those customers that "can't" or "won't" participate."*

- **The Lower Achievable Potential** assumes that existing CDM programs and the scope of technologies addressed are expanded, but at a more modest level than in the Upper Achievable Potential. Market interest and customer commitment to energy efficiency and sustainable environmental practices remain approximately as current. Similarly, federal, provincial and municipal government energy-efficiency and GHG mitigation efforts remain similar to the present.

**Exhibit 6.1: Annual Electricity Consumption – Illustration of Achievable Potential Relative to Reference Case and Economic Potential Forecast for the Residential Sector (GWh/yr.)**



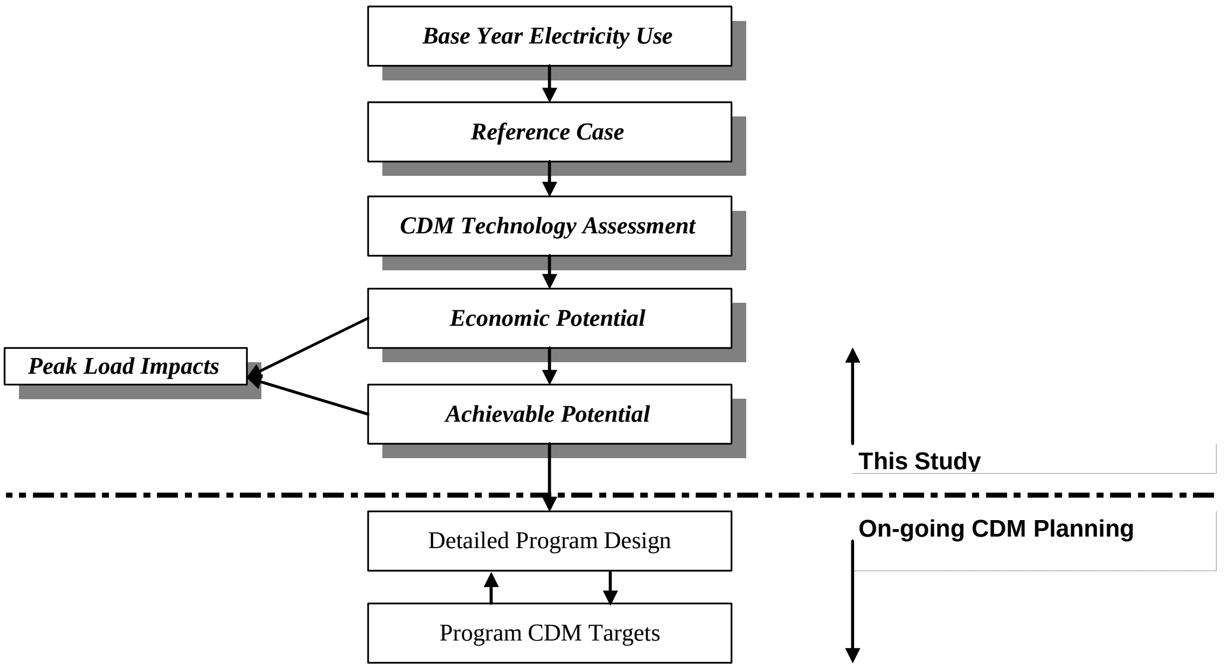

## ❑ Achievable Potential versus Detailed Program Design

It should also be emphasized that the estimation of Achievable Potential is not synonymous with either the setting of specific program targets or with program design. While both are closely linked to the discussion of Achievable Potential, they involve more detailed analysis that is beyond the scope of this study.[119]

Exhibit 6.2 illustrates the relationship between Achievable Potential and the more detailed program design.

[119] The Achievable Potential savings assume program start-up in 2007. Consequently, electricity savings in the first milestone year of 2011 will need to be adjusted to reflect actual program initiation dates. This step will occur during the detailed program design phase, which will follow this study.

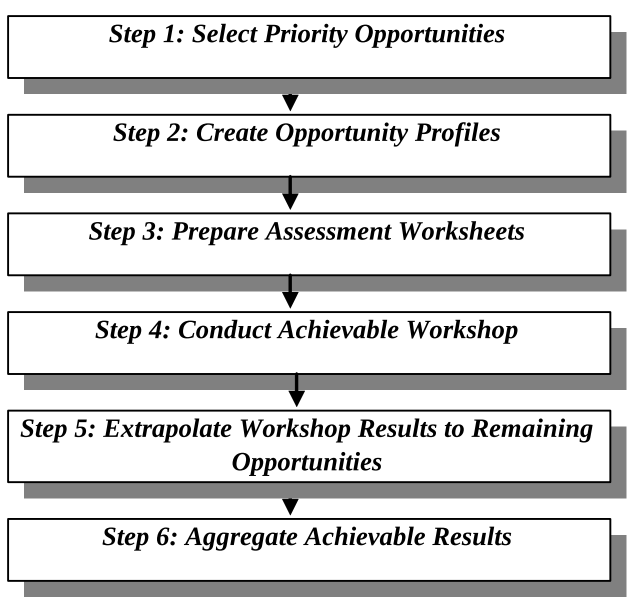
**Exhibit 6.2: Achievable Potential versus Detailed Program Design**




## 6.3 APPROACH TO THE ESTIMATION OF ACHIEVABLE POTENTIAL

Achievable Potential was estimated in a six-step approach. A schematic showing the major steps is shown in Exhibit 6.3 and each step is discussed below.

**Exhibit 6.3: Approach to Estimating Achievable Potential**



### ❑ Step 1: Select Priority Opportunities

The first step in developing the Achievable Potential estimates required that the energy saving opportunities identified in the Economic Potential Forecasts be "bundled" into a set of opportunity areas that would facilitate the subsequent assessment of their potential market penetration.

The amount of time available in the Achievable Potential workshop for the discussion of energy-efficiency opportunities was limited. Consequently, the energy-efficiency opportunity areas shown in Exhibit 6.4 were selected based primarily on the basis that they represent a significant portion of the energy savings potential identified in the Economic Potential Forecast. Where two or more opportunities offered similar levels of potential energy savings, consideration was also given to whether discussion of the selected opportunity area in the workshop would provide insights into the participation rates to be used for related opportunities that could not be covered during the workshop.

Nine energy-efficiency opportunity areas were selected for discussion in the Residential sector workshop that was held on October 30, 2007. Exhibit 6.4 identifies the opportunity areas and shows the approximate percentage that each represents of the total Residential sector potential contained in the Economic Potential Forecast.

**Exhibit 6.4: Residential Sector Opportunity Areas**

| Opportunity Area | Title | Approximate % of Economic Savings Potential |
|---|---|---|
| R1 | Programmable thermostats | 5% |
| R2 | Convert incandescent lighting to CFL | 11% |
| R3 | Foundation insulation | 28% |
| R4 | Air leakage sealing | 3% |
| R5 | Efficient windows | 6% |
| R6 | EnerGuide 80 (EG80) for new housing | 3% |
| R7 | Power bar with integrated timer | 10% |
| R8 | ENERGY STAR computer | 6% |
| R9 | ENERGY STAR clothes washer | 11% |
| | **Total** | 83% |

### ❑ Step 2: Create Opportunity Profiles

The next step involved the development of brief profiles for the priority opportunity areas noted above in Exhibit 6.4. A sample profile for Opportunity R1 (programmable thermostats) is presented in Exhibit 6.5; the remaining Opportunity Profiles are provided in Appendix B.

The purpose of the Opportunity Profiles was to provide a "high-level" logic framework that would serve as a guide for participant discussions in the achievable workshop. These Profiles state technical and program assumptions upon which to base an estimate of potential market penetration. The intent was to define a broad rationale and direction without getting into the much greater detail required of program design, which, as noted previously, is beyond the scope of this project.

## Exhibit 6.5: Sample Opportunity Profile

**R1: Programmable Thermostat**

***Overview:***
Digital programmable thermostats provide improved temperature setting accuracy and are capable of multiple time settings. When combined with an assumed 4ºC temperature setback during night and unoccupied periods, typical space heat savings are in the range of 10% to 15% relative to the baseline, depending on the type of dwelling and its vintage.

Other utility studies have indicated that a lower savings percentage should be used to reflect the fact that the thermostat's setback capabilities do not completely reflect how they are used, e.g., some home occupants reliably set back manual thermostats, and some home occupants do not use the setback features on their electronic thermostats. Accordingly a value of 6% savings has been used in this study.

***Target Technologies and Dwelling Types:***
- The programmable setback thermostat is a mature technology
- This technology is applicable to all dwelling types but is most easily applied where a limited number of thermostats can be used to control all the heating devices in the dwelling.

***Opportunity Costs and Savings Profile***:
- This technology is assumed to cost an average of $70 per dwelling.
- In single-family dwellings with baseboard electric heating, it is possible, in most cases, to combine more than one baseboard per thermostat so that three to four thermostats can be used.[120] In dwellings with forced air systems, one thermostat will usually control the whole dwelling.
- Customer payback is approximately one year, somewhat longer in Labrador.
- The CCE for this measure in detached dwellings ranges from 0.6 in Labrador to 1.2 on the Island, or somewhat higher for attached dwellings and apartments.
- Potential energy performance or technology price trends affecting this opportunity include:
- Pricing and performance are relatively stable for this technology.
- For homes with a need for more thermostats because of multiple baseboards, another option is the high-efficiency (more accurate) thermostat, which is lower cost but is still expected to save approximately 3%.
- There is added uncertainty in the savings estimates for this technology because of the behavioural aspect.

***Target Audience(s)& Potential Delivery Allies:***
- Homeowners and renters
- HVAC contractors and retailers

***Constraints & Challenges:***
- Some consumers still think a thermostat behaves like a gas pedal (the higher you set it, the faster the house warms up!)
- Tendency for some users to override the setback
- Installation is simple for central thermostats on 24-V loops, but not for in-line thermostats controlling a powerful baseboard.

***Opportunities & Synergies:***
- Could build on/expand previous thermostat rebate programs
- Could be offered in conjunction with other programs, through trade allies or even used as a premium to entice consumers to participate in other programs
- Amenable to use of point-of-sale rebates or other in-store promotions.

***Experience Related to Possible Participation Rates:***

[120] Workshop discussion found that the use of one thermostat to control multiple baseboard heaters was rarely practical.

As illustrated in Exhibit 6.5, each Opportunity Profile addresses the following areas:

- ***Overview*** – provides a summary statement of the broad goal and rationale for the opportunity.

- ***Target Technologies and Dwelling Types*** **–** highlights the major technologies and the dwelling types where the most significant opportunities have been identified in the Economic Potential Forecast.

- ***Opportunity Costs and Savings Profile*** – provides information on the financial attractiveness of the opportunity from the perspective of both the customer and NLH or NP.

- ***Target Audiences and Potential Delivery Allies*** **–** identifies key market players that would be expected to be involved in the actual delivery of services. The list of stakeholders shown is intended to be "indicative" and is by no means comprehensive.

- ***Constraints and Challenges*** **–** identifies key market barriers that are currently constraining the increased penetration of energy-efficient technologies or measures. Interventions for addressing the identified barriers are noted. Again, it is recognized that the interventions are not necessarily comprehensive; rather, their primary purpose was to help guide the workshop discussions.

- ***Opportunities and Synergies*** **–** identifies information or possible synergies with other opportunities that may affect workshop participant views on possible customer participation rates.

- ***Experience Related to Possible Participation Rates*** **–** provides benchmark data on the past performance of the Utilities' programs, where available.

### ❑ Step 3: Prepare Draft Opportunity Assessment Worksheets

A draft Assessment Worksheet was prepared for each Opportunity Profile in advance of the workshop. The Assessment Worksheets complemented the information contained in the Opportunity Profiles by providing quantitative data on the potential energy savings for each opportunity as well as providing information on the size and composition of the eligible population of potential participants. Energy impacts and population data were taken from the detailed modelling results contained in the Economic Potential Forecast.

A sample Assessment Worksheet for Opportunity R1 – Programmable Thermostats is presented in Exhibit 6.6 (worksheets for the remaining opportunity areas are provided in Appendix B). As illustrated in Exhibit 6.6, each Assessment Worksheet addresses the following areas:

- ***Economic Potential Annual Savings*** **–** shows the total economically attractive potential for electricity savings, by milestone period, for the measures included in the opportunity area.

- ***Cumulative Thousands of Dwellings Affected* –** shows the total population of potential participants that could theoretically take part in the opportunity area. Numbers shown are from the eligible populations used in the Economic Potential Forecasts. The definition of "participant" varies by opportunity area. In the example shown, a participant is defined as a "dwelling."

- ***Achievable Participation* –** show the percentage of economic savings that workshop participants concluded could be achieved in each milestone period. As noted in the introduction to this section, two achievable scenarios are shown: Lower and Upper. For example, Exhibit 6.6 shows a participation rate of 20% (Lower) and 90% (Upper) in existing single-family dwellings by the year 2026. This means that by 2026, between 20% and 90% of the potential savings contained in the Economic Potential Forecast could be achieved.

- ***Achievable Potential Annual Savings* –** shows the calculated electricity savings in each milestone period based on the savings and participation rates presented in the preceding columns of the Worksheet.

- ***Achievable Thousands of Dwellings Affected* –** shows the number of participants that would be affected in order to achieve the electricity savings shown.

## Exhibit 6.6: Sample Residential Sector Opportunity Assessment Worksheet[121]

### *R1: Space heating, Programmable Thermostats: Economic Scenario, Residential Sector, Island and Isolated Region **

***Existing/Renovated***

| Building Type | Economic Potential Annual Savings (GWh) | | Cumulative Thousands of Dwellings Affected | | Lower Achievable Scenario: Achievable Participation | | Lower Achievable Scenario: Achievable Potential Annual Savings (GWh) | | Lower Achievable Scenario: Achievable Thous. Dwellings Affected | | Upper Achievable Scenario: Achievable Participation | | Upper Achievable Scenario: Achievable Potential Annual Savings (GWh) | | Upper Achievable Scenario: Achievable Thous. Dwellings Affected | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2011 | 2026 | 2011 | 2026 | 2011 | 2026 | 2011 | 2026 | 2011 | 2026 | 2011 | 2026 | 2011 | 2026 | 2011 | 2026 |
| Detached | 31 | 27 | 79 | 79 | | 20% | | 5 | | 16 | | 90% | | 24 | | 71 |
| Attached | 5 | 5 | 10 | 10 | | | | | | | | | | | | |
| Apartment | 3 | 2 | 10 | 10 | | | | | | | | | | | | |
| Other | 1 | 1 | 11 | 11 | | 20% | | 0 | | 2 | | | | | | |
| Total | 40 | 35 | 110 | 109 | | | | 6 | | 18 | | | | 24 | | 71 |

***New***

Curve B (Lower Achievable Scenario) Curve C (Upper Achievable Scenario)

| Building Type | Economic Potential Annual Savings (GWh) | | Cumulative Thousands of Dwellings Affected | | Lower Achievable Scenario: Achievable Participation | | Lower Achievable Scenario: Achievable Potential Annual Savings (GWh) | | Lower Achievable Scenario: Achievable Thous. Dwellings Affected | | Upper Achievable Scenario: Achievable Participation | | Upper Achievable Scenario: Achievable Potential Annual Savings (GWh) | | Upper Achievable Scenario: Achievable Thous. Dwellings Affected | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2011 | 2026 | 2011 | 2026 | 2011 | 2026 | 2011 | 2026 | 2011 | 2026 | 2011 | 2026 | 2011 | 2026 | 2011 | 2026 |
| Detached | 2 | 5 | 3 | 12 | 20% | 20% | 0 | 1 | 1 | 2 | 20% | 20% | 0 | 1 | 1 | 2 |
| Attached | 0 | 1 | 1 | 2 | 20% | 20% | 0 | 0 | 0 | 0 | 20% | 20% | 0 | 0 | 0 | 0 |
| Apartment | 0 | 1 | 1 | 2 | 20% | 20% | 0 | 0 | 0 | 0 | 20% | 20% | 0 | 0 | 0 | 0 |
| Other | 0 | 0 | 0 | 0 | 20% | 20% | 0 | 0 | 0 | 0 | 20% | 20% | 0 | 0 | 0 | 0 |
| Total | 3 | 7 | 5 | 16 | | | 1 | 1 | 1 | 3 | | | 1 | 1 | 1 | 3 |
| Grand Total | 42 | 41 | 114 | 125 | | | 1 | 7 | 1 | 21 | | | 1 | 25 | 1 | 74 |

**NOTES:**
* Includes savings of heating and ventilation.

[121] This exhibit shows the worksheet as it was after the workshop. Discussion focused on the existing detached dwellings for the Island and Isolated service region, developing Upper and Lower participation estimates for the milestone year 2026, and a curve shape between 2006 and 2026. All other percentage values shown are either left blank or are placeholders that were in the worksheet before the workshop. Only the values for existing detached Island and Isolated dwellings were transferred to the RSEEM model. Values for other types of dwellings were based on those and on the discussions with workshop participants about how participation might vary between regions, housing types, and vintages. Any differences in totals are due to rounding.

### ❑ Step 4: Achievable Potential Workshop

The most critical step in developing the estimates of Achievable Potential was the one-day workshop held October 30, 2007. Workshop participants consisted of core members of the consultant team, program personnel from the Utilities and local trade allies.

The purpose of this workshop was twofold:

- Promote discussion regarding the technical and market conditions confronting the identified energy-efficiency opportunities

- Compile participant views related to how much of the identified economic savings could realistically be achieved over the study period.

The discussion of each opportunity area began with a brief consultant presentation. The floor was then opened to participant discussion. Key areas that were explored for each opportunity area included:

- Target audiences and potential delivery allies
- Constraints, barriers and challenges
- Potential opportunities and synergies
- Estimates of Lower Achievable and Upper Achievable for milestone years
- Guidelines for consultants for extrapolating to related sub sectors.

Following discussion of the broad market and intervention conditions affecting each opportunity area, workshop participant views were recorded on Lower and Upper customer participation rates. To facilitate this portion of the workshop, the discussion of the Residential sector opportunity areas focused initially on single-family detached dwellings in the Island and Isolated service region. The following process was employed:

- The participation rate for the Upper Potential in 2026 was estimated. As noted previously, this participation rate was "roughly" defined as 100% of the Economic Potential minus the market share represented by the "can't" or 'won't" population.

- The shape of the adoption curve was selected for the Upper scenario. Rather than seek consensus on the specific values to be employed in each of the intervening milestone years, workshop participants selected one of four curve shapes that best matched their view of the appropriate "ramp-up" rate for each opportunity.

- The preceding process was repeated for the Lower scenario.

Exhibit 6.7 shows the four curves that were used in the workshop discussions.

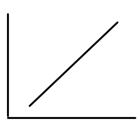
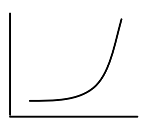
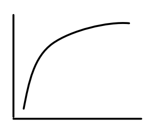
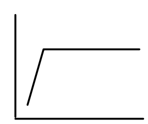
- **Curve A** represents a steady increase in the expected participation rate over the 20-year study period

- **Curve B** represents a relatively slow participation rate during the first half of the 20-year study period followed by a rapid growth in participation during the second half of the 20-year study period

- **Curve C** represents a rapid initial participation rate followed by a relatively slow growth in participation during the remainder of the 20-year study period

- **Curve D** represents a very rapid initial participation rate that results in virtual full saturation of the applicable market during the first milestone period of the 20-year study period.

**Exhibit 6.7: Adoption Curve Shapes (2006 to 2026)**

| Curve A | Curve B | Curve C | Curve D |
|---|---|---|---|
|  |  |  |  |

Finally, as applicable, workshop participants provided guidelines to the consultants for extrapolating the results of the workshop discussion to the remaining sub sectors and service regions.

### ❑ Step 5: Extrapolate Workshop Results to Remaining Opportunities

As noted earlier, it was not possible to fully address all opportunities in the one-day workshop. Consequently, the workshop focused on the “big ticket” opportunities. Participation rates for the remaining opportunities were completed by the consultants, guided by the workshop results and discussions. The values shown in the summary tables incorporate the results of the two sets of inputs.

### ❑ Step 6: Aggregate Achievable Potential Results

The final step involved aggregating the results of the individual opportunity areas to provide a view of the potential Achievable savings for the total Residential sector.

## 6.4 WORKSHOP RESULTS

The following subsection provides a summary of the participation rates established by the workshop participants for each of the opportunity areas discussed during the workshop.[122] As noted previously, the Residential sector opportunity areas were:

- R1 - Programmable thermostats
- R2 - Convert incandescent lighting to CFL
- R3 - Foundation insulation
- R4 - Air leakage sealing
- R5 - Efficient windows
- R6 - EnerGuide 80 (EG80) for new housing
- R7 - Power bar with integrated timer
- R8 - ENERGY STAR computer
- R9 - ENERGY STAR clothes washer.

Further detail on each of the above opportunity areas is provided below; as applicable, the following information is provided for each:

- Summary of Upper and Lower Achievable participation rates
- Shape of Adoption Curve selected by the workshop participants
- Highlights of key issues arising during the workshop discussions
- Summary of major assumptions employed by the consultants for extrapolating the workshop results to other sub sectors.

### 6.4.1 R1 – Programmable Thermostats

Workshop participants concluded that, under the conditions represented by the Upper Achievable scenario, participation rates up to 90% could be achieved in single-family detached homes in the Island and Isolated service region by 2026. Workshop participants agreed that Adoption Curve C represented the best fit with the pace of participation in the intervening years from 2007 to 2026 under this Upper Achievable scenario.

Under the more modest market conditions represented by the Lower Achievable scenario, participation rates up to 20% could be achieved in single-family detached homes in the Island and Isolated service region by 2026. Workshop participants agreed that Adoption Curve B represented the best fit with the pace of participation in the intervening years from 2007 to 2026 under this Lower Achievable scenario.

Based on the workshop discussions, it was assumed that participation rates in the remaining dwelling types would be similar to the above values. Participation rates in the

[122] Measures from the Commercial sector that were applicable to apartment buildings were discussed in the commercial Achievable workshop. Refer to the companion report on the Commercial sector for details on the workshop discussions. Apartment measures discussed in the commercial Achievable workshop included: C1, Standard T8 Lighting and Redesign with High-performance T8s - Common Areas, Existing Buildings; C2, Redesign with high-performance T8s, New Buildings; C4, High-performance glazings; C5, Building recommissioning; C6, Ground source heat pumps; and C7, 40% Lower Energy Apartment Building.

Labrador Interconnected service region were assumed to be similar to those for the Island and Isolated service region.

Selected highlights:

- Discussion focused on the high-efficiency thermostats with accuracy within 0.5ºC. Programmable thermostats were regarded as having much lower potential because of the low incidence of electrically heated houses that can be controlled with a small number of thermostats (such as one thermostat controlling a forced air system). The cost of a large number of programmable thermostats to control individual baseboards would generally not be justified.
- Behaviour is a major factor in savings from programmable thermostats (e.g., some people with manual thermostats diligently set them back, and some people with programmable thermostats do not).
- Humidity control is a concern with set-back strategies in some houses, where condensation on windows can cause damage and mould. Ability to adopt temperature setback could be a selling point for efficient windows.
- The presence of thermostats accurate to within 1ºC was estimated to be approximately 65% of existing stock, with lower penetration in rural areas. Many rural houses have baseboards installed with only the built-in thermostatic control on the baseboard itself.
- There is potential for using the high-efficiency thermostats through most of the house and installing programmable thermostats in main living areas (such as the living room or the most-used bedroom).

### 6.4.2 R2 – Convert Incandescent Lighting to CFLs

Workshop participants concluded that, under the conditions represented by the Upper Achievable scenario, participation rates up to 98% could be achieved in single-family detached homes in the Island and Isolated service region by 2026. Workshop participants agreed that Adoption Curve B represented the best fit with the pace of participation in the intervening years from 2007 to 2026 under this Upper Achievable scenario.

Under the more modest market conditions represented by the Lower Achievable scenario, participation rates up to 90% could be achieved in single-family detached homes in the Island and Isolated service region by 2026. Workshop participants agreed that Adoption Curve A represented the best fit with the pace of participation in the intervening years from 2007 to 2026 under this Lower Achievable scenario.

Based on the workshop discussions, it was assumed that participation rates in the remaining dwelling types would be similar to the above values. Participation rates in the Labrador Interconnected service region were assumed to be similar to those for the Island and Isolated service region.

Selected highlights:

- 
- There are fewer barriers to uptake of CFLs than for other measures. There is continuing improvement in quality and the suitability of lamps to more applications continues to broaden.
- There are still issues around disposal, light quality, product quality and lighting levels, some of them real and some of them perceptions based on earlier products. Workshop participants expected these issues to be addressed during the timeframe of the study.
- Uptake of CFLs has been high in Labrador. It tends to be lower in rural areas.

The preceding results were used as a reference point for estimating participation rates related to other opportunities in the Residential sector.

Highlights:

- Participation rates for standard CFLs were also applied to LED holiday lighting, motion sensors and timers.
- Participation rates for specialized CFLs were also informed by the discussion on standard CFLs.
- Other technologies that are well established in the marketplace were estimated to have similar uptake if supported by the Utilities' program activity. These included ECPM furnace fan motors, low-flow showerheads and faucets, DHW tank insulating blankets and DHW piping insulation.
- T8 lighting in apartment buildings drew on the participation rates identified during the Commercial sector workshop (see Section 6.4.1 in the companion Commercial report.

### 6.4.3 R3 – Insulate Foundations

Workshop participants concluded that, under the conditions represented by the Upper Achievable scenario, participation rates up to 75% in existing single-family detached homes and up to 98% in new single-family detached homes could be achieved in the Island and Isolated service region by 2026. Workshop participants agreed that Adoption Curve B for existing homes and Curve C for new homes represented the best fits with the pace of participation in the intervening years from 2007 to 2026 under this Upper Achievable scenario.

Under the more modest market conditions represented by the Lower Achievable scenario, participation rates up to 25% in existing single-family detached homes and up to 55% in new single-family detached homes could be achieved in the Island and Isolated service region by 2026. Workshop participants agreed that Adoption Curve B for existing homes and Curve A for new homes represented the best fits with the pace of participation in the intervening years from 2007 to 2026 under this Lower Achievable scenario.

Based on the workshop discussions, it was assumed that participation rates in the remaining dwelling types would be similar to the above values. The measure is not applicable to apartment buildings. Participation rates in the Labrador Interconnected service region were assumed to be somewhat lower than those for the Island and Isolated service region because there are fewer basements and more crawl spaces. If the program could be broadened to include crawl space insulation, overall savings potential in the Labrador Interconnected service region would be increased.

Selected highlights:

- Code for basement insulation is often ignored (up to 90%) because of lack of enforcement. Insulation is often installed within a few years as part of basement refinishing
- NP has had surprisingly good uptake for a program on foundation insulation, without a great deal of marketing. NLH has had smaller uptake in Labrador Interconnected due to the lack of financial drivers
- There were concerns about encouraging consumers to install insulation as a do-it-yourself project (e.g., consumers may not be familiar with code)
- Technical innovation is a possibility in future, lowering the installation cost and the payback.

The preceding results were used as a reference point for estimating participation rates related to other insulation opportunities in the Residential sector.

Highlights:

- Participation rates for foundation insulation were also applied to crawl space insulation
- The estimate of participation for attic insulation was also informed by the discussion of foundation insulation.

### 6.4.4 R4 – Seal Air Leaks

Workshop participants concluded that, under the conditions represented by the Upper Achievable scenario, participation rates up to 90% could be achieved in new single-family detached homes in the Island and Isolated service region by 2026. Workshop participants agreed that Adoption Curve B represented the best fit with the pace of participation in the intervening years from 2007 to 2026 under this Upper Achievable scenario.

Under the more modest market conditions represented by the Lower Achievable scenario, participation rates up to 55% could be achieved in single-family detached homes in the Island and Isolated service region by 2026. Workshop participants agreed that Adoption Curve B represented the best fit with the pace of participation in the intervening years from 2007 to 2026 under this Lower Achievable scenario.

The workshop discussions focused on single-family detached homes and did not include consideration of other dwelling types. Participation rates in the Labrador Interconnected service region were assumed to be somewhat lower than those for the Island and Isolated service region, because of lower electricity prices.

Selected highlights:

- Opinions ranged widely on the capital cost of undertaking this upgrade, from as little as $400 to over $1,000 per house. Opinions on savings ranged from 10% of heating energy to as much as 15%
- For the purposes of discussion, reduction of leakage to 1.75 air changes per hour was considered a target
- Improved comfort in the home is likely to be an attractive selling feature.

### 6.4.5 R5 – Upgrade to ENERGY STAR Windows at Time of Window Replacement or New Installation

Workshop participants concluded that, under the conditions represented by the Upper Achievable scenario, participation rates up to 100% could be achieved in both existing and new single-family detached homes in the Island and Isolated service region by 2026. Workshop participants agreed that Adoption Curve B in existing homes and Curve C in new homes represented the best fits with the pace of participation in the intervening years from 2007 to 2026 under this Upper Achievable scenario.

Under the more modest market conditions represented by the Lower Achievable scenario, participation rates up to 80% in existing single-family detached homes and up to 85% in new single-family detached homes could be achieved in the Island and Isolated service region by 2026. Workshop participants agreed that Adoption Curve B for existing homes and Curve C for new homes represented the best fits with the pace of participation in the intervening years from 2007 to 2026 under this Lower Achievable scenario.

Based on the workshop discussions, it was assumed that participation rates in the remaining dwelling types would be similar to the above values. The measure is replaced by the high-performance glazing commercial measure in apartment buildings. Participation rates in the Labrador Interconnected service region were assumed to be similar to those for the Island and Isolated service region.

Selected highlights:

- Workshop participants questioned the assumption that incremental cost of high-efficiency windows in the replacement (retail) market is higher than it is in the new construction (wholesale) market. Although high mark ups on the increment are the pattern in other jurisdictions, workshop participants said that retailers in Newfoundland and Labrador are not following that pattern. The measure already passes the economic screens with the current assumptions so this change would not increase the potential.

The preceding results were used as a reference point for estimating participation rates related to other window opportunities in the Residential sector.

Highlights:

- Participation rates for the super high-performance windows were assumed to trail participation rates for ENERGY STAR windows by approximately 10 years.

### 6.4.6 R6 – Construct New Houses to Achieve EG80 Rating

Workshop participants concluded that, under the conditions represented by the Upper Achievable scenario, participation rates up to 98% could be achieved in new single-family detached homes in the Island and Isolated service region by 2026. Workshop participants agreed that Adoption Curve D represented the best fit with the pace of participation in the intervening years from 2007 to 2026 under this Upper Achievable scenario. Curve D rises linearly and reaches a plateau; for this technology and scenario, that is assumed to occur in 2015.

Under the more modest market conditions represented by the Lower Achievable scenario, participation rates up to 10% could be achieved in single-family detached homes in the Island and Isolated service region by 2026. Workshop participants agreed that Adoption Curve A represented the best fit with the pace of participation in the intervening years from 2007 to 2026 under this Lower Achievable scenario.

Based on the workshop discussions, it was assumed that participation rates in the remaining dwelling types would be similar to the above values. Participation rates in the Labrador Interconnected service region were assumed to be similar to those for the Island and Isolated service region.

Selected highlights:

- A relatively small number of builders can be targeted for program activity (approximately 15-20 builders construct 50% of the homes each year)
- Provincial legislation may change the building code to require this level of energy performance at some point in the study period. That change is occurring in Nova Scotia as of 2011
- In the absence of legislation, education will be a critical program component. It is particularly important to involve the real estate community.

### 6.4.7 R7 – Reduce Standby Losses for Household Electronics using Power Bar Timers

Workshop participants concluded that, under the conditions represented by the Upper Achievable scenario, participation rates up to 25% could be achieved in single-family detached homes in the Island and Isolated service region by 2021; these rates would then descend to 0% as the technology is superseded by features built into the electronic devices. Workshop participants created Adoption Curve E to represent this bell curve shape.

The Lower Achievable scenario was assumed to be similar to the Upper Achievable scenario for this technology.

Based on the workshop discussions, it was assumed that participation rates in the remaining dwelling types would be similar to the above values. Participation rates in the Labrador Interconnected service region were assumed to be similar to those for the Island and Isolated service region.

Selected highlights:

- Discussions focused on a specific technology solution to standby losses, namely a power bar with a built-in timer that controls several of the outlets. These power bars are available in the marketplace. Discussion also focused on the television and its peripherals (especially set-top boxes), although the approach is applicable to other household electronics
- There were concerns that this device may not be suitable for some television peripherals, because power loss will erase their programming
- Workshop participants believed that a combination of technology improvements and energy standards would result in manufacturers incorporating power management features into the electronic devices themselves, eventually rendering this technology obsolete.

### 6.4.8 R8 – Upgrade to New ENERGY STAR Computer at Time of Replacement or New Purchase

Workshop participants concluded that, under the conditions represented by the Upper Achievable scenario, participation rates up to 80% could be achieved in single-family detached homes in the Island and Isolated service region by 2026. Workshop participants agreed that Adoption Curve B represented the best fit with the pace of participation in the intervening years from 2007 to 2026 under this Upper Achievable scenario.

Under the more modest market conditions represented by the Lower Achievable scenario, participation rates up to 15% could be achieved in single-family detached homes in the Island and Isolated service region by 2026. Workshop participants agreed that Adoption Curve B represented the best fit with the pace of participation in the intervening years from 2007 to 2026 under this Lower Achievable scenario.

Based on the workshop discussions, it was assumed that participation rates in the remaining dwelling types would be similar to the above values. Participation rates in the Labrador Interconnected service region were assumed to be similar to those for the Island and Isolated service region.

Selected highlights:

- ENERGY STAR for most appliances has generally been lower in Newfoundland and Labrador than in other jurisdictions, partly because of poor product availability. ENERGY STAR computers may fare somewhat better because there is no incremental cost.

The preceding results were used as a reference point for estimating participation rates related to other opportunities in the Residential sector.

Highlights:

- The discussion of ENERGY STAR computers informed the participation rates used for ENERGY STAR appliances, such as fridges, freezers, clothes washers and televisions.

### 6.4.9 R9 – Upgrade to New ENERGY STAR Clothes Washer at Time of Replacement or New Purchase

Workshop participants did not discuss this measure separately, but did discuss ENERGY STAR appliances in general during the discussion of computers. The clothes washer measure, although it has a large potential, has a CCE very close to the threshold. This leaves very little room for program activity or incentives. It would therefore be difficult to achieve significant penetration. Further, the efficient top loading clothes washer is the one that passes the CCE test. It is very rare in the marketplace, with only one or two models available in Canada. The front loading washer is more available and is even more efficient, but is also more expensive and does not pass the CCE test. For these reasons this measure was seen as a lower priority for workshop discussion.

### 6.4.10 Extrapolated Participation Rates – Remaining Energy-efficiency Opportunities

As noted previously, the workshop results and follow up email responses were used as a reference point, combined with consultant experience, to estimate participation rates for the remaining energy-efficiency opportunities that are contained in the Economic Potential Forecast.

Exhibits 6.8 and 6.9 provide, respectively, a summary of the estimated Upper and Lower participation rates for the remaining energy-efficiency opportunities. As illustrated, each exhibit shows:

- Workshop reference number, which refers to the package of Opportunity Profiles that were provided to workshop participants
- The affected technology
- The participation rates for each of the milestone years
- Notes that illustrate sources used by the consultants when estimating the participation rates shown.

## Exhibit 6.8: Participation Rates – Upper Achievable Potential[123]

| Measure Information | | Participation Rates | | Notes |
|---|---|---|---|---|
| **Workshop Reference #** | **Technology** | **F2026** | **Curve** | |
| R1 | Efficient (More Accurate) Thermostat | 90% | B | R1: Workshop input. |
| R2 | CFLs - Standard | 98% | B | R2: Workshop input. |
| R3 | Foundation Insulation, Existing | 75% | B | R3: Workshop input. |
| R3 | Foundation Insulation, New | 98% | A | R3: Workshop input. |
| R4 | Air Leakage Sealing | 90% | B | R4: Workshop input. |
| R5 | Energy Star Windows , Existing | 100% | B | R5: Workshop input. |
| R5 | Energy Star Windows , New | 100% | C | R5: Workshop input. |
| R6 | New House Designed to an EGNH 80 Rating | 98% | A | R6: Workshop input. |
| R7 | Standby Losses | 0% | E* | R7: Workshop input. |
| R8 | Energy Star Computer | 80% | B | R8: Workshop input. |
| C1 | Standard T8 Lighting - Common Areas, Existing Bldgs | 97% | A | C1: Workshop input. |
| C1 | Redesign with high performance T8s, Existing Bldgs | 40% | A | C1: Workshop input. |
| C2 | Redesign with high performance T8s, New Bldgs | 100% | C | C2: Workshop input. |
| C4 | High performance glazings | 20% | A | C4: Workshop input. |
| C5 | Building recommissioning | 85% | B | C5: Workshop input. |
| C6 | Ground source heat pumps | 20% | A | C6: Workshop input. |
| C7 | 40% Lower Energy Apartment Building | 56% | A/B** | C7: Workshop input. |
| | Super High Performance Windows | 25% | | Trail the participation rates for R5 by 10 years. |
| | Attic Insulation | 56% | | Similar participation to R3. |
| | Crawl-space Insulation | 75% | | Similar participation to R3, but much smaller incidence of crawlspaces. |
| | Programmable Thermostats | 5% | | Not much forced air electric heating (cf R1), but install on grouped baseboards in main areas. |
| | High Efficiency HRV | 25% | | Advanced version of accepted technology: use rates for Super windows. |
| | High Efficiency HRV | 75% | | Advanced version of accepted technology: use rates for Super windows. |
| | Furnace Fan Motor (ECPMM) | 98% | | Based on CFLs - standard, where it passes, because it can have high adoption if pushed |
| | Low-Flow Showerheads and Faucets | 98% | | Based on CFLs - standard, where it passes, because it can have high adoption if pushed |
| | DHW Tank Insulating Blanket | 98% | | Based on CFLs - standard, where it passes, because it can have high adoption if pushed |
| | DHW Pipe Wrap | 98% | | Based on CFLs - standard, where it passes, because it can have high adoption if pushed |
| | Energy Star Fridge | 80% | | R8 input probably reasonable for participation above E* reference penetration. |
| | Energy Star Fridge | 80% | | R8 input probably reasonable for participation above E* reference penetration. |
| | Energy Efficient Freezer | 80% | | R8 input probably reasonable for participation above E* reference penetration. |
| | Energy Star Top Loading Clothes Washer | 80% | | R8 input probably reasonable for participation above E* reference penetration. |
| | Energy Star TV | 80% | | Based on Energy Star Computer (R8) |
| | LED Holiday Lights | 98% | | Based on CFLs (R2). |
| | Timer | 98% | | Based on CFLs (R2). |
| | Motion Sensor | 98% | | Based on CFLs (R2). |
| | CFLs Specialised | 98% | | Based on CFL standard (R2). |
| | Replace air-source heat pump with a low temperature heat pump | 10% | | Not available yet. Use 0% until 2011, climb to 10% by 2026. |

* E - this curve, created by the workshop participants, is a bell-shaped curve that peaks in 2021 and descends back to zero after the technology is superseded by other advances
** A/B - this curve is a hybrid between curves A and B

[123] The low-temperature heat pump measure in this exhibit is for apartment buildings only. Units designed for apartments are under development. The low-temperature heat pumps for single detached homes, which are available, did not pass the economic screen and are not included in this exhibit.

## Exhibit 6.9: Participation Rates – Lower Achievable Potential [124]

| Measure Information | | Participation Rates | | Notes |
|---|---|---|---|---|
| Workshop Reference # | Technology | F2026 | Curve | |
| R1 | Efficient (More Accurate) Thermostat | 20% | C | R1: Workshop input. |
| R2 | CFLs - Standard | 90% | A | R2: Workshop input. |
| R3 | Foundation Insulation, Existing | 25% | B | R3: Workshop input. |
| R3 | Foundation Insulation, New | 55% | C | R3: Workshop input. |
| R4 | Air Leakage Sealing | 55% | B | W4: Workshop input. |
| R5 | Energy Star Windows , Existing | 80% | B | R5: Workshop input. |
| R5 | Energy Star Windows , New | 100% | C | R5: Workshop input. |
| R6 | New House Designed to an EGNH 80 Rating | 10% | D | R6: Workshop input. |
| R7 | Standby Losses | 0% | E* | R7: Workshop input. |
| R8 | Energy Star Computer | 15% | B | R8: Workshop input. |
| C1 | Standard T8 Lighting - Common Areas, Existing Bldgs | 80% | A | C1: Workshop input. |
| C1 | Redesign with high performance T8s, Existing Bldgs | 15% | A | C1: Workshop input. |
| C2 | Redesign with high performance T8s, New Bldgs | 80% | C | C2: Workshop input. |
| C4 | High performance glazings | 7% | A | C4: Workshop input. |
| C5 | Building recommissioning | 40% | A/B** | C5: Workshop input. |
| C6 | Ground source heat pumps | 2% | B | C6: Workshop input. |
| C7 | 40% Lower Energy Apartment Building | 38% | A/B** | C7: Workshop input. |
| | Super High Performance Windows | 20% | | Trail the rates for R5 by 10 years. |
| | Attic Insulation | 19% | | Similar participation to R3. |
| | Crawl-space Insulation | 25% | | Similar participation to R3, but much smaller incidence of crawlspaces. |
| | Programmable Thermostats | 2% | | Not much forced air electric heating (informed by R1 discussion). |
| | High Efficiency HRV | 20% | | Advanced version of accepted technology: use rates for Super windows. |
| | High Efficiency HRV | 25% | | Advanced version of accepted technology: use rates for Super windows. |
| | Furnace Fan Motor (ECPMM) | 90% | | Based on CFLs - standard, where it passes, because it can have high adoption if pushed |
| | Low-Flow Showerheads and Faucets | 90% | | Based on CFLs - standard, where it passes, because it can have high adoption if pushed |
| | DHW Tank Insulating Blanket | 90% | | Based on CFLs - standard, where it passes, because it can have high adoption if pushed |
| | DHW Pipe Wrap | 90% | | Based on CFLs - standard, where it passes, because it can have high adoption if pushed |
| | Energy Star Fridge | 15% | | R8 input probably reasonable for participation above E* reference penetration. |
| | Energy Star Fridge | 15% | | R8 input probably reasonable for participation above E* reference penetration. |
| | Energy Efficient Freezer | 15% | | R8 input probably reasonable for participation above E* reference penetration. |
| | Energy Star Top Loading Clothes Washer | 15% | | R8 input probably reasonable for participation above E* reference penetration. |
| | Energy Star TV | 15% | | Based on Energy Star Computer (R8) |
| | LED Holiday Lights | 90% | | Based on CFLs (R2). |
| | Timer | 90% | | Based on CFLs (R2). |
| | Motion Sensor | 90% | | Based on CFLs (R2). |
| | CFLs Specialised | 90% | | Based on CFL standard (R2). |
| | Replace air-source heat pump with a low temperature heat pump | 5% | | Not available yet. Use 0% until 2011, climb to 5% by 2026. |

* E - this curve, created by the workshop participants, is a bell-shaped curve that peaks in 2021 and descends back to zero after the technology is superseded by other advances
** A/B - this curve is a hybrid between curves A and B

[124] The low-temperature heat pump measure in this exhibit is for apartment buildings only. Units designed for apartments are under development. The low-temperature heat pumps for single detached homes, which are available, did not pass the economic screen and are not included in this exhibit.

## 6.5 SUMMARY OF ACHIEVABLE ELECTRICITY SAVINGS

Exhibit 6.10 provides a summary of the Achievable electricity savings under both the Lower and Upper scenarios for the Island and Isolated service region.

As illustrated, under the Reference Case residential electricity use would grow from the Base Year level of 3,228 GWh/yr. to approximately 3,968 GWh/yr. by 2026. This contrasts with the Upper Achievable scenario in which electricity use would increase to approximately 3,529 GWh/yr. for the same period, a difference of approximately 439 GWh/yr., or about 11% reduction. Under the Lower Achievable scenario, electricity use would increase to approximately 3,732 GWh/yr. for the same period, a difference of approximately 236 GWh/yr., or about 6% reduction.

**Exhibit 6.10: Reference Case versus Upper and Lower Achievable Potential Electricity Consumption in Residential Sector for the Island and Isolated Service Region (GWh/yr.)**

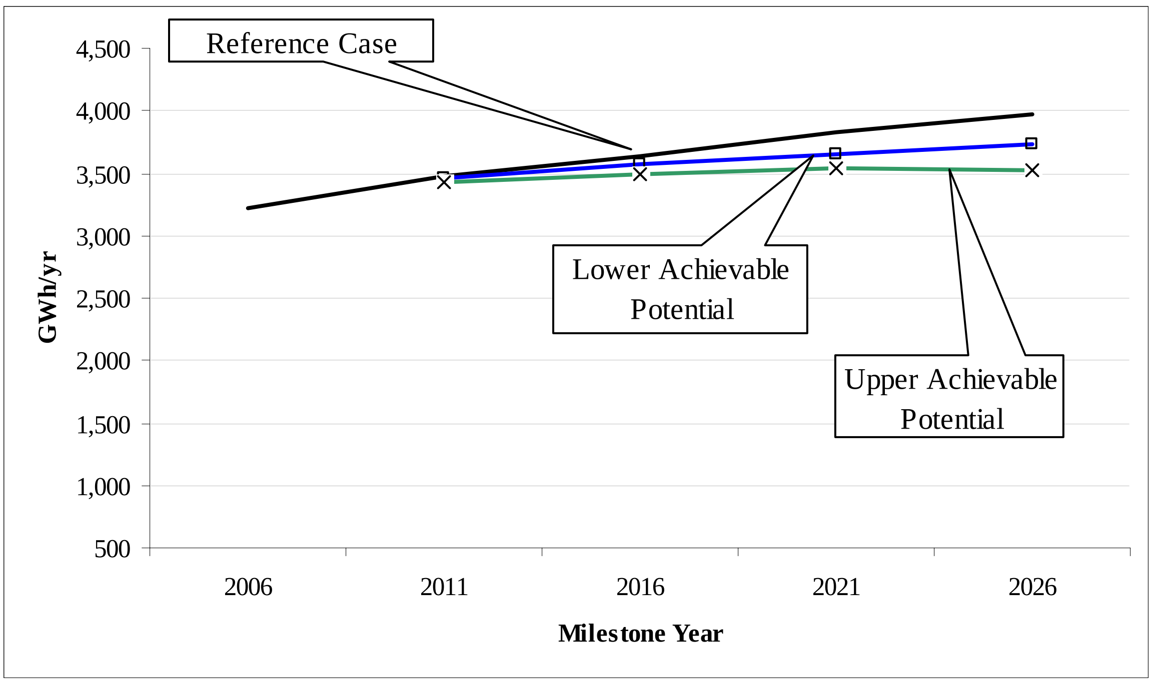
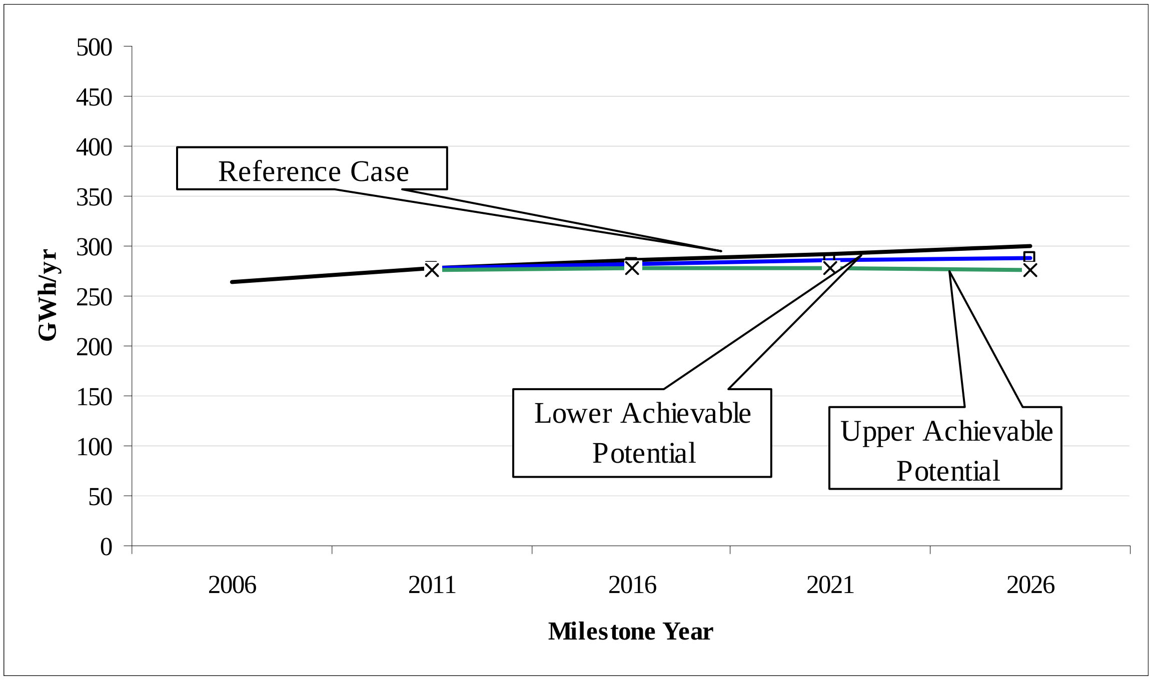



Exhibit 6.11 provides a summary of the achievable electricity savings under both the Lower and Upper scenarios for the Labrador Interconnected service region.

As illustrated, under the Reference Case residential electricity use would grow from the Base Year level of 264 GWh/yr. to approximately 300 GWh/yr. by 2026. This contrasts with the Upper Achievable scenario in which electricity use would increase to approximately 275 GWh/yr. for the same period, a difference of approximately 25 GWh/yr., or about 8% reduction. Under the Lower Achievable scenario, electricity use would increase to approximately 287 GWh/yr. for the same period, a difference of approximately 13 GWh/yr., or about 4% reduction.

**Exhibit 6.11: Reference Case versus Upper and Lower Achievable Potential Electricity Consumption in Residential Sector for the Labrador Interconnected Service Region (GWh/yr.)**




Further detail on the total potential electricity savings provided by the Achievable Potential forecasts is provided in the following exhibits:

- Exhibits 6.12 and 6.13 present, respectively, the Upper and Lower Achievable results by end use, dwelling type and milestone year for the Island and Isolated service region
- Exhibits 6.14 and 6.15 present, respectively, the Upper and Lower Achievable results by end use, dwelling type and milestone year for the Labrador Interconnected service region
- Exhibits 6.16 and 6.17 present, respectively, the Upper and Lower Achievable savings in 2026 by major end use and dwelling type for the Island and Isolated service region
- Exhibits 6.18 and 6.19 present, respectively, the Upper and Lower Achievable savings in 2026 by major end use and service region for the Labrador Interconnected service region
- Exhibit 6.20 presents the Upper and Lower Achievable savings by milestone year and service region.

## Exhibit 6.12: Summary of Annual Electricity Savings for the Island and Isolated Service Region by End Use and Dwelling Type, Upper Achievable Potential (GWh/yr.)

| Dwelling Type | Milestone Year | Residential | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Total | Space Heating | Ventilation | DHW | Cooking | Refrigerator | Freezer | Dishwasher | Clothes Washer | Clothes Dryer | Lighting | Computer and peripherals | Television | Television Peripherals | Other Electronics | Small Appliances & Other |
| Detached | 2011 | 47.1 | 1.9 | 0.0 | 9.0 | | 0.0 | 0.0 | | 0.0 | 0.0 | 34.4 | 1.0 | 0.0 | 0.7 | 0.0 | |
| | 2016 | 121.6 | 15.0 | 0.1 | 14.9 | | 0.6 | 0.3 | | 0.3 | 2.4 | 70.2 | 8.0 | 1.3 | 8.2 | 0.2 | |
| | 2021 | 233.0 | 45.9 | 0.1 | 24.7 | | 2.2 | 1.2 | | 0.9 | 7.8 | 107.0 | 16.0 | 4.8 | 21.8 | 0.5 | |
| | 2026 | 362.0 | 116.0 | 0.2 | 38.6 | | 4.4 | 2.6 | | 2.1 | 17.5 | 144.6 | 26.3 | 9.7 | 0.0 | 0.0 | |
| | | | | | | | | | | | | | | | | | |
| Attached | 2011 | 5.6 | 0.0 | 0.0 | 1.1 | | 0.0 | 0.0 | | 0.0 | 0.0 | 4.2 | 0.1 | 0.0 | 0.1 | 0.0 | |
| | 2016 | 15.5 | 1.6 | 0.0 | 1.8 | | 0.1 | 0.0 | | 0.0 | 0.2 | 8.6 | 1.2 | 0.2 | 1.7 | 0.0 | |
| | 2021 | 29.6 | 4.6 | 0.0 | 3.0 | | 0.4 | 0.0 | | 0.1 | 0.8 | 13.3 | 2.4 | 0.6 | 4.3 | 0.1 | |
| | 2026 | 41.6 | 10.4 | 0.0 | 4.8 | | 0.8 | 0.0 | | 0.2 | 1.8 | 18.2 | 4.0 | 1.3 | 0.0 | 0.0 | |
| | | | | | | | | | | | | | | | | | |
| Apartment | 2011 | 3.5 | 0.3 | 0.1 | 0.7 | | 0.0 | 0.0 | | 0.0 | 0.0 | 2.2 | 0.1 | 0.0 | 0.1 | 0.0 | |
| | 2016 | 9.5 | 0.6 | 0.2 | 1.6 | | 0.1 | 0.0 | | 0.0 | 0.1 | 4.6 | 0.8 | 0.1 | 1.3 | 0.0 | |
| | 2021 | 18.0 | 1.2 | 0.4 | 3.2 | | 0.3 | 0.0 | | 0.0 | 0.3 | 7.1 | 1.6 | 0.4 | 3.4 | 0.0 | |
| | 2026 | 25.1 | 4.5 | 0.7 | 5.2 | | 0.7 | 0.0 | | 0.1 | 0.8 | 9.6 | 2.7 | 0.9 | 0.0 | 0.0 | |
| | | | | | | | | | | | | | | | | | |
| Isolated | 2011 | 1.0 | 0.0 | 0.0 | 0.2 | | 0.0 | 0.0 | | 0.0 | 0.0 | 0.8 | 0.0 | 0.0 | 0.0 | 0.0 | |
| | 2016 | 2.2 | 0.0 | 0.0 | 0.3 | | 0.0 | 0.0 | | 0.0 | 0.0 | 1.5 | 0.1 | 0.0 | 0.1 | 0.0 | |
| | 2021 | 3.7 | 0.1 | 0.0 | 0.5 | | 0.0 | 0.0 | | 0.0 | 0.2 | 2.3 | 0.2 | 0.1 | 0.3 | 0.0 | |
| | 2026 | 5.0 | 0.2 | 0.0 | 0.8 | | 0.1 | 0.1 | | 0.0 | 0.3 | 3.1 | 0.3 | 0.1 | 0.0 | 0.0 | |
| | | | | | | | | | | | | | | | | | |
| Other | 2011 | 0.4 | -0.1 | 0.0 | 0.0 | | 0.0 | 0.0 | | 0.0 | 0.0 | 0.6 | 0.0 | 0.0 | 0.0 | 0.0 | |
| | 2016 | 1.0 | -0.1 | 0.0 | 0.0 | | 0.0 | 0.0 | | 0.0 | 0.0 | 1.1 | 0.0 | 0.0 | 0.0 | 0.0 | |
| | 2021 | 1.6 | -0.1 | 0.0 | 0.0 | | 0.0 | 0.0 | | 0.0 | 0.0 | 1.7 | 0.0 | 0.0 | 0.0 | 0.0 | |
| | 2026 | 2.1 | -0.1 | 0.0 | 0.0 | | 0.0 | 0.0 | | 0.0 | 0.0 | 2.2 | 0.0 | 0.0 | 0.0 | 0.0 | |
| | | | | | | | | | | | | | | | | | |
| Vacant and Partial | 2011 | 0.6 | -0.1 | 0.0 | 0.0 | | 0.0 | 0.0 | | 0.0 | 0.0 | 0.8 | 0.0 | 0.0 | 0.0 | 0.0 | |
| | 2016 | 1.4 | -0.1 | 0.0 | 0.0 | | 0.0 | 0.0 | | 0.0 | 0.0 | 1.5 | 0.0 | 0.0 | 0.0 | 0.0 | |
| | 2021 | 2.1 | -0.1 | 0.0 | 0.0 | | 0.0 | 0.0 | | 0.0 | 0.0 | 2.2 | 0.0 | 0.0 | 0.0 | 0.0 | |
| | 2026 | 2.8 | -0.1 | 0.0 | 0.0 | | 0.0 | 0.0 | | 0.0 | 0.0 | 2.9 | 0.0 | 0.0 | 0.0 | 0.0 | |
| | | | | | | | | | | | | | | | | | |
| TOTAL | 2011 | 58.2 | 2.0 | 0.1 | 10.9 | | 0.0 | 0.0 | | 0.0 | 0.0 | 42.8 | 1.2 | 0.1 | 1.0 | 0.0 | |
| | 2016 | 151.1 | 17.0 | 0.3 | 18.6 | | 0.8 | 0.4 | | 0.3 | 2.8 | 87.6 | 10.0 | 1.6 | 11.3 | 0.3 | |
| | 2021 | 287.9 | 51.6 | 0.6 | 31.4 | | 2.9 | 1.3 | | 1.1 | 9.1 | 133.5 | 20.1 | 5.9 | 29.7 | 0.7 | |
| | 2026 | 438.7 | 130.9 | 0.9 | 49.5 | | 5.9 | 2.7 | | 2.5 | 20.5 | 180.7 | 33.2 | 12.1 | 0.0 | 0.0 | |

•

*Notes: 1) Results are measured at the customer's point-of-use and do not include line losses. 2) Any differences in totals are due to rounding. 3) A value displays as 0 if it is between 0 and 0.5. Totals are calculated using the actual numerical value. 4) Negative values in the space heating end use are a result of the reduction in internal heat gains due to lighting and appliance measures being greater than any savings from space heating measures. 5) Savings for television peripherals and other electronics are from standby loss reduction measures. Workshop participants believed that by 2026 advances in the appliances themselves would eliminate the savings available from add-on devices such as timed power bars. Savings in the last milestone period therefore drop to zero.*

## Exhibit 6.13: Summary of Annual Electricity Savings for the Island and Isolated Service Region by End Use and Dwelling Type, Lower Achievable Potential (GWh/yr.)

| Dwelling Type | Milestone Year | Residential | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **Total** | **Space Heating** | **Ventilation** | **DHW** | **Cooking** | **Refrigerator** | **Freezer** | **Dishwasher** | **Clothes Washer** | **Clothes Dryer** | **Lighting** | **Computer and peripherals** | **Television** | **Television Peripherals** | **Other Electronics** | **Small Appliances & Other** |
| Detached | 2011 | 12.2 | 0.5 | 0.0 | 2.2 | | 0.0 | 0.0 | | 0.0 | 0.0 | 8.4 | 0.3 | 0.0 | 0.7 | 0.0 | |
| | 2016 | 54.8 | 3.3 | 0.0 | 6.0 | | 0.1 | 0.1 | | 0.1 | 0.5 | 33.1 | 2.5 | 0.7 | 8.2 | 0.2 | |
| | 2021 | 128.2 | 11.1 | 0.1 | 11.0 | | 0.4 | 0.2 | | 0.2 | 1.4 | 74.5 | 5.3 | 1.8 | 21.8 | 0.5 | |
| | 2026 | 190.8 | 30.8 | 0.1 | 15.3 | | 0.8 | 0.5 | | 0.4 | 3.3 | 132.9 | 5.0 | 1.8 | 0.0 | 0.0 | |
| Attached | 2011 | 1.5 | 0.0 | 0.0 | 0.3 | | 0.0 | 0.0 | | 0.0 | 0.0 | 1.0 | 0.0 | 0.0 | 0.1 | 0.0 | |
| | 2016 | 7.2 | 0.1 | 0.0 | 0.7 | | 0.0 | 0.0 | | 0.0 | 0.0 | 4.0 | 0.4 | 0.1 | 1.7 | 0.0 | |
| | 2021 | 16.6 | 0.4 | 0.0 | 1.3 | | 0.1 | 0.0 | | 0.0 | 0.1 | 9.2 | 0.8 | 0.2 | 4.3 | 0.1 | |
| | 2026 | 22.3 | 2.1 | 0.0 | 1.9 | | 0.2 | 0.0 | | 0.0 | 0.3 | 16.7 | 0.8 | 0.2 | 0.0 | 0.0 | |
| Apartment | 2011 | 1.3 | 0.2 | 0.0 | 0.3 | | 0.0 | 0.0 | | 0.0 | 0.0 | 0.6 | 0.0 | 0.0 | 0.1 | 0.0 | |
| | 2016 | 5.2 | 0.4 | 0.1 | 0.8 | | 0.0 | 0.0 | | 0.0 | 0.0 | 2.3 | 0.2 | 0.1 | 1.3 | 0.0 | |
| | 2021 | 11.6 | 0.7 | 0.2 | 1.5 | | 0.1 | 0.0 | | 0.0 | 0.1 | 5.0 | 0.5 | 0.2 | 3.4 | 0.0 | |
| | 2026 | 14.6 | 2.1 | 0.3 | 2.6 | | 0.1 | 0.0 | | 0.0 | 0.1 | 8.7 | 0.5 | 0.2 | 0.0 | 0.0 | |
| Isolated | 2011 | 0.2 | 0.0 | 0.0 | 0.0 | | 0.0 | 0.0 | | 0.0 | 0.0 | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 | |
| | 2016 | 1.0 | 0.0 | 0.0 | 0.1 | | 0.0 | 0.0 | | 0.0 | 0.0 | 0.7 | 0.0 | 0.0 | 0.1 | 0.0 | |
| | 2021 | 2.3 | 0.0 | 0.0 | 0.2 | | 0.0 | 0.0 | | 0.0 | 0.0 | 1.6 | 0.1 | 0.0 | 0.3 | 0.0 | |
| | 2026 | 3.4 | 0.0 | 0.0 | 0.3 | | 0.0 | 0.0 | | 0.0 | 0.1 | 2.9 | 0.0 | 0.0 | 0.0 | 0.0 | |
| Other | 2011 | 0.1 | 0.0 | 0.0 | 0.0 | | 0.0 | 0.0 | | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | |
| | 2016 | 0.4 | -0.1 | 0.0 | 0.0 | | 0.0 | 0.0 | | 0.0 | 0.0 | 0.5 | 0.0 | 0.0 | 0.0 | 0.0 | |
| | 2021 | 1.1 | -0.1 | 0.0 | 0.0 | | 0.0 | 0.0 | | 0.0 | 0.0 | 1.2 | 0.0 | 0.0 | 0.0 | 0.0 | |
| | 2026 | 1.9 | -0.1 | 0.0 | 0.0 | | 0.0 | 0.0 | | 0.0 | 0.0 | 2.0 | 0.0 | 0.0 | 0.0 | 0.0 | |
| Vacant and Partial | 2011 | 0.1 | 0.0 | 0.0 | 0.0 | | 0.0 | 0.0 | | 0.0 | 0.0 | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 | |
| | 2016 | 0.6 | -0.1 | 0.0 | 0.0 | | 0.0 | 0.0 | | 0.0 | 0.0 | 0.7 | 0.0 | 0.0 | 0.0 | 0.0 | |
| | 2021 | 1.4 | -0.1 | 0.0 | 0.0 | | 0.0 | 0.0 | | 0.0 | 0.0 | 1.5 | 0.0 | 0.0 | 0.0 | 0.0 | |
| | 2026 | 2.6 | -0.1 | 0.0 | 0.0 | | 0.0 | 0.0 | | 0.0 | 0.0 | 2.7 | 0.0 | 0.0 | 0.0 | 0.0 | |
| TOTAL | 2011 | 15.5 | 0.7 | 0.0 | 2.8 | | 0.0 | 0.0 | | 0.0 | 0.0 | 10.6 | 0.3 | 0.1 | 1.0 | 0.0 | |
| | 2016 | 69.2 | 3.7 | 0.1 | 7.6 | | 0.2 | 0.1 | | 0.1 | 0.6 | 41.4 | 3.1 | 0.8 | 11.3 | 0.3 | |
| | 2021 | 161.3 | 12.0 | 0.3 | 14.1 | | 0.5 | 0.2 | | 0.2 | 1.7 | 93.0 | 6.6 | 2.3 | 29.7 | 0.7 | |
| | 2026 | 235.7 | 34.8 | 0.4 | 20.1 | | 1.1 | 0.5 | | 0.5 | 3.8 | 166.0 | 6.3 | 2.2 | 0.0 | 0.0 | |

*Notes: 1) Results are measured at the customer's point-of-use and do not include line losses. 2) Any differences in totals are due to rounding. 3) A value displays as 0 if it is between 0 and 0.5. Totals are calculated using the actual numerical value. 4) Negative values in the space heating end use are a result of the reduction in internal heat gains due to lighting and appliance measures being greater than any savings from space heating measures. 5) Savings for television peripherals and other electronics are from standby loss reduction measures. Workshop participants believed that by 2026 advances in the appliances themselves would eliminate the savings available from add-on devices such as timed power bars. Savings in the last milestone period therefore drop to zero.*

## Exhibit 6.14: Summary of Annual Electricity Savings for the Labrador Interconnected Service Region by End Use and Dwelling Type, Upper Achievable Potential (GWh/yr.)

| Dwelling Type | Milestone Year | Residential | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Total | Space Heating | Ventilation | DHW | Cooking | Refrigerator | Freezer | Dishwasher | Clothes Washer | Clothes Dryer | Lighting | Computer and peripherals | Television | Television Peripherals | Other Electronics | Small Appliances & Other |
| Detached | 2011 | 1.8 | 0.2 | 0.0 | 0.4 | | | | | | | 1.1 | 0.0 | | 0.0 | 0.0 | |
| | 2016 | 5.3 | 2.0 | 0.0 | 0.5 | | | | | | | 2.3 | 0.2 | | 0.2 | 0.0 | |
| | 2021 | 11.1 | 6.1 | 0.0 | 0.6 | | | | | | | 3.5 | 0.4 | | 0.5 | 0.0 | |
| | 2026 | 19.2 | 13.3 | 0.0 | 0.5 | | | | | | | 4.7 | 0.7 | | 0.0 | 0.0 | |
| | | | | | | | | | | | | | | | | | |
| Attached | 2011 | 0.5 | 0.0 | 0.0 | 0.1 | | | | | | | 0.4 | 0.0 | | 0.0 | 0.0 | |
| | 2016 | 1.4 | 0.3 | 0.0 | 0.2 | | | | | | | 0.7 | 0.1 | | 0.1 | 0.0 | |
| | 2021 | 2.8 | 1.1 | 0.0 | 0.2 | | | | | | | 1.1 | 0.1 | | 0.2 | 0.0 | |
| | 2026 | 4.5 | 2.7 | 0.0 | 0.2 | | | | | | | 1.5 | 0.2 | | 0.0 | 0.0 | |
| | | | | | | | | | | | | | | | | | |
| Apartment | 2011 | 0.1 | 0.0 | 0.0 | 0.0 | | | | | | | 0.0 | 0.0 | | 0.0 | 0.0 | |
| | 2016 | 0.2 | 0.0 | 0.0 | 0.0 | | | | | | | 0.1 | 0.0 | | 0.0 | 0.0 | |
| | 2021 | 0.3 | 0.0 | 0.0 | 0.0 | | | | | | | 0.2 | 0.0 | | 0.1 | 0.0 | |
| | 2026 | 0.4 | 0.1 | 0.0 | 0.0 | | | | | | | 0.2 | 0.0 | | 0.0 | 0.0 | |
| | | | | | | | | | | | | | | | | | |
| Isolated | 2011 | 0.0 | 0.0 | 0.0 | 0.0 | | | | | | | 0.0 | 0.0 | | 0.0 | 0.0 | |
| | 2016 | 0.0 | 0.0 | 0.0 | 0.0 | | | | | | | 0.0 | 0.0 | | 0.0 | 0.0 | |
| | 2021 | 0.0 | 0.0 | 0.0 | 0.0 | | | | | | | 0.0 | 0.0 | | 0.0 | 0.0 | |
| | 2026 | 0.0 | 0.0 | 0.0 | 0.0 | | | | | | | 0.0 | 0.0 | | 0.0 | 0.0 | |
| | | | | | | | | | | | | | | | | | |
| Other | 2011 | 0.0 | 0.0 | 0.0 | 0.0 | | | | | | | 0.0 | 0.0 | | 0.0 | 0.0 | |
| | 2016 | 0.0 | 0.0 | 0.0 | 0.0 | | | | | | | 0.0 | 0.0 | | 0.0 | 0.0 | |
| | 2021 | 0.1 | 0.0 | 0.0 | 0.0 | | | | | | | 0.1 | 0.0 | | 0.0 | 0.0 | |
| | 2026 | 0.1 | 0.0 | 0.0 | 0.0 | | | | | | | 0.1 | 0.0 | | 0.0 | 0.0 | |
| | | | | | | | | | | | | | | | | | |
| TOTAL | 2011 | 2.5 | 0.2 | 0.0 | 0.6 | | | | | | | 1.6 | 0.0 | | 0.0 | 0.0 | |
| | 2016 | 6.9 | 2.4 | 0.0 | 0.7 | | | | | | | 3.2 | 0.3 | | 0.3 | 0.0 | |
| | 2021 | 14.3 | 7.2 | 0.0 | 0.8 | | | | | | | 4.8 | 0.5 | | 0.8 | 0.0 | |
| | 2026 | 24.2 | 16.1 | 0.0 | 0.7 | | | | | | | 6.5 | 0.9 | | 0.0 | 0.0 | |

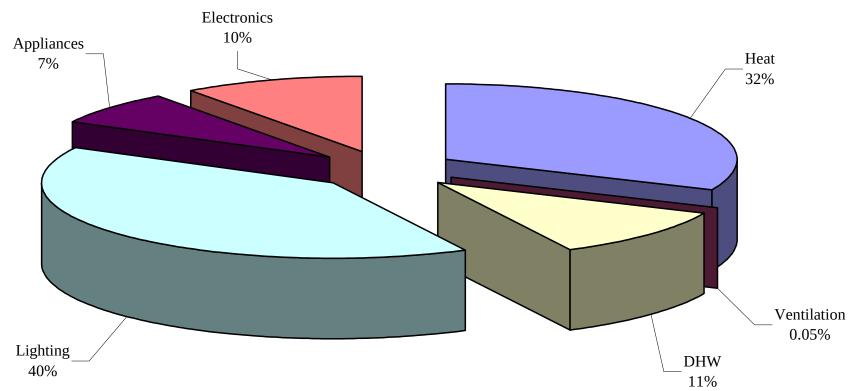
*Notes: 1) Results are measured at the customer's point-of-use and do not include line losses. 2) Any differences in totals are due to rounding. 3) A value displays as 0 if it is between 0 and 0.5. Totals are calculated using the actual numerical value. 4) Negative values in the space heating end use are a result of the reduction in internal heat gains due to lighting and appliance measures being greater than any savings from space heating measures. 5) Savings for television peripherals and other electronics are from standby loss reduction measures. Workshop participants believed that by 2026 advances in the appliances themselves would eliminate the savings available from add-on devices such as timed power bars. Savings in the last milestone period therefore drop to zero.*

## Exhibit 6.15: Summary of Annual Electricity Savings for the Labrador Interconnected Service Region by End Use and Dwelling Type, Lower Achievable Potential (GWh/yr.)

| | | Residential | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Dwelling Type** | **Milestone Year** | **Total** | **Space Heating** | **Ventilation** | **DHW** | **Cooking** | **Refrigerator** | **Freezer** | **Dishwasher** | **Clothes Washer** | **Clothes Dryer** | **Lighting** | **Computer and peripherals** | **Television** | **Television Peripherals** | **Other Electronics** | **Small Appliances & Other** |
| Detached | 2011 | 0.6 | 0.1 | 0.0 | 0.1 | | | | | | | 0.3 | 0.0 | | 0.0 | 0.0 | |
| | 2016 | 2.2 | 0.6 | 0.0 | 0.3 | | | | | | | 1.1 | 0.1 | | 0.2 | 0.0 | |
| | 2021 | 5.3 | 1.7 | 0.0 | 0.4 | | | | | | | 2.4 | 0.1 | | 0.5 | 0.0 | |
| | 2026 | 9.5 | 4.5 | 0.0 | 0.5 | | | | | | | 4.3 | 0.1 | | 0.0 | 0.0 | |
| Attached | 2011 | 0.2 | 0.0 | 0.0 | 0.0 | | | | | | | 0.1 | 0.0 | | 0.0 | 0.0 | |
| | 2016 | 0.6 | 0.1 | 0.0 | 0.1 | | | | | | | 0.3 | 0.0 | | 0.1 | 0.0 | |
| | 2021 | 1.4 | 0.3 | 0.0 | 0.1 | | | | | | | 0.8 | 0.0 | | 0.2 | 0.0 | |
| | 2026 | 2.4 | 0.9 | 0.0 | 0.1 | | | | | | | 1.3 | 0.0 | | 0.0 | 0.0 | |
| Apartment | 2011 | 0.0 | 0.0 | 0.0 | 0.0 | | | | | | | 0.0 | 0.0 | | 0.0 | 0.0 | |
| | 2016 | 0.1 | 0.0 | 0.0 | 0.0 | | | | | | | 0.0 | 0.0 | | 0.0 | 0.0 | |
| | 2021 | 0.2 | 0.0 | 0.0 | 0.0 | | | | | | | 0.1 | 0.0 | | 0.1 | 0.0 | |
| | 2026 | 0.3 | 0.1 | 0.0 | 0.0 | | | | | | | 0.2 | 0.0 | | 0.0 | 0.0 | |
| Isolated | 2011 | 0.0 | 0.0 | 0.0 | 0.0 | | | | | | | 0.0 | 0.0 | | 0.0 | 0.0 | |
| | 2016 | 0.0 | 0.0 | 0.0 | 0.0 | | | | | | | 0.0 | 0.0 | | 0.0 | 0.0 | |
| | 2021 | 0.0 | 0.0 | 0.0 | 0.0 | | | | | | | 0.0 | 0.0 | | 0.0 | 0.0 | |
| | 2026 | 0.0 | 0.0 | 0.0 | 0.0 | | | | | | | 0.0 | 0.0 | | 0.0 | 0.0 | |
| Other | 2011 | 0.0 | 0.0 | 0.0 | 0.0 | | | | | | | 0.0 | 0.0 | | 0.0 | 0.0 | |
| | 2016 | 0.0 | 0.0 | 0.0 | 0.0 | | | | | | | 0.0 | 0.0 | | 0.0 | 0.0 | |
| | 2021 | 0.1 | 0.0 | 0.0 | 0.0 | | | | | | | 0.1 | 0.0 | | 0.0 | 0.0 | |
| | 2026 | 0.1 | 0.0 | 0.0 | 0.0 | | | | | | | 0.1 | 0.0 | | 0.0 | 0.0 | |
| TOTAL | 2011 | 0.7 | 0.2 | 0.0 | 0.1 | | | | | | | 0.4 | 0.0 | | 0.0 | 0.0 | |
| | 2016 | 2.9 | 0.7 | 0.0 | 0.3 | | | | | | | 1.5 | 0.1 | | 0.3 | 0.0 | |
| | 2021 | 7.0 | 2.0 | 0.0 | 0.6 | | | | | | | 3.3 | 0.2 | | 0.8 | 0.0 | |
| | 2026 | 12.3 | 5.5 | 0.0 | 0.7 | | | | | | | 6.0 | 0.2 | | 0.0 | 0.0 | |

*Notes: 1) Results are measured at the customer's point-of-use and do not include line losses. 2) Any differences in totals are due to rounding. 3) A value displays as 0 if it is between 0 and 0.5. Totals are calculated using the actual numerical value. 4) Negative values in the space heating end use are a result of the reduction in internal heat gains due to lighting and appliance measures being greater than any savings from space heating measures. 5) Savings for television peripherals and other electronics are from standby loss reduction measures. Workshop participants believed that by 2026 advances in the appliances themselves would eliminate the savings available from add-on devices such as timed power bars. Savings in the last milestone period therefore drop to zero.*

**Exhibit 6.16: Savings by Major End Use,
Upper Achievable – Island and Isolated Service Region 2026 (%)**




*Totals for Exhibits 6.16 and 6.17 may not add to 100% due to rounding.*

**Exhibit 6.17: Savings by Major End Use,
Lower Achievable – Island and Isolated Service Region 2026 (%)**

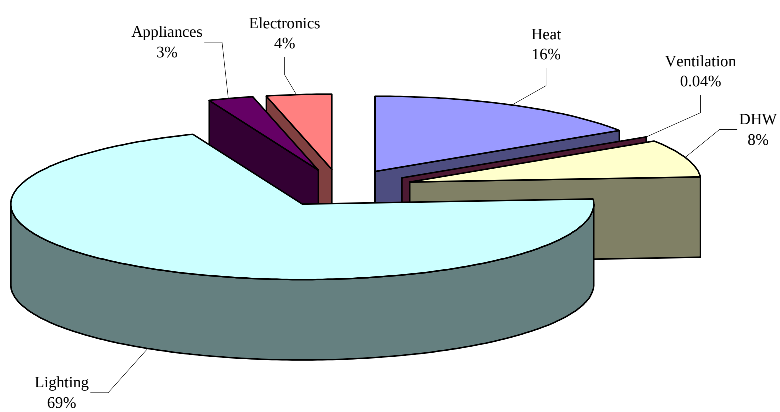
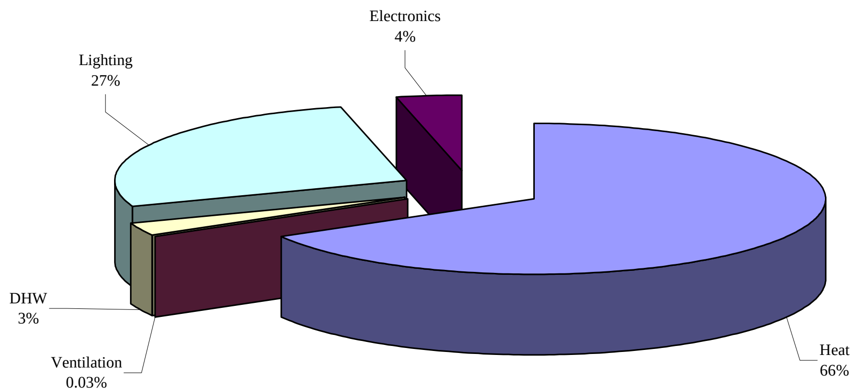


**Exhibit 6.18: Savings by Major End Use,
Upper Achievable – Labrador Interconnected Service Region 2026 (%)**




*Totals for Exhibits 6.18 and 6.19 may not add to 100% due to rounding.*

**Exhibit 6.19: Savings by Major End Use and Dwelling Type,
Lower Achievable – Labrador Interconnected Service Region 2026 (GWh/yr.)**

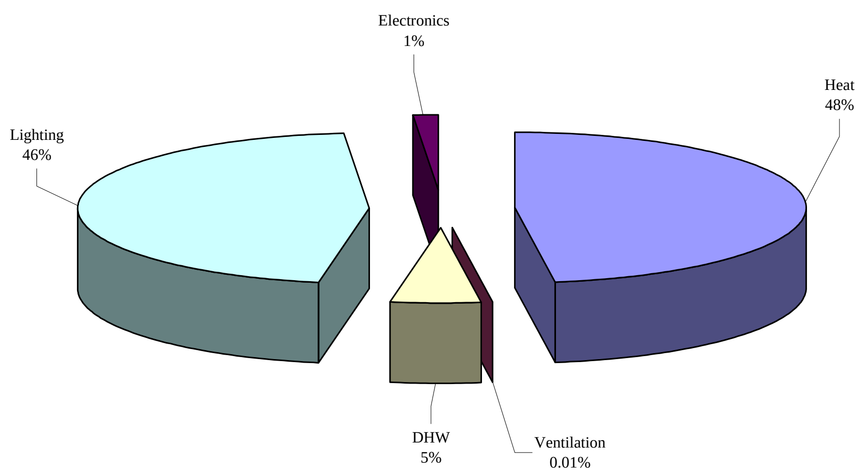
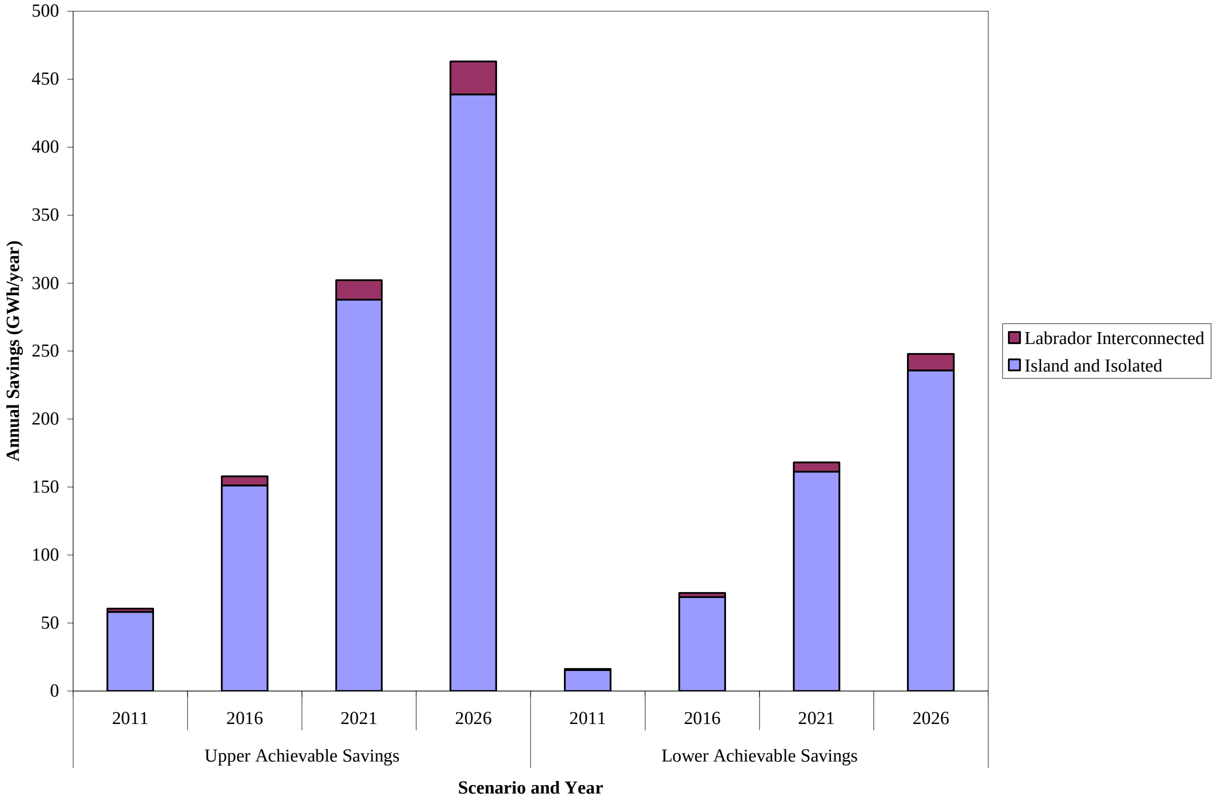


**Exhibit 6.20: Savings by Scenario, Milestone Year and Service Region (GWh/yr.)**




## 6.6 PEAK LOAD IMPACTS

The electricity (electric energy) savings (GWh) contained in the preceding scenarios also result in a reduction in electric demand (MW).[125]

The conversion of electricity savings to hourly demand requires the following steps:

- Annual electricity savings for each combination of sub sector and end use are disaggregated *by month*
- Monthly electricity savings are then further disaggregated *by day type* (weekday, weekend day and peak day)
- Finally, each day type is disaggregated *by hour*.

The above steps that convert electricity to electric demand require the development and application of the following four factors (sets of ratios).

[125] Peak load savings were modelled using Applied Energy Group's Cross-Sector Load Shape Library Model (LOADLIB).

- **Monthly Usage Factor**

This factor represents the percentage of annual electricity use that occurs in each month of the year. This set of monthly fractions (percentages) reflects the seasonality of the load shape, whether a facility, process or end use, and is dictated by weather or other seasonal factors. This allocation factor can be obtained from either (in decreasing order of priority): (a) monthly consumption statistics from end-use load studies; (b) monthly seasonal sales (preferably weather normalized) obtained by subtracting a "base" month from winter and summer heating and cooling months; or (c) heating or cooling degree days on an appropriate base.

- **Weekend to Weekday Factor**

This factor is a ratio that describes the distribution of electricity use between weekends and weekdays

- **Peak Day Factor**

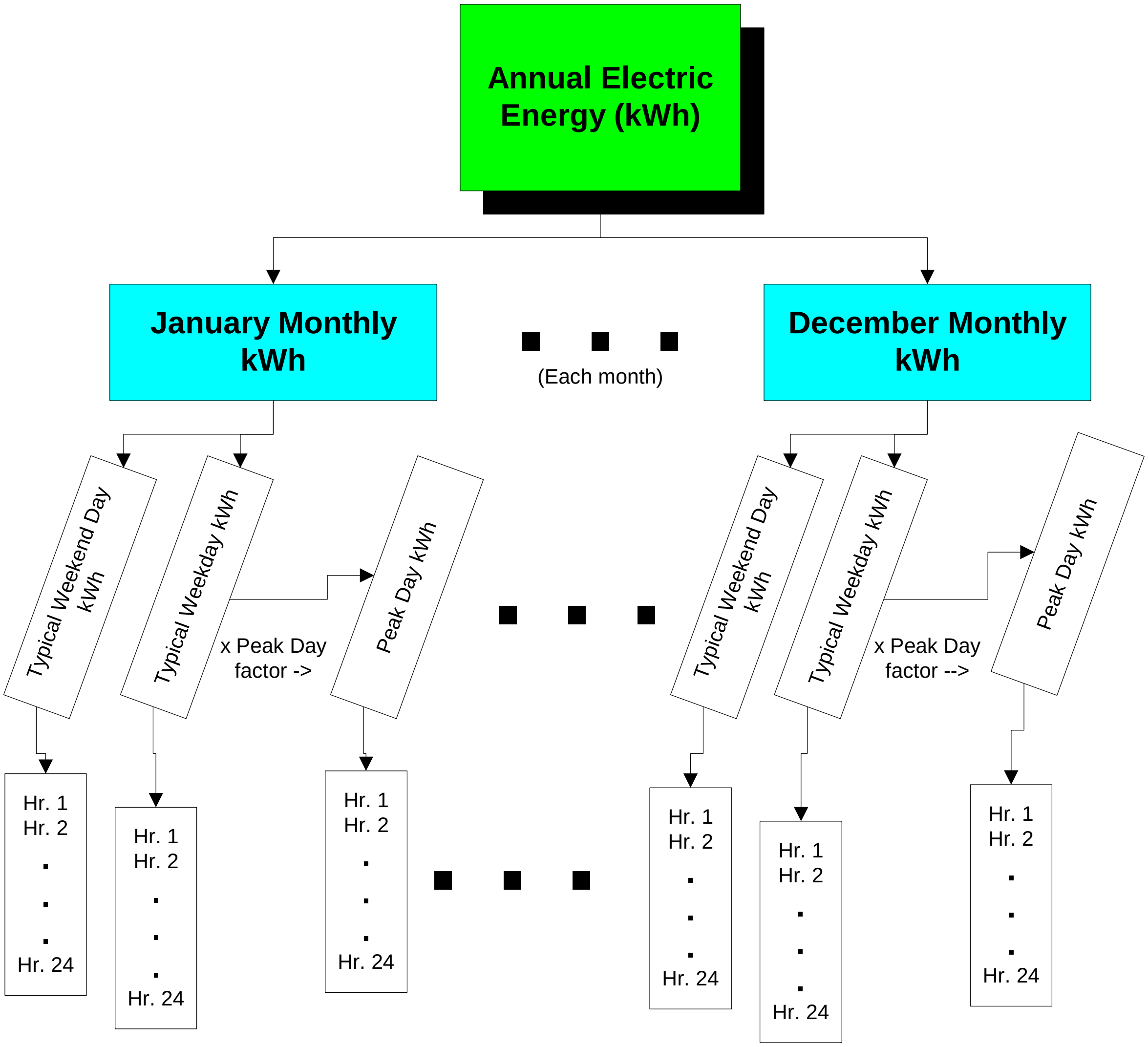
This factor defines the degree of daily weather sensitivity associated with the load shape, particularly heating or cooling; it compares a peak (e.g., hottest or coldest) day to a typical weekday in that month.

- **Hourly Factor**

This factor describes the typical distribution of daily electricity use for each day type (weekday, weekend day, peak day) and for each month. It reflects the operating hours of the electric equipment or end use by sub sector. For example, for lighting, this would be affected by time of day and season (affected by daylight).

Exhibit 6.21 provides an illustration of the sequential application of the above factors to convert annual electricity to hourly demand. Further description is provided in Appendix C.

**Exhibit 6.21: Illustration of Electricity to Peak load Calculation**




The study defined the Newfoundland Labrador system peak as:

> *The morning period from 7 am to noon and the evening period from 4 pm to 8 pm on the four coldest days in the December to March period; this is a total of 36 hours per year.*

Exhibit 6.22 presents a summary of the peak load reductions that would occur during the peak period noted above as a result of the electricity savings contained in Upper and Lower Achievable scenarios. In each case, the reductions are an average value over the peak period and are defined relative to the Reference Case.

**Exhibit 6.22: Peak load Reductions (MW) Relative to Reference Case by Milestone Year, Service Region and Achievable Scenario**

| Service Region | Milestone Year | Peak Demand Reduction MW | |
|---|---|---|---|
| | | Upper Achievable | Lower Achievable |
| Island and Isolated | 2011 | 10.8 | 2.9 |
| | 2016 | 29.1 | 13.3 |
| | 2021 | 57.8 | 32.4 |
| | 2026 | 91.1 | 48.9 |
| | | | |
| Labrador Interconnected | 2011 | 0.6 | 0.2 |
| | 2016 | 1.8 | 0.8 |
| | 2021 | 3.8 | 1.9 |
| | 2026 | 6.5 | 3.3 |
| | | | |
| TOTAL | 2011 | 11.4 | 3.1 |
| | 2016 | 30.9 | 14.1 |
| | 2021 | 61.6 | 34.3 |
| | 2026 | 97.6 | 52.2 |

# 7. CONCLUSIONS AND NEXT STEPS

This study has confirmed the existence of significant cost-effective CDM potential within Newfoundland and Labrador's Residential sector. The study results provide:

- Specific estimates of the potential CDM savings opportunities, defined by sector, sub sector, end use and, in several cases, specific technology(s)

- A baseline set of energy technology penetrations and energy use practices that can assist in the design of specific programs.

The next step[126] in this process involves the selection of a cost-effective portfolio of CDM programs and the setting of specific CDM targets and spending levels. To provide a preliminary reference point for this next step in the program development process, the study team conducted a brief literature search in an attempt to identify typical CDM spending levels in other jurisdictions. The literature search identified two (relatively) recent studies that had addressed similar issues on behalf of other Canadian utilities. The two studies are:

- *Demand-Side Management: Determining Appropriate Spending Levels and Cost-Effectiveness Testing,* which was prepared by Summit Blue Consulting and the Regulatory Assistance Project for the Canadian Association of Members of Public Utility Tribunals (CAMPUT). The study was completed in January 2006.

- *Planning and Budgeting for Energy Efficiency/Demand-Side Management Programs,* which was prepared by Navigant Consulting for Union Gas (Ontario) Limited. The study was completed in July 2005.

The CAMPUT study, which included a review of U.S. and Canadian jurisdictions, concluded that an annual CDM expenditure equal to about 1.5% of annual electricity revenues might be appropriate for a utility (or jurisdiction) that is in the early stages of CDM[127] programming. This level of funding recognizes that it takes time to properly introduce programs into the market place.

The same study found that once program delivery experience is gained, a ramping up to a level of about 3% of annual electricity revenues is appropriate. The study also notes that higher percentages may be warranted if rapid growth in electricity demand is expected, or if there is an increasing gap between demand and supply due to such things as plant retirements or siting limitations. The current emphasis on climate change mitigation measures would presumably also fall into a similar category of potential CDM drivers.

The CAMPUT study also notes that even those states with 3% of annual revenues as their CDM target have found that there are more cost-effective CDM opportunities than could be met by the 3% funding. The finding is consistent with the situation in British Columbia. In the case of BC Hydro, CDM expenditures over the past few years have been about 3.3% of electricity

[126] Full treatment of these next steps is beyond the scope of the current project.
[127] The term DSM (demand-side management) and CDM are used interchangeably in this section.

revenues.[128] However, the results of BC Hydro's recently completed study (Conservation Potential Review (CPR) 2007) identified over 20,000 GWh of remaining cost-effective CDM opportunities by 2026. The magnitude of remaining cost-effective CDM opportunities combined with the aggressive targets set out in British Columbia's provincial Energy Plan suggest that BC Hydro's future CDM expenditures are likely to increase significantly if the new targets are to be met.

**Additional notes:**

- Neither of the studies noted above found any one single, simple model for setting CDM spending levels and targets. Rather, the more general conclusion is that utilities use a number of different approaches that are reasonable for their context. In fact, the CAMPUT report identified seven approaches to setting CDM spending levels:

    - Based on cost-effective CDM potential estimates
    - Based on percentages of utility revenues
    - Based on Mills/kWh of utility electric sales
    - Levels set through resource planning process
    - Levels set through the restructuring process
    - Tied to projected load growth
    - Case-by-case approach.

- The CAMPUT study also notes that, although not always explicit, a key issue in most jurisdictions is resolving the trade off between wanting to procure all cost-effective energy-efficiency measures and concerns about the resulting short-term effect on rates. The study concluded that CDM budgets based on findings from an Integrated Resource Plan or a benefit-cost assessment tend to accept whatever rate effects are necessary to secure the overall resource plan, inclusive of the cost-effective energy-efficiency measures.

[128] CAMPUT, 2006. p. 14.

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# CONSERVATION AND DEMAND MANAGEMENT (CDM) POTENTIAL

# NEWFOUNDLAND and LABRADOR

# Commercial Sector

## *–Final Report–*

*Prepared for:*

**Newfoundland & Labrador Hydro and**
**Newfoundland Power**

*Prepared by:*

**Marbek Resource Consultants Ltd.**

*In association with:*

**CBCL Ltd.**
**and**
**Applied Energy Group**

*January 18, 2008*

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# EXECUTIVE SUMMARY

## ❑ Background and Objectives

Newfoundland and Labrador Hydro and Newfoundland Power (collectively the Utilities) have partnered to produce this study, recognizing the role that each has in energy conservation and least cost electric utility planning within the province. Increasing electricity costs and the expectations of a growing number of their customers and stakeholders have contributed to the increased focus on conservation and demand management (CDM) and resulted in a number of recent initiatives and projects targeting energy savings in the province. This study is the next step in the Utilities efforts to develop a comprehensive plan for CDM in Newfoundland and Labrador. The Utilities envision electricity conservation and demand management (CDM) to be a valuable component in meeting the province's future electricity requirements.

This study will also be a significant component in the further implementation of the Province's recently released Energy Plan. The Energy Plan establishes a long-term vision for how the province's energy resources will be developed and utilized to benefit the people of the province today as well as for future generations. Electricity conservation and demand management (CDM) are an important component of the provincial Energy Plan as are the conservation and demand management components for the other energy resources of the province.

This report meets, in part, the requirements of the Public Utilities Board Order PU 8 2007 requiring NLH to file this study and a five-year plan for implementation of CDM programs in 2008.

The objective of this study is to identify the potential contribution of specific CDM technologies and measures in the Residential, Commercial and Industrial sectors and to assess their economic costs and benefits. The Newfoundland and Labrador economy is expected to grow over the next 20 years, with an associated increase in energy consumption. The benefits of increased penetration of energy efficiency technologies include reduced energy costs for individuals and businesses, as well as environmental benefits through reduced pollution and greenhouse gas emissions.

The outputs from this study will assist the Utilities CDM planners and others to develop specific CDM programs for implementation and to optimize the contribution of CDM technologies and measures to the province's overall energy future.

## ❑ Scope and Organization

This study covers a 20-year study period from 2006 to 2026 and addresses the Residential, Commercial and Industrial sectors as well as street lighting. The study results combine customers from both NLH and NP and are presented for two service regions: Island and Isolated and the Labrador Interconnected. For the purposes of this study, the isolated diesel system customers have been combined with those in the Island and Isolated service region due to their relatively small size and electricity usage. Given pending load constraints, the study emphasizes the Island and Isolated service region.

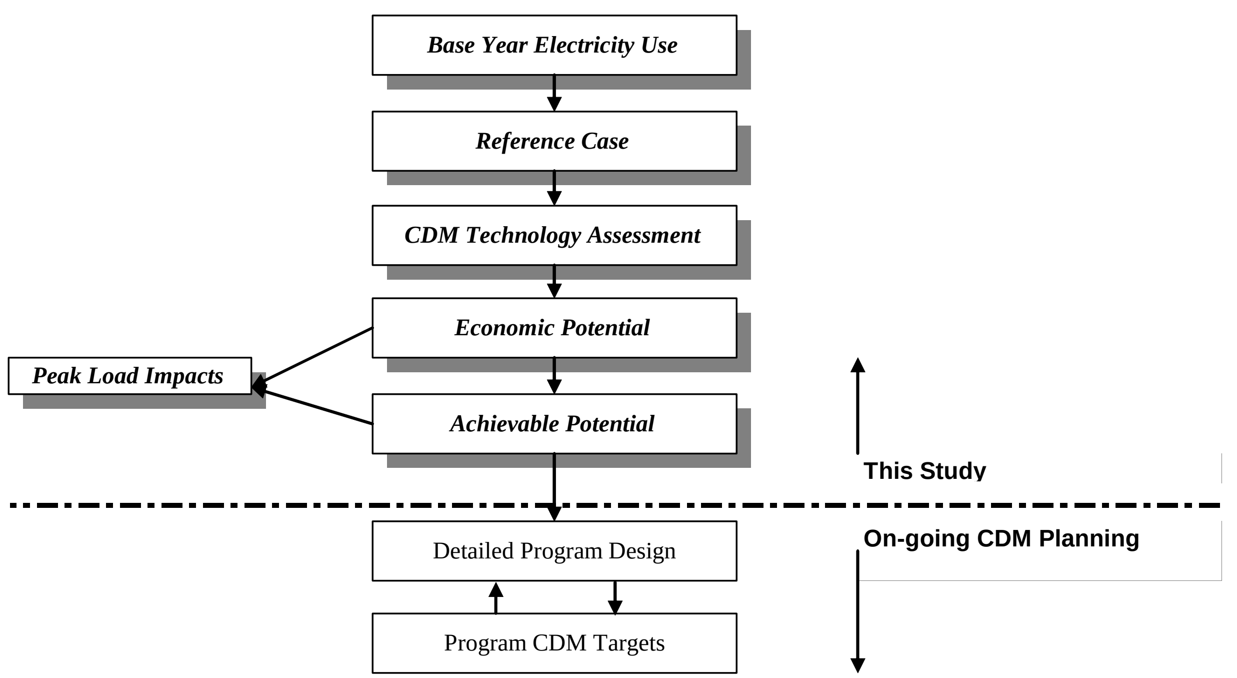
The study reviews all commercially viable electrical efficiency technologies or measures. In addition, the study also reviews selected peak load reduction and fuel switching measures.

- **Approach**

The detailed end-use analysis of electrical efficiency opportunities in the Commercial sector employed two linked modelling platforms: **CEEAM** (Commercial Electricity and Emissions Analysis Model), a Marbek in-house simulation model developed in conjunction with Natural Resources Canada (NRCan) for modelling electricity use in commercial/institutional building stock, and **CSEEM** (Commercial Sector Energy End-use Model), an in-house spreadsheet-based macro model. Peak load savings were modelled using Applied Energy Group's Cross-Sector Load Shape Library Model (LOADLIB).

The major steps involved in the analysis are shown in Exhibit ES1 and are discussed in greater detail in Chapter 1. As illustrated in Exhibit ES1, the results of this study, and in particular the estimation of Achievable Potential,[1] support the on-going work of the Utilities; however, it should be emphasized that the estimation of Achievable Potential is not synonymous with either the setting of specific targets or with program design.

**Exhibit ES1: Study Approach - Major Analytical Steps**




[1] The proportion of savings identified that could realistically be achieved within the study period without consideration for budgetary constraints.

## ❑ Overall Study Findings[2]

As in any study of this type, the results presented in this report are based on a large number of important assumptions. Assumptions such as those related to the current penetration of energy-efficient technologies, the rate of future growth in the stock of commercial buildings and customer willingness to implement new CDM measures are particularly influential. Wherever possible, the assumptions used in this study are consistent with those used by the Utilities and are based on best available information, which in many cases includes the professional judgement of the consultant team, Utilities' personnel and local experts. The reader should, therefore, use the results presented in this report as best available estimates; major assumptions, information sources and caveats are noted throughout the report.

The study findings confirm the existence of significant potential cost-effective opportunities for CDM in Newfoundland and Labrador's Commercial sector. Electricity savings from efficiency improvements within the Island and Isolated service region would provide between 387 and 261 GWh/yr. of electricity savings by 2026 in, respectively, the Upper and Lower Achievable scenarios. The most significant Achievable Savings opportunities were in the actions that addressed lighting, HVAC fans and pumps and space heating.

The study also assessed the peak load reductions that would result from the electricity savings (noted above). Electricity savings would provide peak load reductions of approximately 54 to 35 MW during the Utilities' typical Winter Peak Day[3] by 2026 in, respectively, the Upper and Lower Achievable scenarios.

## ❑ Summary of Electricity Savings

A summary of the levels of annual electricity consumption contained in each of the forecasts addressed by the study is presented in Exhibits ES2 and ES3, by milestone year, and discussed briefly in the paragraphs below.

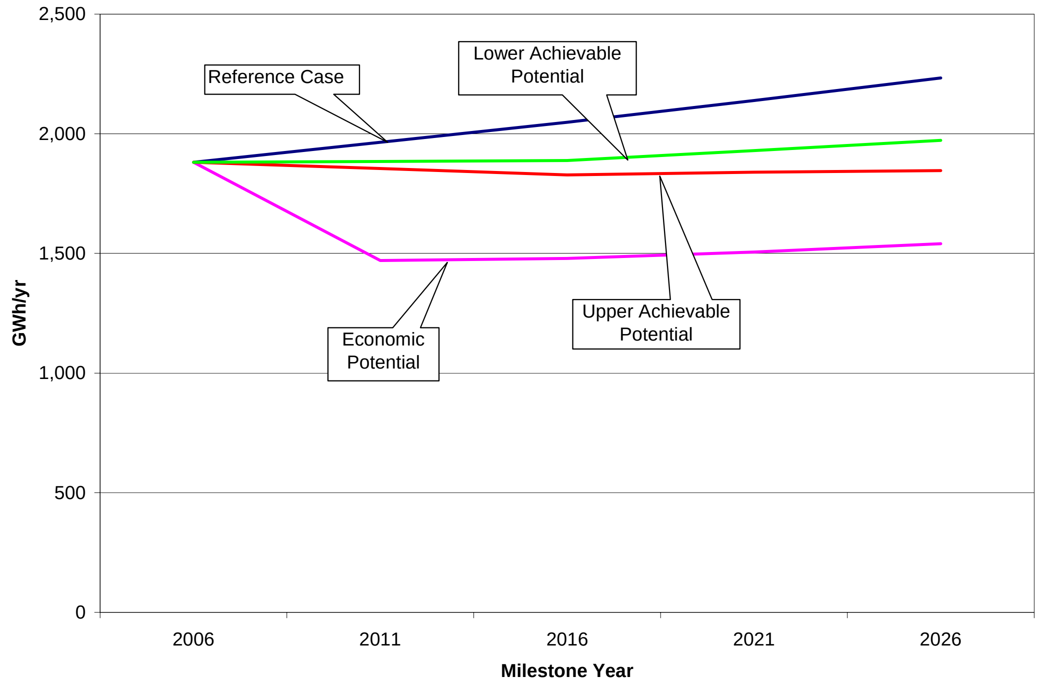
**Exhibit ES2: Summary of Forecast Results for the Island and Isolated Service Region – Annual Electricity Consumption, Commercial Sector (GWh/yr.)**

| *Annual Consumption (GWh/yr.) Commercial Sector* | | | | | | *Potential Annual Savings (GWh/yr.)* | | |
|---|---|---|---|---|---|---|---|---|
| *Milestone Year* | *Base Year* | *Reference Case* | *Economic* | *Achievable* | | *Economic* | *Achievable* | |
| | | | | *Upper* | *Lower* | | *Upper* | *Lower* |
| ***2006*** | 1,881 | 1,881 | 1,881 | 1,881 | 1,881 | | | |
| ***2011*** | | 1,965 | 1,471 | 1,855 | 1,884 | 494 | 110 | 80 |
| ***2016*** | | 2,048 | 1,479 | 1,828 | 1,888 | 569 | 220 | 160 |
| ***2021*** | | 2,138 | 1,506 | 1,840 | 1,930 | 632 | 298 | 209 |
| ***2026*** | | 2,233 | 1,541 | 1,846 | 1,972 | 693 | 387 | 261 |

*Results are measured at the customer's point-of-use and do not include line losses.

[2] Consistent with the study scope, the results presented in this Executive Summary address the Island and Isolated service region. The main report provides a similar breakdown for the Labrador Interconnected service region.
[3] Winter Peak Day is defined as the week day hours from 7 am to 12 pm and 4 pm to 8 pm on the four coldest days in the December to March period; totals 36 hours.

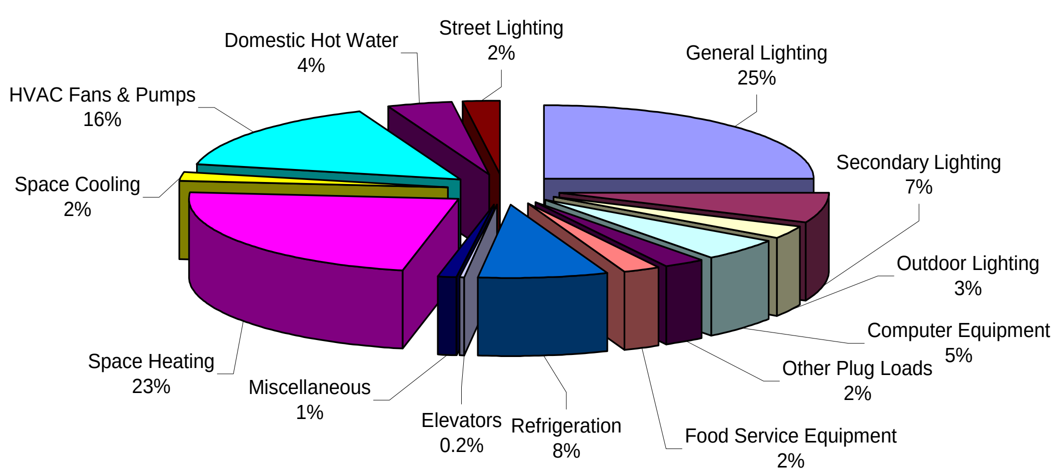
**Exhibit ES3: Graphic of Forecast Results for the Island and Isolated Service Region – Annual Electricity Consumption, Commercial Sector (GWh/yr.)**




### *Base Year Electricity Use*

In the Base Year of 2006, the Commercial sector in the Island and Isolated service region consumed about 1,881 GWh. Exhibit ES4 shows that space lighting (general and secondary lighting) accounts for about 32% of total commercial electricity use, space heating accounts for about 23%, followed by HVAC fans and pumps (16%) and refrigeration (8%).

**Exhibit ES4: Base Year Electricity Use by End Use in the Island and Isolated Service Region, Commercial Sector**




*Totals may not add to 100% due to rounding.*

In the Island and Isolated Service Region, the Small Commercial sub sector accounts for the largest share of the total electricity consumption at 28%, followed by Office at 17%, Other Buildings at 8% and Food Retail at 7%.

***Reference Case***

In the absence of new Utility initiatives, the study estimates that electricity consumption in the Commercial sector will grow from 1,881 GWh/yr. in 2006 to about 2,233 GWh/yr. by 2026 in the Island and Isolated service region. This represents an overall growth of about 19% in the period and compares very closely with NLH's load forecast, which also included consideration of the impacts of "natural conservation."

***Economic Potential Forecast***

Under the conditions of the Economic Potential Forecast,[4] the study estimated that electricity consumption in the Commercial sector would fall to about 1,541 GWh/yr. by 2026 in the Island and Isolated service region. Annual savings relative to the Reference Case are 693 GWh/yr., or about 31%.

***Achievable Potential***

The Achievable Potential is the proportion of the economic electricity savings (as noted above) that could realistically be achieved within the study period. In the Commercial sector within the Island and Isolated service region, the Achievable Potential for electricity savings was estimated to be 387 GWh/yr. and 261 GWh/yr. by 2026 in, respectively, the Upper and Lower scenarios.

Consistent with the results in the Economic Potential Forecast, the most significant achievable savings opportunities were in the actions that addressed lighting, HVAC fans and pumps and space heating.

- ❑ **Peak Load Savings**

The electricity savings noted above also result in a reduction in capacity requirements (MW), which can be of particular value to the Utilities during periods of high electricity demand. The study defined the Newfoundland and Labrador system peak period as:

> *The morning period from 7 am to noon and the evening period from 4 pm to 8 pm on the four coldest days in the December to March period; this is a total of 36 hours per year.*

The resulting peak load reductions are presented in Exhibit ES5. The Commercial sector peak load savings was estimated to be 54 MW and 35 MW by 2026 in, respectively, the Upper and Lower scenarios. In each case, the reductions are an average value over the peak period and are defined relative to the Reference Case.

[4] The level of electricity consumption that would occur if all equipment and building envelopes were upgraded to the level that is cost effective against future avoided electricity costs.

**Exhibit ES5: Peak Load Savings from Electricity Savings in the Island and Isolated Service Region, Commercial Sector**

| Milestone Year | Energy Savings (GWh/yr.) | | Peak Load Reduction (MW) | |
|---|---|---|---|---|
| | Upper Achievable | Lower Achievable | Upper Achievable | Lower Achievable |
| 2011 | 110 | 80 | 16 | 11 |
| 2016 | 220 | 160 | 31 | 23 |
| 2021 | 298 | 209 | 41 | 29 |
| 2026 | 387 | 261 | 53 | 34 |

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**APPENDICES**

## List of Exhibits

# 1. INTRODUCTION

## 1.1 BACKGROUND AND OBJECTIVES

Newfoundland and Labrador Hydro and Newfoundland Power (collectively the Utilities) have partnered to produce this study, recognizing the role that each has in energy conservation and least cost electric utility planning within the province. Increasing electricity costs and the expectations of a growing number of their customers and stakeholders have contributed to the increased focus on conservation and demand management (CDM) and resulted in a number of recent initiatives and projects targeting energy savings in the province. This study is the next step in the Utilities efforts to develop a comprehensive plan for CDM in Newfoundland and Labrador. The Utilities envision electricity conservation and demand management (CDM) to be a valuable component in meeting the province’s future electricity requirements.

This study will also be a significant component in the further implementation of the Province's recently released Energy Plan. The Energy Plan establishes a long-term vision for how the province's energy resources will be developed and utilized to benefit the people of the province today as well as for future generations. Electricity conservation and demand management (CDM) are an important component of the provincial Energy Plan as are the conservation and demand management components for the other energy resources of the province.

This report is prepared to meet, in part, the requirements of the Public Utilities Board Order PU 8 2007 requiring NLH to file this study and a five year plan for implementation of CDM programs in 2008.

The objective of this study is to identify the potential contribution of specific CDM technologies and measures in the Residential, Commercial and Industrial sectors and to assess their economic costs and benefits. The Newfoundland and Labrador economy is expected to grow over the next 20 years, with an associated increase in energy consumption. The benefits of increased penetration of energy efficiency technologies include reduced energy costs for individuals and businesses, as well as environmental benefits through reduced pollution and greenhouse gas emissions.

The outputs from this study will assist the Utilities CDM planners and others to develop specific CDM programs for implementation and to optimize the contribution of CDM technologies and measures to the province's overall energy future.

## 1.2 STUDY SCOPE

The scope of this study is summarized below:

- **Sector Coverage:** This study addresses three sectors: Residential, Commercial and Industrial as well as street lighting. It was agreed that the primary focus is on the Residential and Commercial sectors; the Industrial sector will be treated at a “high level.”

- **Geographical Coverage**: The study addresses the customers of both utilities. Due to differences in cost and rate structures, the Utilities’ customers are organized into two service regions, which in this report are referred to as the Island and Isolated and Labrador Interconnected. For the purposes of this study, the isolated diesel system customers have been combined with those in the Island and Isolated service region due to their relatively small size and electricity usage.

- **Study Period**: This study covers a 20-year period. The Base Year is the calendar year 2006, with milestone periods at five-year increments: 2011, 2016, 2021 and 2026. The Base Year of 2006 was selected as this was the most recent calendar year for which complete customer data were available.

- **Technologies:** The study addresses conservation and demand management (CDM) measures. Although CDM refers to a broad range of potential measures (see Section 1.3, Definitions), for the purposes of this study, it was agreed that the primary focus is on energy-efficiency measures. This includes measures that reduce electricity use as well as the associated capacity impact on a winter peak period. The study also provides a high-level treatment of selected demand management measures, such as direct control of space heating loads, etc.[5]

### 1.2.1 Data Caveat

As in any study of this type, the results presented in this report are based on a large number of important assumptions. Assumptions such as those related to the current penetration of energy-efficient technologies, the rate of future growth in the stock of commercial buildings and customer willingness to implement new CDM measures are particularly influential. Wherever possible, the assumptions used in this study are consistent with those used by the Utilities and are based on best available information, which in many cases includes the professional judgement of the consultant team, Utilities' personnel and local experts. The reader should, therefore, use the results presented in this report as best available estimates; major assumptions, information sources and caveats are noted throughout the report.

## 1.3 DEFINITIONS

This study uses numerous terms that are unique to analyses such as this one and consequently it is important to ensure that readers have a clear understanding of what each term means when applied to this study.

A brief description of some of the most important terms and their application within this study is included below. The reader is also referred to the Terms Used in Building Profiles, found in Section 8 of this report.

[5] The information provided is based on the detailed analysis that Marbek is currently undertaking in other jurisdictions.

***Base Year Electricity Use***

The Base Year is the starting point for the analysis. It provides a detailed description of "where" and "how" electrical energy is currently used in the existing Commercial sector building stock. Building electricity use simulations were undertaken for the major sub sector types and calibrated to actual utility customer billing data for the Base Year. As noted previously, the Base Year for this study is the calendar year 2006.

***Reference Case Electricity Use (includes Natural Conservation)***

The Reference Case Electricity Use estimates the expected level of electrical energy consumption that would occur over the study period in the absence of new (post-2006) utility-based CDM initiatives. It provides the point of comparison for the subsequent calculation of "economic" and "achievable" electricity savings potentials. Creation of the Reference Case required the development of profiles for new buildings in each of the sub sectors, estimation of the expected growth in building stock and finally an estimation of "natural" changes affecting electricity consumption over the study period. The Reference Case is calibrated to the NLH Long Term Planning (PLF) Review Forecast, Summer/Fall 2006.

***Conservation and Demand Management (CDM) Measures***

CDM refers to a broad range of potential measures that can include energy efficiency (use more efficiently), energy conservation (use less), demand management (use less during peak periods), fuel switching (use a different fuel to provide the energy service) and self-generation/co-generation (displace load off of grid).

As noted in Section 1.2, it was agreed that the primary focus is on energy-efficiency measures. This includes measures that reduce electricity use as well as the associated capacity impact on a winter peak period.

***The Cost of Conserved Energy (CCE)***

The CCE is calculated for each energy-efficiency measure. The CCE is the annualized incremental capital and operating and maintenance (O&M) cost of the upgrade measure divided by the annual energy savings achieved, excluding any administrative or program costs. The CCE represents the cost of conserving one kWh of electricity; it can be compared directly to the cost of supplying one new kWh of electricity.

***Economic Potential Electricity Forecast***

The Economic Potential Electricity Forecast is the level of electricity consumption that would occur if all equipment and building envelopes were upgraded to the level that is cost effective against the future avoided cost of electricity in the Newfoundland and Labrador Hydro service area (for this study, the value was set at $0.0980/kWh for the Island and Isolated service region and $0.0432/kWh for the

Labrador Interconnected service region).[6] All the energy-efficiency upgrades included in the technology assessment that had a CCE equal to, or less than, the preceding avoided costs of new electricity supply were incorporated into the Economic Potential Forecast.

***Achievable Potential*** The Achievable Potential is the proportion of the savings identified in the Economic Potential Forecast that could realistically be achieved within the study period. Achievable Potential recognizes that it is difficult to induce customers to purchase and install all the electrical efficiency technologies that meet the criteria defined by the Economic Potential Forecast. The results are presented as a range, defined as "Lower" and "Upper."

## 1.4 APPROACH

To meet the objectives outlined above, the study was conducted within an iterative process that involved a number of well-defined steps. At the completion of each step, the client reviewed the results and, as applicable, revisions were identified and incorporated into the interim results. The study then progressed to the next step. A summary of the steps is presented below.

***Step 1:*** **Develop Base Year Electricity Calibration Using Actual Utility Billing Data**

- Compile and analyze available data on Newfoundland and Labrador's existing building stock.
- Develop detailed technical descriptions of the existing building stock.
- Undertake computer simulations of electricity use in each building type and compare these with actual building billing and audit data.
- Compile actual utility billing data.
- Create sector model inputs and generate results.
- Calibrate sector model results using actual utility billing data.

***Step 2:*** **Develop Reference Case Electricity Use**

- Compile and analyze building design, equipment and operations data and develop detailed technical descriptions of the new building stock.
- Develop computer simulations of electricity use in each new building type.
- Compile data on forecast levels of building stock growth and "natural" changes in equipment efficiency levels and/or practices.
- Define sector model inputs and create forecasts of electricity use for each of the milestone years.
- Compare sector model results with NLH load forecast for the study period.

***Step 3:*** **Identify and Assess Energy-efficiency Measures**

- Develop list of energy-efficiency upgrade measures.
- Compile detailed cost and performance data for each measure.

[6] Sensitivity analysis was also conducted using avoided cost values expected to prevail if the Lower Churchill/DC Link project is completed.

- Identify the baseline technologies employed in the Reference Case, develop energy-efficiency upgrade options and associated electricity savings for each option, and determine the CCE for each upgrade option.

***Step 4:*** **Estimate Economic Electricity Savings Potential**

- Compile utility economic data on the forecast cost of new electricity generation; costs of $0.0980kWh and $0.0432/kWh were selected as the economic screens for, respectively, the Island and Isolated and Labrador Interconnected service regions.
- Identify the combinations of energy-efficiency upgrade options and building types where the cost of saving one kilowatt of electricity is equal to, or less than, the cost of new electricity generation.
- Apply the economically attractive electrical efficiency measures from Step 3 within the energy use simulation model developed previously for the Reference Case.
- Determine annual electricity consumption in each building type and end use when the economic efficiency measures are employed.
- Compare the electricity consumption levels when all economic efficiency measures are used with the Reference Case consumption levels and calculate the electricity savings.

***Step 5:*** **Estimate Achievable Potential Electricity Savings**

- "Bundle" the electricity and peak load reduction opportunities identified in the Economic Potential Forecasts into a set of opportunities.
- For each of the identified opportunities, create an Opportunity Profile that provides a "high-level" implementation framework, including measure description, cost and savings profile, target sub sectors, potential delivery allies, barriers and possible synergies.
- Review historical achievable program results and prepare preliminary Assessment Worksheets.
- Conduct a full day workshop involving the client, the consultant team and technical experts to reach general agreement on "upper" and "lower" range of Achievable Potential.

***Step 6:*** **Estimate Peak Load Impacts of Electricity Savings**

- The electricity (electric energy) savings (GWh) calculated in the preceding steps were converted to peak load (electric demand) savings (MW).[7]
- The study defined the Newfoundland and Labrador system peak period as the morning period from 7 am to noon and the evening period from 4 to 8 pm on the four coldest days of the year during the December to March period; this is a total of 36 hours per year.
- The conversion of electricity savings to hourly demand drew on a library of specific sub sector and end use electricity load shapes. Using the load shape data, the following steps were applied:

[7] Peak load savings were modeled using Applied Energy Group's Cross-Sector Load Shape Library Model (LOADLIB).

- Annual electricity savings for each combination of sub sector and end use were disaggregated *by month*
- Monthly electricity savings were then further disaggregated *by day type* (weekday, weekend day and peak day)
- Finally, each day type was disaggregated *by hour*.

## 1.5 ANALYTICAL MODELS

The analysis of the Commercial sector employed two linked modelling platforms:

- CEEAM (*C*ommercial *E*lectricity and *E*missions *A*nalysis *M*odel), an in-house, simulation model developed in conjunction with Natural Resources Canada (NRCan) for modelling electricity use in commercial/institutional building stock.

- CSEEM (*C*ommercial *S*ector *E*lectricity *E*nd-use *M*odel), an in-house spreadsheet-based macro model.

CEEAM was used to develop commercial electricity end-use intensities (EUIs) for each of the commercial and institutional building archetypes. CEEAM has been successfully employed in numerous domestic and international CDM work. Domestically, this includes assignments for BC Hydro, Terasen Gas, Manitoba Hydro, the Ontario Power Authority (OPA), Consumers Gas and NRCan, including the extensive national climate change analysis conducted for the Federal Buildings Table. CEEAM is a robust modelling platform and its results have been verified against actual end-use metered data for commercial buildings in the cities of Ottawa and Toronto and against DOE-2.1E.

CEEAM was developed specifically for applications such as this study. One of its particular strengths is the capability to simulate electricity performance not only in a given building but also in an entire stock of similar buildings (e.g., all Large Offices). In particular, it is capable of tracking the penetration of multiple technologies and combinations that are not possible in other simulation software, such as DOE-2.

CEEAM simulates the electricity consumption and peak load for all electricity end uses present in a given commercial building segment. CEEAM calculates energy use and emissions by end use and reports them in $kWh/m^2/yr.$ and kg $eCO_2/m^2$. Because CEEAM is a full modelling program, it calculates both building heating and cooling loads (internal and transmission). It therefore accounts for interactive effects such as the increase in heating electricity use and decrease in cooling electricity use from lighting retrofits. CEEAM also uses equipment part load performance curves to accurately model the seasonal efficiency of heating and cooling plants.

The commercial EUIs derived by CEEAM provide inputs into Marbek's in-house CSEEM. CSEEM consists of two modules:

- A General Parameters module that contains general sector data (e.g., floor space, growth rates, etc.)

- A Building Profile module that contains the EUI data for each of the selected building sub sectors.

CSEEM combines the data from each of the modules and provides total electricity use by service region, building sub sector and end use. CSEEM also enables the analyst to estimate the demand impacts of the electrical efficiency measures introduced in the Economic Potential Forecast.

## 1.6 STUDY ORGANIZATION AND REPORTS

The study was organized and conducted by sector using a common methodology, as outlined above. The results for each sector are presented in individual reports as well as in a summary report. They are entitled:

- *Conservation and Demand Management Potential (2006 to 2026), Newfoundland and Labrador, Residential Sector*
- *Conservation and Demand Management Potential (2006 to 2026), Newfoundland and Labrador, Commercial Sector*
- *Conservation and Demand Management Potential (2006 to 2026), Newfoundland and Labrador, Industrial Sector*
- *Conservation and Demand Management Potential (2006 to 2026), Newfoundland and Labrador, Residential, Commercial and Industrial Sectors, Summary Report*

The study also prepared a brief CDM program evaluation report, which is entitled:

- *Conservation and Demand Management Potential (2006 to 2026), Newfoundland and Labrador, Program Evaluation Guidelines*.

This report presents the Commercial sector results; it is organized as follows:

- Section 2 presents a profile of Commercial sector Base Year Electricity Use in Newfoundland and Labrador, including a discussion of the major steps involved and the data sources employed.
- Section 3 presents a profile of Commercial sector Reference Case Electricity Use in Newfoundland and Labrador for the study period 2006 to 2026, including a discussion of the major steps involved.
- Section 4 identifies and assesses the economic attractiveness of the selected energy-efficiency technology measures for the Commercial sector.
- Section 5 presents the Commercial sector Economic Potential Electricity Forecast for the study period 2006 to 2026.

- Section 6 presents the estimated Upper and Lower Achievable Potential for electricity savings for the study period 2006 to 2026.
- Section 7 presents conclusions and next steps.
- Section 8 presents a listing of major references.
- Section 9 provides an explanation of terms used in the building profiles.

# 2. BASE YEAR (2006) ELECTRICITY USE

## 2.1 INTRODUCTION

This section provides a profile of Base Year (2006) electricity use in Newfoundland and Labrador's Commercial[8] sector. The discussion is organized into the following subsections:

- Segmentation of Commercial Sector
- Definition of End Uses
- End-use Saturation and Fuel Share Data
- Detailed Building and Equipment Specifications
- Floor Area Calculations
- Summary of Model Results.

## 2.2 SEGMENTATION OF COMMERCIAL SECTOR

The first major task in developing the Base Year calibration involved the segmentation of the commercial building stock into specific sub sectors. The choice of specific building sub sectors is driven by both data availability and the need to facilitate the subsequent analysis and modelling of potential electrical efficiency improvements.

To facilitate the subsequent modelling and analysis of energy-efficiency opportunities, the selected building sub sectors need to be reasonably similar in terms of major design and operating considerations, such as building size, mechanical and electrical systems, annual operating hours, etc.

A summary of the Commercial sub sectors that are used in this study is provided in Exhibit 2.1.

**Exhibit 2.1: Commercial Sub Sectors**

- Office
- Non-food Retail
- Food Retail
- Accommodations (Hotels & Motels)
- Health Care (Hospitals & Nursing Homes)
- Schools (Elementary and Secondary)
- Universities and Colleges
- Warehouse/Wholesale
- Small Commercial (all customers in sector below approx. 50 kW)
- Isolated C/I Buildings
- Other Buildings
- Other Institutional
- Non-Buildings

[8] Throughout this report, use of the word "commercial" includes both commercial and institutional buildings unless otherwise noted.

The types of buildings included in most of the sub sectors shown in Exhibit 2.1 are self-explanatory. However, additional explanation is provided for four of the sub sectors:

- **Isolated C/I Buildings**. This sub sector includes buildings such as restaurants, schools, variety stores, medical clinics and multi-purpose garages and sheds that are located in isolated communities served by local diesel-powered systems.

- **Other Buildings**. This sub sector represents buildings that do not fit into the specific sub sectors shown in Exhibit 2.1 including churches, theatres, community centres, transportation buildings and recreation complexes.

- **Other Institutional**. This sub sector includes buildings such as barracks, mess halls, hangers and warehouses located at Canadian Forces Base Goose Bay.

- **Non-Buildings.** This sub sector includes facilities such as micro wave repeater stations and telephone exchanges. Although these facilities are housed within a "building," the majority of their electricity use is consumed by the unique equipment that it houses. This sub sector will be tracked throughout the study but will not be subjected to detailed analysis.

## 2.3 DEFINITION OF END USES

Electricity use within each of the sub sectors noted above is further defined on the basis of specific end uses. In this study, an end use is defined as, "the final application or final use to which energy is applied. End uses are the services of economic value to the users of energy." A summary of the major Commercial sector end uses used in this study is provided in Exhibit 2.2 together with a brief description of each.

**Exhibit 2.2: Commercial Sector End Uses**

| End-Use | Description/Comments |
|---|---|
| General Lighting | Lighting in main areas of a building, e.g., classrooms in a school |
| Secondary Lighting | Lighting in secondary areas of a building, e.g., corridors/lobbies in a school |
| Outdoor Lighting | Lighting used for parking lots and exterior building illumination |
| Computer Equipment | Computers, monitors, printers, fax machines, copiers and servers |
| Other Plug Loads | Other plug loads excluding computer equipment |
| Food Service Equipment | Food preparation equipment including ranges, broilers, ovens, etc. |
| Refrigeration | Fridges, freezers, coolers, and display cases |
| Elevator | Passenger and freight elevators |
| Miscellaneous Equipment | Air compressors, sump pumps, clothes washers, etc. |
| Space Heating | Electric boilers, unit heaters, baseboard heaters |
| Space Cooling | Air-conditioning compressors |
| HVAC Fans & Pumps | Fans, pumps, cooling tower fans, etc. |
| Domestic Hot Water | Electric water heaters |
| Street Lighting | Roadway lighting |

## 2.4 END-USE SATURATION AND FUEL SHARE DATA

The next step in the analysis involved an estimation of the electric fuel share for both space heating and domestic hot water,[9] and an estimation of saturation for space cooling.[10] Various information sources were used to derive these estimates, including analysis of utility sales data, and consultations with NLH/NP and local technical advisors.

Exhibits 2.3 and 2.4 present the estimated fuel shares and saturations for each sub sector and service region.

**Exhibit 2.3: Electric Fuel Share by Sub Sector and Service Region, (%)**

| Sub Sector | Island and Isolated | | Labrador Interconnected | |
|---|---|---|---|---|
| | Space Heating | Domestic Hot Water | Space Heating | Domestic Hot Water |
| Office | 79% | 90% | 100% | 100% |
| Non-food Retail | 62% | 90% | 100% | 100% |
| Food Retail | 67% | 70% | 100% | 100% |
| Health Care | 23% | 30% | 90% | 100% |
| Schools | 74% | 80% | 75% | 100% |
| Accommodations | 74% | 80% | 100% | 100% |
| University/College | 11% | 50% | 100% | 100% |
| Warehouse/Wholesale | 56% | 80% | 100% | 100% |
| Small Commercial | 63% | 83% | 98% | 100% |
| Other Buildings | 52% | 62% | 98% | 98% |
| Isolated Buildings | 15% | 10% | | |
| Other Institutional | | | 30% | 30% |

**Exhibit 2.4: Space Cooling Saturation by Sub Sector and Service Region, (%)**

| Sub Sector | Island and Isolated | Labrador Interconnected |
|---|---|---|
| Office | 80% | 50% |
| Non-food Retail | 70% | 25% |
| Food Retail | 60% | 15% |
| Health Care | 75% | 35% |
| Schools | 0% | 0% |
| Accommodations | 50% | 50% |
| University/College | 10% | 25% |
| Warehouse/Wholesale | 5% | 0% |
| Small Commercial | 31% | 26% |
| Other Buildings | 18% | 9% |
| Isolated Buildings | 0% | |
| Other Institutional | | 21% |

[9] Space heating fuel share refers to the percentage of the total floor space that is electrically heated; similarly, DHW fuel share refers to the percentage of the total floor space that is served by electric domestic hot water.
[10] Space cooling saturation refers to the percentage of the total floor space that is air conditioned.

## 2.5 DETAILED BUILDING AND EQUIPMENT SPECIFICATIONS

The next major task involved the development of detailed technical data on building specifications, mechanical and electrical equipment, operating practices and electricity use for each sub sector and end use identified above.

To facilitate the subsequent analysis of the potential impacts of energy-efficiency measures, the detailed data on building, equipment and operating practices were compiled using Marbek's commercial/institutional building energy use simulation model (CEEAM). Detailed building profiles were created for the stock of buildings within each sub sector, using weather data from Environment Canada.

Development of the detailed building profiles relied on an analysis of existing data sources. They included:

- Site visits
- Consultations with local technical advisors
- Building information and utility consumption provided by various organizations
- Professional experience of the study team personnel.

Exhibit 2.5 presents a sample summary building profile. Detailed profiles for each existing building sub sector are provided in Appendix A.

# Exhibit 2.5: Sample Summary Building Profile

| **Building Type:** | Office | **Location:** | Island and Isolated |
|---|---|---|---|

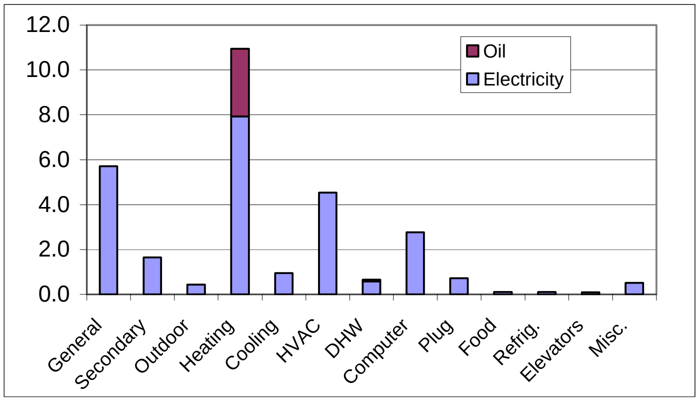
The building characteristics used to define the Office archetype are as follows:
- Average gross floor area of 40,000 ft²
- Average footprint of 13,333 ft² (approx. 115 ft x 115 ft)
- Average height of 3 storeys.

## Technical Profile of Major Building Systems

| | | | | | | |
|---|---|---|---|---|---|---|
| **Building Envelope:** | | | | | | |
| Roof U Value | 0.12 Btu/hr.ft² .°F | | | | | |
| Wall U Value | 0.09 Btu/hr.ft² .°F | | | | | |
| Window U Value | 0.70 Btu/hr.ft² .°F | | | | | |
| Shading Coefficient (SC) | 0.58 | | | | | |
| Window to Wall Ratio (WWR) | 0.36 | | | | | |
| **General Lighting:** | 550 Lux | | 1.5 W/ft² | | | |
| System Types | INC | CFL | T12 | T8 | MH | HPS |
| | 0% | 0% | 70% | 30% | 0% | 0% |
| **Secondary Lighting:** | 350 Lux | | 3.1 W/ft² | | | |
| System Types | INC | CFL | T12 | T8 | MH | HPS |
| | 50% | 45% | 0% | 0% | 5% | 0% |
| **Outdoor Lighting:** | | | 0.1 W/ft² | | | |
| System Types | FLUOR | INC | HID | Other | | |
| | 26% | 19% | 54% | 1% | | |
| Overall LPD | | | 1.8 W/ft² | | | |
| **Fans:** | | | | | | |
| System Types | CAV | VAV | | | | |
| | 75% | 25% | | | | |
| System Air Flow | 0.71 CFM/ft² | | | | | |
| Fan Power | 0.57 W/ft² | | | | | |
| **Space Heating:** | | | | | | |
| System Types | AS HP | WS HP | Resistance | Oil | | |
| | 0% | 0% | 79% | 21% | | |
| Peak Heating Load | 19 Btu/hr.ft² | | | | | |
| **Space Cooling** | | | | | | |
| System Types | Centrifugal | Centri HE | Recip Open | DX | | |
| | 20% | 0% | 0% | 80% | | |
| Peak Cooling Load | 27 Btu/hr.ft² | | 448 ft²/Ton | | | |
| **Pumps:** | | | | | | |
| Circulating Pumps | 0.1 W/ft² | | | | | |
| Condenser Pumps | 0.1 W/ft² | | | | | |

## Energy Profile

| **End Use** | **Elec** kWh/ft².yr | **Oil** kWh/ft².yr |
|---|---|---|
| GENERAL LIGHTING | 5.7 | |
| SECONDARY LIGHTING | 1.7 | |
| OUTDOOR LIGHTING | 0.4 | |
| SPACE HEATING | 7.9 | 3.0 |
| SPACE COOLING | 1.0 | |
| HVAC FANS & PUMPS | 4.5 | |
| DOMESTIC HOT WATER | 0.6 | 0.1 |
| COMPUTER EQUIPMENT | 2.8 | |
| OTHER PLUG LOADS | 0.7 | |
| FOOD SERVICE EQUIPMENT | 0.1 | |
| REFRIGERATION | 0.1 | |
| ELEVATORS | 0.1 | |
| MISCELLANEOUS | 0.5 | |
| | | |
| **Total** | **26.1** | **3.1** |



## 2.6 FLOOR AREA CALCULATIONS

Floor area is used to drive changes in Newfoundland and Labrador's commercial building stock over the study period, including changes to equipment and electricity use. For the purposes of this study, floor space was derived by dividing the actual sales data for each building sub sector by the applicable fuel share and saturation-weighted, whole-building electricity use intensity (EUI). Exhibit 2.6 shows the resulting estimates of floor area within each building sub sector in the Island and Isolated and Labrador Interconnected service regions.

**Exhibit 2.6: Floor Area by Sub Sector and Service Region, ($ft^2$)**

| Sub Sector | Island and Isolated | Labrador Interconnected | Total |
|---|---|---|---|
| Office | 12,178,467 | 316,584 | 12,495,051 |
| Non-food Retail | 4,326,634 | 911,653 | 5,238,286 |
| Food Retail | 2,356,898 | 173,358 | 2,530,256 |
| Health Care | 3,790,192 | 670,349 | 4,460,542 |
| Schools | 9,509,360 | 631,026 | 10,140,387 |
| Accommodations | 4,694,717 | 155,325 | 4,850,042 |
| University/College | 7,374,889 | 198,785 | 7,573,675 |
| Warehouse/Wholesale | 3,780,305 | 431,856 | 4,212,161 |
| Small Commercial | 23,464,658 | 1,368,078 | 24,832,736 |
| Other Buildings | 9,528,256 | 1,025,539 | 10,553,794 |
| Isolated Buildings | 1,919,228 | | 1,919,228 |
| Other Institutional | | 2,488,528 | 2,488,528 |
| **Total** | **82,923,605** | **8,371,081** | **91,294,686** |

*Note: Any differences in totals are due to rounding.*

For the Island and Isolated service region, the total floor area of the modelled sub sectors is approximately 83 million square feet. The largest sub sector is Small Commercial, which accounts for 28%[11] of the total floor area, followed by Office at 15%, Other Buildings at 11% and Schools at 11%.

For the Labrador Interconnected service region, the total floor area of the modelled sub sectors is approximately 8.4 million square feet. The largest sub sector is Other Institutional, which accounts for 30% of the total floor area, followed by Small Commercial at 16%, Other Buildings at 12% and Non-food Retail at 11%.

## 2.7 SUMMARY OF MODEL RESULTS

This section presents the results of the analysis of electricity consumption for the Base Year 2006. Electricity consumption is measured at the customer's point-of-use and does not include line losses.

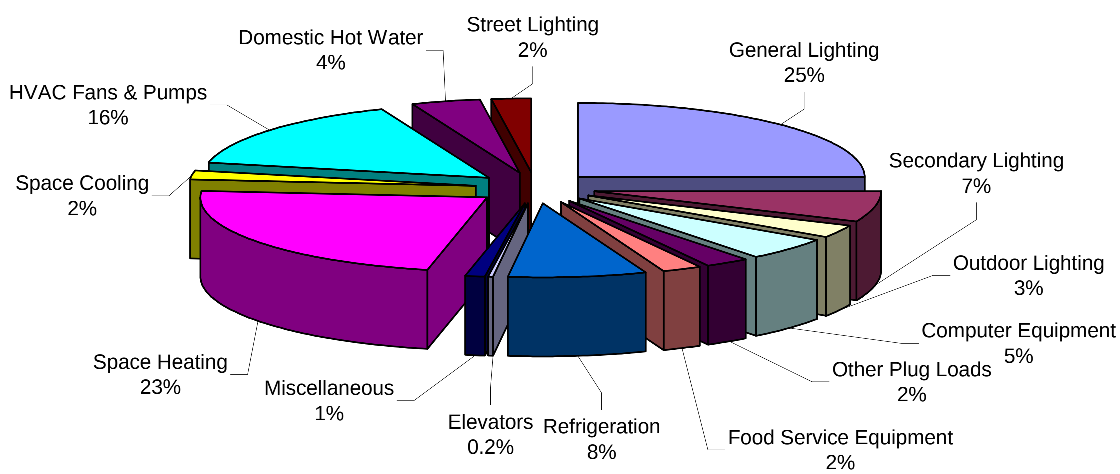
[11] Retail stores located in malls with individual metering that use less than 50 kW are included in the Small Commercial sub sector.

Exhibits 2.7 and 2.8 present the electricity consumption for, respectively, the Island and Isolated and Labrador Interconnected service regions by building sub sector and end use. Note: the Non-Buildings sub sector was not modelled and, therefore, the electricity consumption is carried as a total for the sub sector.

### Exhibit 2.7: Base Year Annual Electricity Consumption for the Island and Isolated Service Region by Sub Sector and End Use, (GWh/yr.)[12]

| Sub Sector | Electricity Consumption by End Use (GWh/yr) | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | General Lighting | Secondary Lighting | Outdoor Lighting | Computer Equipment | Other Plug Loads | Food Service Equipment | Refrigeration | Elevators | Miscellaneous | Space Heating | Space Cooling | HVAC Fans & Pumps | Domestic Hot Water | Street Lighting | Total |
| Office | 69.5 | 20.1 | 5.3 | 33.8 | 8.7 | 1.3 | 1.3 | 1.2 | 6.3 | 96.6 | 11.6 | 55.2 | 7.1 | | 317.9 |
| Non-food Retail | 50.4 | 4.6 | 3.8 | 3.9 | 2.8 | 1.1 | 1.0 | 0.0 | 1.1 | 23.1 | 4.1 | 22.6 | 1.9 | | 120.3 |
| Food Retail | 21.2 | 3.1 | 3.1 | 2.1 | 2.0 | 3.7 | 73.0 | 0.0 | 0.6 | 8.0 | 1.2 | 10.6 | 2.1 | | 130.7 |
| Health | 4.3 | 21.2 | 3.3 | 4.2 | 6.6 | 7.8 | 1.5 | 0.8 | 1.0 | 17.6 | 2.8 | 26.0 | 3.8 | | 100.9 |
| Schools | 28.9 | 8.5 | 4.2 | 6.1 | 1.0 | 1.0 | 0.7 | 0.0 | 0.7 | 52.8 | 0.0 | 5.9 | 3.7 | | 113.6 |
| Accommodations | 13.1 | 14.9 | 2.1 | 2.6 | 2.3 | 6.1 | 3.6 | 0.5 | 1.2 | 27.8 | 1.5 | 10.8 | 25.2 | | 111.6 |
| University/College | 40.3 | 6.2 | 3.2 | 10.5 | 4.8 | 2.9 | 3.8 | 0.7 | 1.9 | 6.2 | 0.9 | 36.1 | 2.4 | | 119.9 |
| Warehouse/Wholesale | 18.8 | 2.8 | 1.7 | 1.7 | 3.1 | 0.4 | 5.9 | 0.0 | 1.0 | 12.9 | 0.1 | 3.6 | 1.5 | | 53.4 |
| Small Commercial | 150.0 | 28.5 | 13.2 | 25.4 | 11.5 | 9.8 | 43.2 | 0.5 | 5.2 | 134.3 | 8.4 | 84.2 | 20.0 | | 534.1 |
| Other Buildings | 49.3 | 8.6 | 5.1 | 2.7 | 1.0 | 3.4 | 3.0 | 0.0 | 2.0 | 38.2 | 1.4 | 25.4 | 2.8 | | 142.9 |
| Non-Buildings | | | | | | | | | | | | | | | 81.6 |
| Isolated Buildings | 6.1 | 1.4 | 0.7 | 0.9 | 0.6 | 0.4 | 3.0 | 0.0 | 0.0 | 0.5 | 0.0 | 1.0 | 0.1 | | 14.8 |
| Street Lighting | | | | | | | | | | | | | | 39.4 | 39.4 |
| **Total** | **452** | **120** | **46** | **94** | **45** | **38** | **140** | **4** | **21** | **418** | **32** | **282** | **71** | **39** | **1,881** |

*Note: Any differences in totals are due to rounding.*



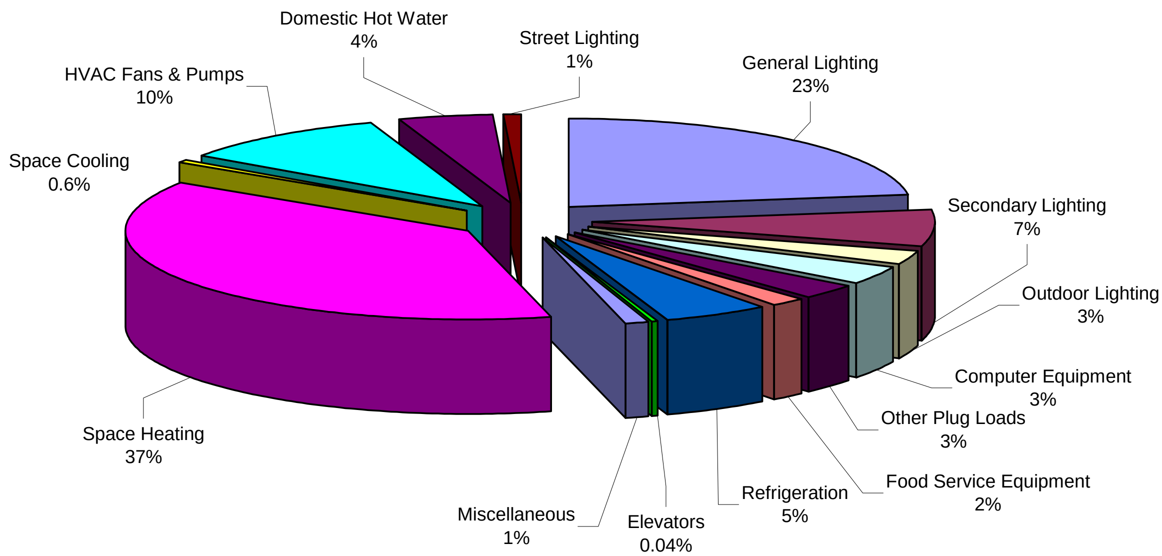

*Totals may not add to 100% due to rounding.*

[12] The pie chart presents percentage of electricity consumption by end use for buildings only; the sub sector Non-Buildings is included in the total load, but not included in the above pie chart.

## Exhibit 2.8: Base Year Annual Electricity Consumption for Labrador Interconnected Service Region by Sub Sector and End Use, (GWh/yr.)[13]

| Sub Sector | Electricity Consumption by End Use (GWh/yr) | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | General Lighting | Secondary Lighting | Outdoor Lighting | Computer Equipment | Other Plug Loads | Food Service Equipment | Refrigeration | Elevators | Miscellaneous | Space Heating | Space Cooling | HVAC Fans & Pumps | Domestic Hot Water | Street Lighting | Total |
| Office | 1.8 | 0.5 | 0.1 | 0.9 | 0.2 | 0.0 | 0.0 | 0.0 | 0.2 | 4.0 | 0.12 | 0.7 | 0.2 | | 8.9 |
| Non-food Retail | 9.8 | 0.9 | 0.8 | 0.8 | 0.6 | 0.2 | 0.2 | 0.0 | 0.2 | 10.7 | 0.24 | 2.3 | 0.4 | | 27.2 |
| Food Retail | 1.4 | 0.2 | 0.2 | 0.2 | 0.1 | 0.3 | 4.5 | 0.0 | 0.0 | 2.6 | 0.02 | 0.4 | 0.2 | | 10.1 |
| Health | 0.8 | 3.8 | 0.6 | 0.7 | 1.2 | 1.4 | 0.3 | 0.1 | 0.2 | 6.8 | 0.09 | 2.1 | 2.2 | | 20.2 |
| Schools | 2.2 | 0.6 | 0.3 | 0.4 | 0.1 | 0.1 | 0.0 | 0.0 | 0.0 | 5.1 | 0.00 | 0.8 | 0.3 | | 9.9 |
| Accommodations | 0.4 | 0.5 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.0 | 0.0 | 1.8 | 0.04 | 0.3 | 1.0 | | 4.6 |
| University/College | 1.1 | 0.2 | 0.1 | 0.3 | 0.1 | 0.1 | 0.1 | 0.0 | 0.2 | 2.4 | 0.04 | 0.6 | 0.1 | | 5.3 |
| Warehouse/Wholesale | 2.1 | 0.3 | 0.2 | 0.2 | 0.4 | 0.0 | 0.7 | 0.0 | 0.1 | 4.6 | 0.00 | 0.6 | 0.2 | | 9.4 |
| Small Commercial | 8.5 | 1.6 | 0.8 | 1.4 | 0.7 | 0.5 | 2.2 | 0.0 | 0.3 | 16.1 | 0.31 | 2.6 | 1.4 | | 36.3 |
| Other Buildings | 5.2 | 0.9 | 0.5 | 0.3 | 0.1 | 0.4 | 0.3 | 0.0 | 0.2 | 11.4 | 0.05 | 2.2 | 0.5 | | 22.1 |
| Non-Buildings | | | | | | | | | | | | | | | 7.2 |
| Other Institutional | 10.7 | 3.8 | 1.2 | 1.0 | 1.7 | 0.5 | 1.5 | 0.0 | 0.7 | 8.4 | 0.18 | 6.9 | 2.0 | | 38.7 |
| Street Lighting | | | | | | | | | | | | | | 1.6 | 1.6 |
| Total | 44.0 | 13.4 | 4.9 | 6.2 | 5.3 | 3.5 | 9.8 | 0.1 | 2.2 | 73.9 | 1.1 | 19.5 | 8.7 | 1.6 | 201.4 |

*Note: Any differences in totals are due to rounding.*




*Totals may not add to 100% due to rounding.*

[13] The pie chart presents percentage of electricity consumption by end use for buildings only; the sub sector Non-Buildings is included in the total load, but not included in the above pie chart.

Highlights of the results shown in Exhibits 2.7 and 2.8 are as follows:

**Base Year Electricity Use by Sub Sector**

- In the Island and Isolated Service Region, the Small Commercial sub sector accounts for the largest share of the total electricity consumption at 28%, followed by Office at 17%, Other Buildings at 8% and Food Retail at 7%.

- In the Labrador Interconnected service region, Other Institutional accounts for the largest share of total electricity consumption at 19%, followed by Small Commercial at 18%, Non-food Retail at 14% and Other Buildings at 11%.

**Base Year Electricity Use by End Use**

- In the Island and Isolated Service Region, general and secondary lighting combined account for the largest share of building electricity consumption at 32%, followed by space heating at 23%, HVAC fans and pumps at 16% and refrigeration at 8%.

- In the Labrador Interconnected service region, space heating accounts for the largest share of building electricity consumption at 37%, followed by general and secondary lighting combined at 30%, HVAC fans and pumps at 10% and refrigeration at 5%.

# 3. REFERENCE CASE ELECTRICITY USE

## INTRODUCTION

This section presents the Commercial sector Reference Case for the study period. The Reference Case estimates the expected level of electricity consumption that would occur over the study period in the absence of new utility-based initiatives or rate changes. The Reference Case, therefore, provides the point of comparison for the calculation of electricity savings opportunities associated with each of the subsequent scenarios that are assessed within this study.

The discussion is presented within the following subsections:

- Development of Detailed "New" Building and Equipment Specifications
- "Natural" Changes Affecting Electricity Consumption
- Expected Growth in Building Stock
- Summary of Model Results – Reference Case.

## 3.2 DEVELOPMENT OF DETAILED "NEW" BUILDING AND EQUIPMENT SPECIFICATIONS

The first task in building the Reference Case involved the development of detailed technical profiles that define building specifications, mechanical equipment, lighting equipment and electricity use for the "new" buildings in each of the commercial building sub sectors. In each case, the new building profiles were developed using Marbek's CSEEM and the same approach as described previously in Section 2.

Exhibit 3.1 presents a sample summary new building profile. It summarizes the major technical assumptions that have been used for new Offices in the development of the Reference Case. Detailed profiles for each new building sub sector are provided in Appendix A.

## Exhibit 3.1: Sample Summary New Building Profile - Office in Island and Isolated Service Region

| Building Type: | Office | Location: | Island and Isolated |
|---|---|---|---|

The building characteristics used to define the Office archetype are as follows:
- Average gross floor area of 40,000 ft²
- Average footprint of 13,333 ft² (approx. 115 ft x 115 ft)
- Average height of 3 storeys.

### Technical Profile of Major Building Systems

| | | | | | | |
|---|---|---|---|---|---|---|
| **Building Envelope:** | | | | | | |
| Roof U Value | 0.07 Btu/hr.ft² .°F | | | | | |
| Wall U Value | 0.03 Btu/hr.ft² .°F | | | | | |
| Window U Value | 0.49 Btu/hr.ft² .°F | | | | | |
| Shading Coefficient (SC) | 0.58 | | | | | |
| Window to Wall Ratio (WWR) | 0.35 | | | | | |
| **General Lighting:** | 500 Lux | | 1.2 W/ft² | | | |
| System Types | INC | CFL | T12 ES | T8 Mag | T8 Elec | MH |
| | 0% | 0% | 0% | 0% | 100% | 0% |
| **Secondary Lighting:** | 350 Lux | | 1.5 W/ft² | | | |
| System Types | INC | CFL | T12 ES | T8 Mag | T8 Elec | MH |
| | 10% | 30% | 0% | 0% | 40% | 20% |
| **Outdoor Lighting:** | | | 0.2 W/ft² | | | |
| System Types | FLUOR | INC | HID | Other | | |
| | 26% | 19% | 54% | 1% | | |
| Overall LPD | | | 1.4 W/ft² | | | |
| **Fans:** | | | | | | |
| System Types | CAV | VAV | | | | |
| | 50% | 50% | | | | |
| System Air Flow | 0.79 CFM/ft² | | | | | |
| Fan Power | 0.63 W/ft² | | | | | |
| **Space Heating:** | | | | | | |
| System Types | AS HP | WS HP | Resistance | Oil | | |
| | 0% | 0% | 100% | 0% | | |
| Peak Heating Load | 18 Btu/hr.ft² | | | | | |
| **Space Cooling** | | | | | | |
| System Types | Centrifugal | Centri HE | Recip Open | DX | | |
| | 0% | 20% | 0% | 80% | | |
| Peak Cooling Load | 26 Btu/hr.ft² | | 454 ft²/Ton | | | |
| **Pumps:** | | | | | | |
| Circulating Pumps | 0.1 W/ft² | | | | | |
| Condenser Pumps | 0.1 W/ft² | | | | | |

### Energy Profile

| End Use | Elec kWh/ft².yr | Oil kWh/ft².yr |
|---|---|---|
| GENERAL LIGHTING | 4.6 | |
| SECONDARY LIGHTING | 0.8 | |
| OUTDOOR LIGHTING | 0.8 | |
| SPACE HEATING | 8.3 | 0.0 |
| SPACE COOLING | 1.1 | |
| HVAC FANS & PUMPS | 4.2 | |
| DOMESTIC HOT WATER | 0.6 | 0.0 |
| COMPUTER EQUIPMENT | 2.8 | |
| OTHER PLUG LOADS | 0.7 | |
| FOOD SERVICE EQUIPMENT | 0.1 | |
| REFRIGERATION | 0.1 | |
| ELEVATORS | 0.0 | |
| MISCELLANEOUS | 0.5 | |
| | | |
| **Total** | **24.6** | **0.0** |

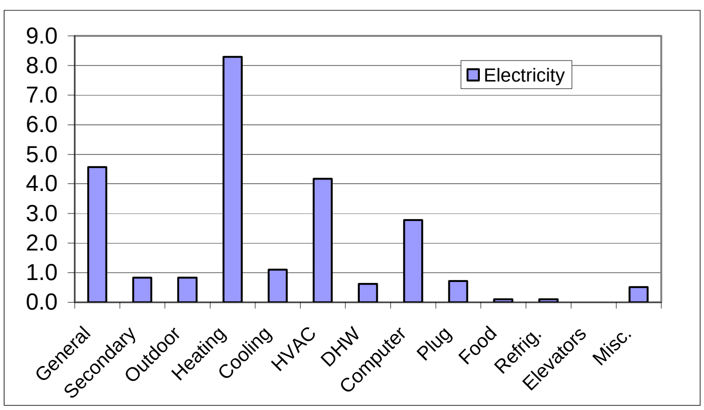


Exhibit 3.2 highlights the resulting whole building electric EUIs for each new commercial building sub sector. For the purposes of comparison, it also shows whole building electric EUIs for each of the existing building sub sectors. As shown, whole building electric EUIs decline for most sub sectors as a result of the following:

- Improved lighting system efficiency, including higher-efficacy lighting sources, more efficient lighting technologies and the use of automatic lighting controls
- Higher-efficiency building envelopes, including improved window U-values and higher levels of wall and roof insulation
- Higher-efficiency HVAC systems, including integrated designs, higher cooling equipment efficiencies and the use of building automation systems.

However, in some cases, gains made through energy efficiency are offset by the following factors that result in increased energy use in new buildings:

- Increased space heating and domestic hot water electric fuel shares, particularly in the Island and Isolated service region
- Increased saturation of space cooling in most sub sectors
- New design guidelines that require higher ventilation rates in selected sub sectors, such as in Schools, Food Retail and Health Care
- Increased use of outdoor lighting, particularly in the retail sub sectors.

# Exhibit 3.2: Comparison of Whole Building Electric EUIs by Sub Sector and Service Region, (kWh/ft$^2$/yr.)

| Sub Sector | Island and Isolated | | | Labrador Interconnected | | |
|---|---|---|---|---|---|---|
| | Existing Buildings | New Buildings | Comments | Existing Buildings | New Buildings | Comments |
| Office | 26.1 | 24.6 | New office buildings have higher efficiency lighting, HVAC and envelope systems, higher space cooling saturation, and higher space heating and hot water fuel shares resulting in a lower whole building EUI. | 28.0 | 27.3 | New office buildings have higher efficiency lighting, HVAC and envelope systems, and higher space cooling saturation resulting in a slightly lower whole building EUI. |
| Non-food Retail | 27.8 | 25.3 | New non-food retail buildings are typically "big box" stores with higher efficiency lighting, HVAC and envelope systems, higher space cooling saturation, and higher space heating and hot water fuel shares resulting in a lower whole building EUI. | 29.9 | 29.0 | New non-food retail buildings are typically "big box" stores with higher efficiency lighting, HVAC and envelope systems, and higher space cooling saturation resulting in a slightly lower whole building EUI. |
| Food Retail | 55.4 | 53.3 | New food retail buildings are typically "big box" stores with higher efficiency lighting, HVAC and envelope systems, higher space cooling saturation, higher space heating and hot water fuel shares, and higher penetration of refrigeration equipment resulting in a lower whole building EUI. | 58.3 | 54.8 | New food retail buildings are typically "big box" stores with higher efficiency lighting, HVAC and envelope systems, higher space cooling saturation, and higher penetration of refrigeration equipment resulting in a lower whole building EUI. |
| Health Care | 26.6 | 36.2 | New health care buildings have higher efficiency lighting, HVAC and envelope systems, higher space cooling saturation, higher ventilation rates, and higher space heating and hot water fuel shares resulting in a significantly higher whole building EUI. | 30.1 | 39.0 | New health care buildings have higher efficiency lighting, HVAC and envelope systems, higher space cooling saturation, higher ventilation rates, and higher space heating fuel shares resulting in a significantly higher whole building EUI. |
| Schools | 11.9 | 12.3 | New school buildings have higher efficiency lighting, HVAC and envelope systems, and higher space heating and hot water fuel shares resulting in a slightly higher whole building EUI. | 15.6 | 14.9 | New school buildings have higher efficiency lighting, HVAC and envelope systems, and higher space heating fuel shares resulting in a slightly lower whole building EUI. |
| Accomodations | 23.8 | 24.3 | New hotel/motel buildings have higher efficiency lighting, HVAC and envelope systems, and higher space heating and hot water fuel shares resulting in a slightly higher whole building EUI. | 29.5 | 28.5 | New hotel/motel buildings have higher efficiency lighting, HVAC and envelope systems, and higher space cooling saturation resulting in a slightly lower whole building EUI. |
| University/College | 16.3 | 19.4 | New university/college buildings have higher efficiency lighting, HVAC and envelope systems, higher space cooling saturation, and higher space heating and hot water fuel shares resulting in a higher whole building EUI. | 26.5 | 21.2 | New university/college buildings have higher efficiency lighting, HVAC and envelope systems, and higher space cooling saturation resulting in a lower whole building EUI. |
| Warehouse/Wholesale | 14.1 | 15.2 | New warehouse buildings have higher efficiency lighting, HVAC and envelope systems, and higher space heating and hot water fuel shares resulting in a slightly higher whole building EUI. | 21.9 | 18.3 | New warehouse buildings have higher efficiency lighting, HVAC and envelope systems resulting in a lower whole building EUI. |
| Small Commercial | 22.8 | 22.4 | New small commercial buildings have higher efficiency lighting, HVAC and envelope systems, higher space cooling saturation, and higher space heating and hot water fuel shares resulting in a slightly lower whole building EUI. | 26.6 | 25.7 | New small commercial buildings have higher efficiency lighting, HVAC and envelope systems, and higher space cooling saturation resulting in a lower whole building EUI. |
| Other Buildings | 15.0 | 15.9 | New other buildings have higher efficiency lighting, HVAC and envelope systems, and higher space heating and hot water fuel shares resulting in a slightly higher whole building EUI. | 21.6 | 19.2 | New other buildings have higher efficiency lighting, HVAC and envelope systems resulting in a lower whole building EUI. |
| Non-Buildings | | | | | | |
| Isolated Buildings | 7.7 | 7.4 | New isolated buildings have higher efficiency lighting and HVAC systems resulting in a slightly lower whole building EUI. | | | |
| Other Institutional | | | | 15.5 | 14.6 | New other institutional buildings have higher efficiency lighting, HVAC and envelope systems resulting in a lower whole building EUI. |

## 3.3 "NATURAL" CHANGES AFFECTING ELECTRICITY CONSUMPTION

The next task involved estimating the expected "natural" changes in electricity consumption patterns over the study period with consideration of three major factors:

- "Naturally occurring" improvements in equipment efficiency
- Expected stock penetration by more efficient equipment
- Changes in equipment density, e.g., computers and plug loads, etc.

These factors strongly influence future electricity use within the Commercial sector. While the first two factors will have the effect of reducing electricity consumption, the last factor will result in increased electricity demand.

Other considerations, such as operating hours, fuel share and end-use saturation changes may also affect future electricity demand. These values were assumed to remain constant for existing and new stock over the study period, with two exceptions. Electric fuel share for space heating and DHW in existing buildings was allowed to increase through time,[14] as was space cooling saturation for existing buildings.

Based on the assessment of current trends, the most significant "natural" changes are expected to involve the following end uses:

- Lighting
- Space cooling
- Computer equipment and other plug loads.

Further discussion of these changes follows and, in each case, the discussion identifies the technical change, the major driver(s) and the assumed electricity impact.

### 3.3.1 Lighting

As a result of natural conservation, it is assumed that the replacement of existing T12 fluorescent lighting and electromagnetic ballasts with new T8 fluorescent lamps and electronic ballasts will continue. Similarly, CFLs will continue to increase their market share over incandescent lamps, particularly in sectors such as Accommodations and Non-food Retail.

The continued growth of CFLs and T8 lighting/electronic ballasts is being driven by:

- Further price decreases and increased consumer recognition of the operating cost savings
- Energy regulations that are gradually removing electromagnetic fluorescent ballasts from the market place.

[14] Electric fuel share is expected to increase as a portion of older, oil-heated buildings are renovated and switched to electric heat and DHW.

Overall, the Reference Case assumes that by 2026 the energy intensity of lighting in the existing building stock will decrease by 10%.

### 3.3.2 Space Cooling

As a result of natural conservation and efficiency gains, it is assumed that new space cooling equipment will provide improved electricity performance compared to existing equipment. New centrifugal chillers achieve performance efficiencies in the range of 0.49-0.60 kW per ton. Similarly, packaged rooftop units are available on the market with energy-efficiency ratios (EER) of up to 12.[15] The combined effects of natural conservation and efficiency gains are estimated to result in a decrease of 6% in space cooling EUI over the length of the study.

As noted above, space cooling is expected to experience an increase in saturation levels, as shown in Exhibit 3.3. This increase will counter the effect of natural conservation and efficiency gains. Overall, total space cooling energy use is expected to increase by varying degrees depending on building sector.

**Exhibit 3.3: Changes to Space Cooling Saturation in Existing Buildings, by Sub Sector and Service Region (%)**

| Sub Sector | Island and Isolated | | Labrador Interconnected | |
|---|---|---|---|---|
| | A/C Saturation Existing Buildings 2006 | A/C Saturation Existing Buildings 2026 | A/C Saturation Existing Buildings 2006 | A/C Saturation Existing Buildings 2026 |
| Office | 80% | 90% | 50% | 60% |
| Non-food Retail | 70% | 80% | 25% | 40% |
| Food Retail | 60% | 80% | 15% | 30% |
| Health Care | 75% | 80% | 35% | 95% |
| Schools | 0% | 5% | 0% | 0% |
| Accommodations | 50% | 70% | 50% | 60% |
| University/College | 10% | 20% | 25% | 35% |
| Warehouse/Wholesale | 5% | 10% | 0% | 0% |
| Small Commercial | 31% | 50% | 26% | 40% |
| Other Buildings | 18% | 30% | 9% | 20% |
| Non-Buildings | | | | |
| Isolated Buildings | 0% | 0% | | |
| Other Institutional | | | 21% | 30% |

### 3.3.3 Computer Equipment and Other Plug Loads

Computer equipment and other plug loads will continue to grow as a result of increased density of computers per occupant, increased use of network computers and servers and growth in other peripherals, such as telephone network equipment. Increased penetration of laptops, more efficient server hardware and higher penetration of ENERGY STAR

[15] Current federal energy-efficiency regulations require a minimum EER of 10.3 for rooftop air conditioning units with a capacity of 5.5 - 11 tons.

rated computer equipment and other plug loads is expected to counterbalance the effect of increasing hardware density to some degree.

Overall, the Reference Case assumes that by 2026 the energy intensity of computer equipment and plug loads in the existing building stock will increase by 15%.[16]

### 3.3.4 Impact on Electricity Use

The net impact of the "natural" changes to the commercial building stock, independent of expected saturation or fuel switching changes, is equivalent to an overall reduction in energy intensity of approximately 1% by 2026 relative to the Base Year 2006. Most sub sectors will experience a reduction in energy use while others such as Health Care will experience a net increase of approximately 1% due to increases in computer equipment and plug loads. Total reductions are expected to be slightly lower in the Labrador Interconnected service region than in the Island and Isolated service region, as lighting and cooling represent a smaller portion of overall electricity use.

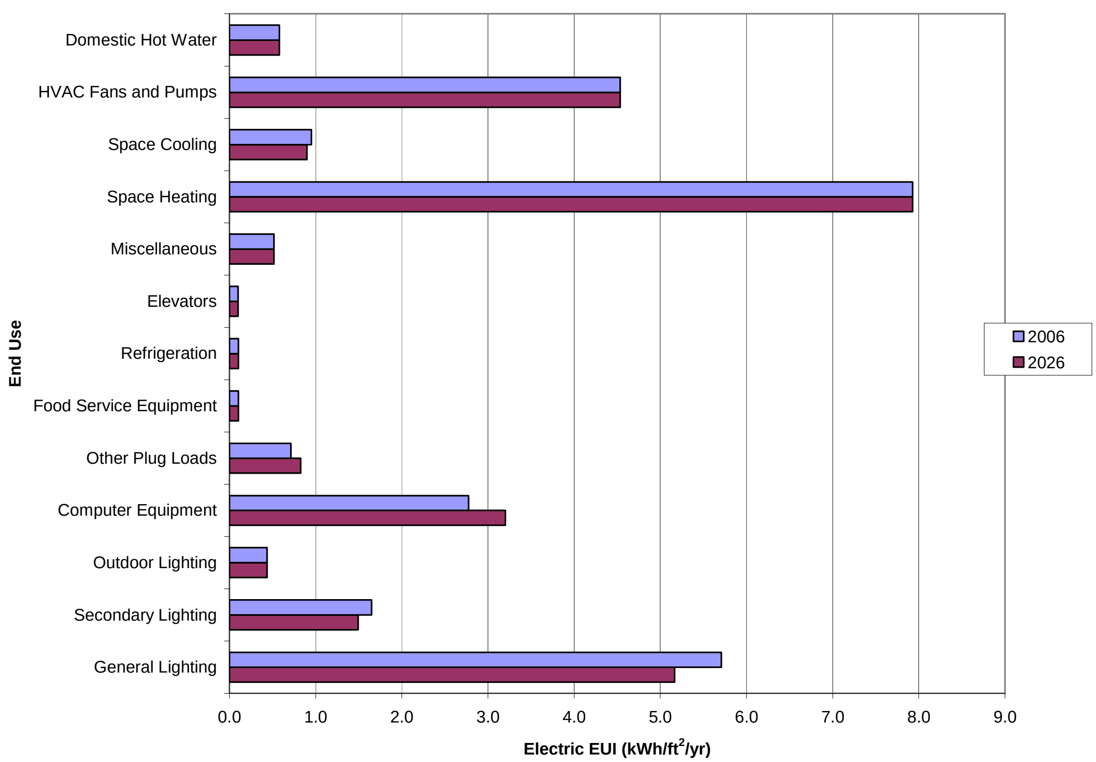
Exhibit 3.4 presents a comparison of electrical EUIs for an existing Office in the Island and Isolated service region for both the Base Year 2006 and 2026. As shown, lighting and space cooling experience a reduction due to the increased penetration of T8 lighting and more efficient cooling equipment, while computer equipment and plug loads increase by 15% due to increased equipment density.

[16] Estimates based on scenarios presented in Arthur D. Little, *Electricity Consumption by Office and Telecommunication Equipment in Commercial Buildings*. U.S. Department of Energy, 2002.

## Exhibit 3.4: Comparison of Electrical EUI for Existing Office in Island and Isolated Service Region[17]

| End Use | 2006 (kWh/ft²/yr) | 2026 (kWh/ft²/yr) | % Reduction |
|---|---|---|---|
| General Lighting | 5.7 | 5.2 | 10% |
| Secondary Lighting | 1.7 | 1.5 | 10% |
| Outdoor Lighting | 0.4 | 0.4 | 0% |
| Computer Equipment | 2.8 | 3.2 | -15% |
| Other Plug Loads | 0.7 | 0.8 | -15% |
| Food Service Equipment | 0.1 | 0.1 | 0% |
| Refrigeration | 0.1 | 0.1 | 0% |
| Elevators | 0.1 | 0.1 | 0% |
| Miscellaneous | 0.5 | 0.5 | 0% |
| Space Heating | 7.9 | 7.9 | 0% |
| Space Cooling | 1.0 | 0.9 | 6% |
| HVAC Fans and Pumps | 4.5 | 4.5 | 0% |
| Domestic Hot Water | 0.6 | 0.6 | 0% |
| **Total** | 26.1 | 25.9 | 1% |

*Note: Any differences in totals are due to rounding.*




[17] Negative reduction shown above for computer equipment and plug loads represents an increased EUI.

## 3.4 EXPECTED GROWTH IN BUILDING STOCK

The next step in developing the Reference Case involved the development and application of estimated levels of floor space growth in each building sector and service region over the study period. The stock growth rates were derived from the sales forecast data provided by NLH from the NLH Long Term Planning (PLF) Review Forecast, Summer/Fall 2006. The derivation of floor space data in each of the milestone periods applied the following steps:

- Estimate and apply the expected impact of "natural conservation" (Section 3.3) for each sub sector (i.e., an updated EUI that includes the effects of natural conservation)

- Use the updated EUI to calculate the floor space required to match the NLH forecast electricity consumption in each combination of sub sector, milestone year and service region.

A summary is provided in Exhibits 3.5 and 3.6 for, respectively, the Island and Isolated and Labrador Interconnected service regions.

**Exhibit 3.5: Commercial Sector Floor Space - Island and Isolated Service Region**

| Subsector | Milestone Year | | | | |
|---|---|---|---|---|---|
| | 2006 | 2011 | 2016 | 2021 | 2026 |
| Office | 12,178,467 | 12,858,186 | 13,550,786 | 14,378,272 | 15,247,773 |
| Non-food Retail | 4,326,634 | 4,532,248 | 4,742,020 | 4,991,339 | 5,254,885 |
| Food Retail | 2,356,898 | 2,462,484 | 2,569,935 | 2,697,329 | 2,831,624 |
| Health Care | 3,790,192 | 3,853,257 | 3,917,019 | 3,986,628 | 4,063,562 |
| Schools | 9,509,360 | 10,018,076 | 10,534,471 | 11,142,498 | 11,783,405 |
| Accomodations | 4,694,717 | 4,917,421 | 5,143,450 | 5,410,901 | 5,691,876 |
| University/College | 7,374,889 | 7,428,897 | 7,483,589 | 7,542,692 | 7,608,872 |
| Warehouse/Wholesale | 3,780,305 | 3,911,537 | 4,044,507 | 4,202,884 | 4,367,996 |
| Small Commercial | 23,464,658 | 24,785,227 | 26,131,069 | 27,330,816 | 28,620,237 |
| Other Buildings | 9,528,256 | 9,854,396 | 10,185,108 | 10,578,414 | 10,989,451 |
| Non-Buildings | | | | | |
| Isolated Buildings | 1,919,228 | 2,159,540 | 2,312,767 | 2,467,213 | 2,621,676 |
| Other Institutional | | | | | |
| Total | 82,923,605 | 86,781,269 | 90,614,721 | 94,728,986 | 99,081,357 |

*Note: Any differences in totals are due to rounding.*

**Exhibit 3.6: Commercial Sector Floor Space - Labrador Interconnected Service Region**

| Subsector | Milestone Year | | | | |
|---|---|---|---|---|---|
| | 2006 | 2011 | 2016 | 2021 | 2026 |
| Office | 316,584 | 347,204 | 362,555 | 377,839 | 393,768 |
| Non-food Retail | 911,653 | 1,003,962 | 1,048,363 | 1,092,570 | 1,138,641 |
| Food Retail | 173,358 | 197,343 | 206,372 | 215,374 | 224,770 |
| Health Care | 670,349 | 760,275 | 785,504 | 785,504 | 785,504 |
| Schools | 631,026 | 703,929 | 735,620 | 735,620 | 735,620 |
| Accomodations | 155,325 | 173,527 | 181,242 | 188,927 | 196,936 |
| University/College | 198,785 | 231,416 | 243,829 | 243,829 | 243,829 |
| Warehouse/Wholesale | 431,856 | 477,745 | 502,304 | 526,924 | 552,752 |
| Small Commercial | 1,368,078 | 1,542,560 | 1,621,353 | 1,700,320 | 1,783,132 |
| Other Buildings | 1,025,539 | 1,109,234 | 1,162,766 | 1,216,272 | 1,272,240 |
| Non-Buildings | | | | | |
| Isolated Buldings | | | | | |
| Other Institutional | 2,488,528 | 2,488,528 | 2,488,528 | 2,488,528 | 2,488,528 |
| Total | 8,371,081 | 9,035,722 | 9,338,436 | 9,571,706 | 9,815,719 |

*Note: Any differences in totals are due to rounding.*

## 3.5 SUMMARY OF MODEL RESULTS – REFERENCE CASE

The Reference Case results for the two service regions are presented in Exhibits 3.7 and 3.8. As illustrated, the Reference Case indicates that, in the absence of new utility-based CDM initiatives, total Commercial sector electricity consumption for the Island and Isolated service region is expected to increase from 1,881 GWh/yr. in the Base Year to approximately 2,233 GWh/yr. in 2026, an increase of about 19%. For the Labrador Interconnected service region, consumption is forecast to grow from 201 GWh/yr. to 240 GWh/yr. over the study period, an increase of approximately 20%.

Highlights:

**Reference Case Electricity use by Sub Sector**

- In the Island and Isolated service region, Isolated Buildings show the greatest increase in electricity consumption over the study period (31%), followed by Office (24%) and Schools (24%). These changes are primarily driven by increases in sub sector building stock.

- Small Commercial buildings have the greatest increase in consumption (27%), followed by Food Retail (26%). Similarly, these increases are primarily driven by growth levels in sub sector building stock.

**Reference Case Electricity use by End Use**

- In the Island and Isolated Service Region, space cooling has the greatest increase over the study period (53%), followed by computers and plug loads (39% and 36% respectively). Increased space cooling electricity consumption is primarily due to an expected increase in cooling saturation, while the computer and plug loads increase is due to an expected increase in equipment density.

- In the Labrador Interconnected Service Region, space cooling again has the greatest increase over the study period (91%), followed by computers and plug loads (40% and 36% respectively). These increases are expected for similar reasons to those stated above.

Further detail is provided below.

- Exhibit 3.7 presents the Reference Case for the Island and Isolated service region, with the results broken out by building sub sector, end use and milestone year.

- Exhibit 3.8 presents the Reference Case for the Labrador Interconnected service region, with the results broken out by building sub sector, end use and milestone year.

## Exhibit 3.7: Reference Case for Annual Electricity Consumption in the Island and Isolated Service Region, (GWh/yr.)[18]

| Building Type | Milestone Year | GWh/yr | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Total | General Lighting | Secondary Lighting | Outdoor Lighting | Computer Equipment | Other Plug Loads | Food Service Equipment | Refrigeration | Elevators | Miscellaneous | Space Heating | Space Cooling | HVAC Fans & Pumps | Domestic Hot Water | Streetlighting |
| Office | 2006 | 318 | 69.5 | 20.1 | 5.3 | 33.8 | 8.7 | 1.3 | 1.3 | 1.2 | 6.3 | 96.6 | 11.6 | 55.2 | 7.1 | |
| | 2011 | 335 | 70.9 | 20.2 | 5.9 | 37.0 | 9.6 | 1.3 | 1.3 | 1.2 | 6.6 | 102.9 | 12.5 | 58.0 | 7.5 | |
| | 2016 | 352 | 72.2 | 20.2 | 6.5 | 40.5 | 10.4 | 1.4 | 1.4 | 1.2 | 7.0 | 109.2 | 13.4 | 60.9 | 8.0 | |
| | 2021 | 373 | 73.9 | 20.4 | 7.2 | 44.5 | 11.5 | 1.5 | 1.5 | 1.2 | 7.4 | 116.7 | 14.4 | 64.4 | 8.5 | |
| | 2026 | 395 | 75.6 | 20.5 | 7.9 | 48.8 | 12.6 | 1.6 | 1.6 | 1.2 | 7.9 | 124.6 | 15.5 | 68.0 | 9.1 | |
| Non-food Retail | 2006 | 120 | 50.4 | 4.6 | 3.8 | 3.9 | 2.8 | 1.1 | 1.0 | 0.0 | 1.1 | 23.1 | 4.1 | 22.6 | 1.9 | |
| | 2011 | 125 | 51.0 | 4.7 | 4.1 | 4.2 | 3.0 | 1.2 | 1.0 | 0.0 | 1.2 | 24.6 | 4.3 | 23.5 | 2.0 | |
| | 2016 | 129 | 51.6 | 4.7 | 4.3 | 4.6 | 3.3 | 1.2 | 1.1 | 0.0 | 1.2 | 26.1 | 4.6 | 24.5 | 2.1 | |
| | 2021 | 135 | 52.4 | 4.8 | 4.7 | 5.0 | 3.6 | 1.3 | 1.1 | 0.0 | 1.3 | 27.9 | 4.9 | 25.7 | 2.3 | |
| | 2026 | 141 | 53.1 | 4.8 | 5.0 | 5.5 | 3.9 | 1.4 | 1.2 | 0.0 | 1.4 | 29.7 | 5.2 | 26.9 | 2.4 | |
| Food Retail | 2006 | 131 | 21.2 | 3.1 | 3.1 | 2.1 | 2.0 | 3.7 | 73.0 | 0.0 | 0.6 | 8.0 | 1.2 | 10.6 | 2.1 | |
| | 2011 | 136 | 21.5 | 3.1 | 3.2 | 2.2 | 2.1 | 3.8 | 76.1 | 0.0 | 0.6 | 8.6 | 1.4 | 11.0 | 2.3 | |
| | 2016 | 142 | 21.7 | 3.2 | 3.4 | 2.4 | 2.3 | 4.0 | 79.2 | 0.0 | 0.7 | 9.2 | 1.5 | 11.5 | 2.5 | |
| | 2021 | 148 | 22.1 | 3.2 | 3.5 | 2.6 | 2.5 | 4.2 | 82.9 | 0.0 | 0.7 | 9.8 | 1.7 | 12.0 | 2.6 | |
| | 2026 | 155 | 22.5 | 3.2 | 3.7 | 2.9 | 2.7 | 4.4 | 86.8 | 0.0 | 0.7 | 10.5 | 1.9 | 12.6 | 2.8 | |
| Health | 2006 | 101 | 4.3 | 21.2 | 3.3 | 4.2 | 6.6 | 7.8 | 1.5 | 0.8 | 1.0 | 17.6 | 2.8 | 26.0 | 3.8 | |
| | 2011 | 104 | 4.3 | 21.1 | 3.4 | 4.5 | 7.0 | 8.0 | 1.5 | 0.8 | 1.0 | 19.1 | 2.8 | 26.5 | 4.1 | |
| | 2016 | 107 | 4.3 | 20.9 | 3.4 | 4.7 | 7.3 | 8.1 | 1.5 | 0.8 | 1.0 | 20.5 | 2.9 | 27.0 | 4.5 | |
| | 2021 | 110 | 4.3 | 20.7 | 3.5 | 5.0 | 7.7 | 8.2 | 1.5 | 0.8 | 1.0 | 22.0 | 2.9 | 27.5 | 4.8 | |
| | 2026 | 113 | 4.2 | 20.5 | 3.6 | 5.2 | 8.2 | 8.4 | 1.6 | 0.8 | 1.0 | 23.6 | 3.0 | 28.1 | 5.2 | |
| Schools | 2006 | 114 | 28.9 | 8.5 | 4.2 | 6.1 | 1.0 | 1.0 | 0.7 | 0.0 | 0.7 | 52.8 | 0.0 | 5.9 | 3.7 | |
| | 2011 | 120 | 29.6 | 8.6 | 4.3 | 6.6 | 1.1 | 1.0 | 0.8 | 0.0 | 0.8 | 56.4 | 0.1 | 6.4 | 4.0 | |
| | 2016 | 126 | 30.2 | 8.7 | 4.4 | 7.2 | 1.2 | 1.1 | 0.8 | 0.0 | 0.8 | 60.0 | 0.3 | 6.8 | 4.3 | |
| | 2021 | 133 | 31.0 | 8.9 | 4.6 | 7.9 | 1.4 | 1.2 | 0.9 | 0.0 | 0.9 | 64.3 | 0.4 | 7.3 | 4.6 | |
| | 2026 | 141 | 31.9 | 9.0 | 4.8 | 8.7 | 1.5 | 1.2 | 0.9 | 0.0 | 0.9 | 68.7 | 0.6 | 7.8 | 4.9 | |
| Accomodations | 2006 | 112 | 13.1 | 14.9 | 2.1 | 2.6 | 2.3 | 6.1 | 3.6 | 0.5 | 1.2 | 27.8 | 1.5 | 10.8 | 25.2 | |
| | 2011 | 117 | 13.3 | 15.2 | 2.2 | 2.8 | 2.5 | 6.2 | 3.7 | 0.5 | 1.3 | 29.5 | 1.7 | 11.3 | 26.9 | |
| | 2016 | 122 | 13.4 | 15.5 | 2.3 | 3.0 | 2.7 | 6.3 | 3.8 | 0.5 | 1.3 | 31.3 | 2.0 | 11.8 | 28.5 | |
| | 2021 | 129 | 13.6 | 15.9 | 2.4 | 3.3 | 3.0 | 6.5 | 3.9 | 0.5 | 1.4 | 33.3 | 2.2 | 12.4 | 30.5 | |
| | 2026 | 136 | 13.7 | 16.3 | 2.5 | 3.6 | 3.2 | 6.7 | 4.0 | 0.6 | 1.5 | 35.5 | 2.5 | 13.0 | 32.5 | |
| University/College | 2006 | 120 | 40.3 | 6.2 | 3.2 | 10.5 | 4.8 | 2.9 | 3.8 | 0.7 | 1.9 | 6.2 | 0.9 | 36.1 | 2.4 | |
| | 2011 | 121 | 39.6 | 6.1 | 3.3 | 11.0 | 5.0 | 2.9 | 3.8 | 0.7 | 1.9 | 7.1 | 1.1 | 36.3 | 2.4 | |
| | 2016 | 123 | 38.9 | 6.0 | 3.3 | 11.5 | 5.2 | 2.9 | 3.9 | 0.7 | 1.9 | 7.9 | 1.3 | 36.5 | 2.5 | |
| | 2021 | 124 | 38.1 | 5.9 | 3.3 | 12.0 | 5.5 | 2.9 | 3.9 | 0.8 | 1.9 | 8.9 | 1.5 | 36.7 | 2.6 | |
| | 2026 | 126 | 37.4 | 5.8 | 3.3 | 12.6 | 5.7 | 2.9 | 3.9 | 0.8 | 2.0 | 9.8 | 1.8 | 36.9 | 2.6 | |
| Warehouse/ Wholesale | 2006 | 53 | 18.8 | 2.8 | 1.7 | 1.7 | 3.1 | 0.4 | 5.9 | 0.0 | 1.0 | 12.9 | 0.1 | 3.6 | 1.5 | |
| | 2011 | 55 | 19.0 | 2.8 | 1.7 | 1.9 | 3.4 | 0.4 | 6.1 | 0.0 | 1.0 | 13.7 | 0.1 | 3.7 | 1.5 | |
| | 2016 | 57 | 19.2 | 2.7 | 1.8 | 2.0 | 3.6 | 0.4 | 6.3 | 0.0 | 1.0 | 14.6 | 0.2 | 3.8 | 1.6 | |
| | 2021 | 60 | 19.5 | 2.7 | 1.8 | 2.1 | 3.9 | 0.4 | 6.5 | 0.0 | 1.1 | 15.6 | 0.2 | 4.0 | 1.7 | |
| | 2026 | 62 | 19.8 | 2.7 | 1.9 | 2.3 | 4.2 | 0.5 | 6.8 | 0.0 | 1.1 | 16.7 | 0.2 | 4.1 | 1.8 | |
| Small Commercial | 2006 | 534 | 150.0 | 28.5 | 13.2 | 25.4 | 11.5 | 9.8 | 43.2 | 0.5 | 5.2 | 134.3 | 8.4 | 84.2 | 20.0 | |
| | 2011 | 563 | 152.8 | 29.0 | 14.2 | 27.9 | 12.7 | 10.3 | 45.5 | 0.5 | 5.4 | 144.9 | 10.1 | 88.6 | 21.4 | |
| | 2016 | 593 | 155.5 | 29.4 | 15.3 | 30.6 | 13.9 | 10.8 | 47.8 | 0.6 | 5.7 | 155.7 | 11.9 | 93.0 | 22.9 | |
| | 2021 | 619 | 157.1 | 29.6 | 16.2 | 33.2 | 15.0 | 11.3 | 49.9 | 0.6 | 6.0 | 165.5 | 13.7 | 97.0 | 24.2 | |
| | 2026 | 648 | 158.9 | 29.9 | 17.2 | 36.0 | 16.3 | 11.8 | 52.1 | 0.6 | 6.3 | 175.9 | 15.6 | 101.2 | 25.7 | |
| Other Buildings | 2006 | 143 | 49.3 | 8.6 | 5.1 | 2.7 | 1.0 | 3.4 | 3.0 | 0.0 | 2.0 | 38.2 | 1.4 | 25.4 | 2.8 | |
| | 2011 | 148 | 49.5 | 8.5 | 5.3 | 2.9 | 1.1 | 3.5 | 3.1 | 0.0 | 2.0 | 41.0 | 1.7 | 26.2 | 3.0 | |
| | 2016 | 153 | 49.7 | 8.5 | 5.5 | 3.1 | 1.2 | 3.7 | 3.2 | 0.0 | 2.1 | 43.8 | 1.9 | 27.0 | 3.2 | |
| | 2021 | 159 | 50.1 | 8.4 | 5.8 | 3.3 | 1.3 | 3.8 | 3.4 | 0.0 | 2.2 | 47.0 | 2.2 | 27.9 | 3.5 | |
| | 2026 | 165 | 50.5 | 8.4 | 6.1 | 3.6 | 1.4 | 3.9 | 3.5 | 0.0 | 2.3 | 50.4 | 2.5 | 28.9 | 3.7 | |
| Non Buildings | 2006 | 82 | | | | | | | | | | | | | | |
| | 2011 | 84 | | | | | | | | | | | | | | |
| | 2016 | 87 | | | | | | | | | | | | | | |
| | 2021 | 91 | | | | | | | | | | | | | | |
| | 2026 | 94 | | | | | | | | | | | | | | |
| Isolated Buildings | 2006 | 15 | 6.1 | 1.4 | 0.7 | 0.9 | 0.6 | 0.4 | 3.0 | 0.0 | 0.0 | 0.5 | 0.0 | 1.0 | 0.1 | |
| | 2011 | 16 | 6.6 | 1.5 | 0.7 | 1.1 | 0.7 | 0.5 | 3.4 | 0.0 | 0.0 | 0.6 | 0.0 | 1.2 | 0.1 | |
| | 2016 | 17 | 6.8 | 1.6 | 0.8 | 1.2 | 0.8 | 0.5 | 3.6 | 0.0 | 0.0 | 0.6 | 0.0 | 1.3 | 0.2 | |
| | 2021 | 18 | 7.0 | 1.6 | 0.9 | 1.3 | 0.9 | 0.6 | 3.9 | 0.0 | 0.0 | 0.6 | 0.0 | 1.4 | 0.2 | |
| | 2026 | 19 | 7.2 | 1.6 | 0.9 | 1.5 | 1.0 | 0.6 | 4.1 | 0.0 | 0.0 | 0.7 | 0.0 | 1.6 | 0.2 | |
| Streetlighting | 2006 | 39 | | | | | | | | | | | | | | 39.4 |
| | 2011 | 39 | | | | | | | | | | | | | | 39.4 |
| | 2016 | 39 | | | | | | | | | | | | | | 39.4 |
| | 2021 | 39 | | | | | | | | | | | | | | 39.5 |
| | 2026 | 40 | | | | | | | | | | | | | | 39.5 |
| Total | 2006 | 1,881 | 452 | 120 | 46 | 94 | 45 | 38 | 140 | 4 | 21 | 418 | 32 | 282 | 71 | 39 |
| | 2011 | 1,965 | 458 | 121 | 48 | 102 | 48 | 39 | 146 | 4 | 22 | 448 | 36 | 293 | 75 | 39 |
| | 2016 | 2,048 | 463 | 121 | 51 | 111 | 52 | 40 | 153 | 4 | 23 | 479 | 40 | 304 | 80 | 39 |
| | 2021 | 2,138 | 469 | 122 | 54 | 120 | 56 | 42 | 159 | 4 | 24 | 512 | 44 | 316 | 85 | 39 |
| | 2026 | 2,233 | 475 | 123 | 57 | 131 | 61 | 43 | 167 | 4 | 25 | 546 | 49 | 329 | 91 | 40 |

*Note: Any differences in totals are due to rounding.*

[18] Results are measured at the customer's point-of-use and do not include line losses. This chart presents percentage of electricity consumption by end use for buildings only; the sub sector Non-Buildings is included in the total load, but is not broken down by end use.

## Exhibit 3.8: Reference Case for Annual Electricity Consumption in the Labrador Interconnected Service Region, (GWh/yr.)[19]

| Building Type | Milestone Year | GWh/yr | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Total | General Lighting | Secondary Lighting | Outdoor Lighting | Computer Equipment | Other Plug Loads | Food Service Equipment | Refrigeration | Elevators | Miscellaneous | Space Heating | Space Cooling | HVAC Fans & Pumps | Domestic Hot Water | Streetlighting |
| Office | 2006 | 9 | 1.8 | 0.5 | 0.1 | 0.9 | 0.2 | 0.0 | 0.0 | 0.0 | 0.2 | 4.0 | 0.1 | 0.7 | 0.2 | |
| | 2011 | 10 | 1.9 | 0.5 | 0.2 | 1.0 | 0.3 | 0.0 | 0.0 | 0.0 | 0.2 | 4.4 | 0.1 | 0.8 | 0.2 | |
| | 2016 | 10 | 1.9 | 0.5 | 0.2 | 1.1 | 0.3 | 0.0 | 0.0 | 0.0 | 0.2 | 4.6 | 0.2 | 0.8 | 0.2 | |
| | 2021 | 11 | 1.9 | 0.5 | 0.2 | 1.2 | 0.3 | 0.0 | 0.0 | 0.0 | 0.2 | 4.8 | 0.2 | 0.9 | 0.2 | |
| | 2026 | 11 | 2.0 | 0.5 | 0.2 | 1.3 | 0.3 | 0.0 | 0.0 | 0.0 | 0.2 | 5.0 | 0.2 | 0.9 | 0.3 | |
| Non-Food Retail | 2006 | 27 | 9.8 | 0.9 | 0.8 | 0.8 | 0.6 | 0.2 | 0.2 | 0.0 | 0.2 | 10.7 | 0.2 | 2.3 | 0.4 | |
| | 2011 | 30 | 10.3 | 1.0 | 0.9 | 0.9 | 0.7 | 0.3 | 0.2 | 0.0 | 0.3 | 11.6 | 0.3 | 2.7 | 0.5 | |
| | 2016 | 31 | 10.5 | 1.0 | 1.0 | 1.0 | 0.7 | 0.3 | 0.2 | 0.0 | 0.3 | 12.1 | 0.4 | 2.9 | 0.5 | |
| | 2021 | 32 | 10.6 | 1.0 | 1.0 | 1.1 | 0.8 | 0.3 | 0.2 | 0.0 | 0.3 | 12.5 | 0.5 | 3.1 | 0.5 | |
| | 2026 | 33 | 10.7 | 1.0 | 1.1 | 1.2 | 0.8 | 0.3 | 0.3 | 0.0 | 0.3 | 13.0 | 0.5 | 3.3 | 0.6 | |
| Food Retail | 2006 | 10 | 1.4 | 0.2 | 0.2 | 0.2 | 0.1 | 0.3 | 4.5 | 0.0 | 0.0 | 2.6 | 0.0 | 0.4 | 0.2 | |
| | 2011 | 11 | 1.6 | 0.2 | 0.3 | 0.2 | 0.2 | 0.3 | 5.1 | 0.0 | 0.1 | 2.7 | 0.0 | 0.5 | 0.3 | |
| | 2016 | 12 | 1.6 | 0.2 | 0.3 | 0.2 | 0.2 | 0.3 | 5.3 | 0.0 | 0.1 | 2.8 | 0.0 | 0.6 | 0.3 | |
| | 2021 | 12 | 1.6 | 0.2 | 0.3 | 0.2 | 0.2 | 0.3 | 5.6 | 0.0 | 0.1 | 2.9 | 0.1 | 0.7 | 0.3 | |
| | 2026 | 13 | 1.7 | 0.2 | 0.3 | 0.2 | 0.2 | 0.3 | 5.8 | 0.0 | 0.1 | 2.9 | 0.1 | 0.7 | 0.3 | |
| Health | 2006 | 20 | 0.8 | 3.8 | 0.6 | 0.7 | 1.2 | 1.4 | 0.3 | 0.1 | 0.2 | 6.8 | 0.1 | 2.1 | 2.2 | |
| | 2011 | 24 | 0.9 | 4.1 | 0.7 | 0.9 | 1.4 | 1.6 | 0.3 | 0.1 | 0.2 | 8.3 | 0.3 | 2.6 | 2.6 | |
| | 2016 | 25 | 0.9 | 4.1 | 0.7 | 0.9 | 1.5 | 1.6 | 0.3 | 0.1 | 0.2 | 8.8 | 0.3 | 2.8 | 2.6 | |
| | 2021 | 25 | 0.9 | 4.0 | 0.7 | 1.0 | 1.5 | 1.6 | 0.3 | 0.1 | 0.2 | 8.8 | 0.3 | 2.8 | 2.6 | |
| | 2026 | 25 | 0.8 | 3.9 | 0.7 | 1.0 | 1.6 | 1.6 | 0.3 | 0.1 | 0.2 | 8.8 | 0.3 | 2.8 | 2.6 | |
| Schools | 2006 | 10 | 2.2 | 0.6 | 0.3 | 0.4 | 0.1 | 0.1 | 0.0 | 0.0 | 0.0 | 5.1 | 0.0 | 0.8 | 0.3 | |
| | 2011 | 11 | 2.3 | 0.7 | 0.3 | 0.5 | 0.1 | 0.1 | 0.0 | 0.0 | 0.1 | 5.8 | 0.0 | 0.9 | 0.3 | |
| | 2016 | 11 | 2.3 | 0.7 | 0.3 | 0.5 | 0.1 | 0.1 | 0.0 | 0.0 | 0.1 | 6.1 | 0.0 | 0.9 | 0.4 | |
| | 2021 | 11 | 2.3 | 0.7 | 0.3 | 0.5 | 0.1 | 0.1 | 0.0 | 0.0 | 0.1 | 6.1 | 0.0 | 0.9 | 0.4 | |
| | 2026 | 11 | 2.2 | 0.6 | 0.3 | 0.5 | 0.1 | 0.1 | 0.0 | 0.0 | 0.1 | 6.2 | 0.0 | 0.9 | 0.4 | |
| Accomodations | 2006 | 5 | 0.4 | 0.5 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.0 | 0.0 | 1.8 | 0.0 | 0.3 | 1.0 | |
| | 2011 | 5 | 0.5 | 0.5 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.0 | 0.0 | 2.0 | 0.1 | 0.4 | 1.2 | |
| | 2016 | 5 | 0.5 | 0.5 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.0 | 0.0 | 2.1 | 0.1 | 0.4 | 1.2 | |
| | 2021 | 5 | 0.5 | 0.6 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.0 | 0.0 | 2.2 | 0.1 | 0.4 | 1.3 | |
| | 2026 | 6 | 0.5 | 0.6 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.0 | 0.1 | 2.3 | 0.1 | 0.4 | 1.3 | |
| University/College | 2006 | 5 | 1.1 | 0.2 | 0.1 | 0.3 | 0.1 | 0.1 | 0.1 | 0.0 | 0.2 | 2.4 | 0.0 | 0.6 | 0.1 | |
| | 2011 | 6 | 1.2 | 0.2 | 0.1 | 0.3 | 0.2 | 0.1 | 0.1 | 0.0 | 0.2 | 2.6 | 0.1 | 0.8 | 0.1 | |
| | 2016 | 6 | 1.2 | 0.2 | 0.1 | 0.4 | 0.2 | 0.1 | 0.1 | 0.0 | 0.2 | 2.7 | 0.1 | 0.8 | 0.2 | |
| | 2021 | 6 | 1.2 | 0.2 | 0.1 | 0.4 | 0.2 | 0.1 | 0.1 | 0.0 | 0.2 | 2.7 | 0.1 | 0.8 | 0.2 | |
| | 2026 | 6 | 1.2 | 0.2 | 0.1 | 0.4 | 0.2 | 0.1 | 0.1 | 0.0 | 0.2 | 2.7 | 0.1 | 0.8 | 0.2 | |
| Warehouse/ Wholesale | 2006 | 9 | 2.1 | 0.3 | 0.2 | 0.2 | 0.4 | 0.0 | 0.7 | 0.0 | 0.1 | 4.6 | 0.0 | 0.6 | 0.2 | |
| | 2011 | 10 | 2.3 | 0.3 | 0.2 | 0.2 | 0.4 | 0.0 | 0.7 | 0.0 | 0.1 | 5.0 | 0.0 | 0.6 | 0.2 | |
| | 2016 | 11 | 2.4 | 0.3 | 0.2 | 0.2 | 0.4 | 0.1 | 0.8 | 0.0 | 0.1 | 5.2 | 0.0 | 0.7 | 0.2 | |
| | 2021 | 11 | 2.5 | 0.3 | 0.2 | 0.3 | 0.5 | 0.1 | 0.8 | 0.0 | 0.1 | 5.3 | 0.0 | 0.7 | 0.3 | |
| | 2026 | 11 | 2.5 | 0.3 | 0.2 | 0.3 | 0.5 | 0.1 | 0.9 | 0.0 | 0.1 | 5.5 | 0.0 | 0.7 | 0.3 | |
| Small Commercial | 2006 | 36 | 8.5 | 1.6 | 0.8 | 1.4 | 0.7 | 0.5 | 2.2 | 0.0 | 0.3 | 16.1 | 0.3 | 2.6 | 1.4 | |
| | 2011 | 41 | 9.2 | 1.7 | 0.9 | 1.6 | 0.8 | 0.6 | 2.4 | 0.0 | 0.3 | 17.9 | 0.5 | 3.1 | 1.6 | |
| | 2016 | 43 | 9.4 | 1.7 | 1.0 | 1.8 | 0.9 | 0.6 | 2.6 | 0.0 | 0.4 | 18.7 | 0.5 | 3.3 | 1.7 | |
| | 2021 | 44 | 9.5 | 1.8 | 1.1 | 1.9 | 0.9 | 0.7 | 2.7 | 0.0 | 0.4 | 19.6 | 0.6 | 3.6 | 1.7 | |
| | 2026 | 46 | 9.7 | 1.8 | 1.1 | 2.1 | 1.0 | 0.7 | 2.8 | 0.0 | 0.4 | 20.5 | 0.7 | 3.8 | 1.8 | |
| Other Buildings | 2006 | 22 | 5.2 | 0.9 | 0.5 | 0.3 | 0.1 | 0.4 | 0.3 | 0.0 | 0.2 | 11.4 | 0.1 | 2.2 | 0.5 | |
| | 2011 | 24 | 5.4 | 0.9 | 0.6 | 0.3 | 0.1 | 0.4 | 0.3 | 0.0 | 0.2 | 12.2 | 0.1 | 2.4 | 0.5 | |
| | 2016 | 25 | 5.5 | 0.9 | 0.6 | 0.4 | 0.1 | 0.4 | 0.4 | 0.0 | 0.2 | 12.7 | 0.1 | 2.5 | 0.5 | |
| | 2021 | 25 | 5.6 | 0.9 | 0.7 | 0.4 | 0.1 | 0.4 | 0.4 | 0.0 | 0.3 | 13.2 | 0.1 | 2.7 | 0.6 | |
| | 2026 | 26 | 5.7 | 0.9 | 0.7 | 0.4 | 0.2 | 0.5 | 0.4 | 0.0 | 0.3 | 13.8 | 0.1 | 2.8 | 0.6 | |
| Non Buildings | 2006 | 7 | | | | | | | | | | | | | | |
| | 2011 | 8 | | | | | | | | | | | | | | |
| | 2016 | 8 | | | | | | | | | | | | | | |
| | 2021 | 9 | | | | | | | | | | | | | | |
| | 2026 | 9 | | | | | | | | | | | | | | |
| Other Institutional Buildings | 2006 | 39 | 10.7 | 3.8 | 1.2 | 1.0 | 1.7 | 0.5 | 1.5 | 0.0 | 0.7 | 8.4 | 0.2 | 6.9 | 2.0 | |
| | 2011 | 39 | 10.4 | 3.7 | 1.2 | 1.1 | 1.8 | 0.5 | 1.5 | 0.0 | 0.7 | 8.9 | 0.2 | 6.9 | 2.1 | |
| | 2016 | 39 | 10.2 | 3.7 | 1.2 | 1.1 | 1.9 | 0.5 | 1.5 | 0.0 | 0.7 | 9.4 | 0.2 | 6.9 | 2.3 | |
| | 2021 | 40 | 9.9 | 3.6 | 1.2 | 1.1 | 1.9 | 0.5 | 1.5 | 0.0 | 0.7 | 9.9 | 0.2 | 6.9 | 2.4 | |
| | 2026 | 40 | 9.7 | 3.5 | 1.2 | 1.2 | 2.0 | 0.5 | 1.5 | 0.0 | 0.7 | 10.4 | 0.2 | 6.9 | 2.5 | |
| Streetlighting | 2006 | 2 | | | | | | | | | | | | | | 1.6 |
| | 2011 | 2 | | | | | | | | | | | | | | 1.6 |
| | 2016 | 2 | | | | | | | | | | | | | | 1.6 |
| | 2021 | 2 | | | | | | | | | | | | | | 1.6 |
| | 2026 | 2 | | | | | | | | | | | | | | 1.6 |
| Total | 2006 | 201 | 44 | 13 | 5 | 6 | 5 | 4 | 10 | 0 | 2 | 74 | 1 | 20 | 9 | 2 |
| | 2011 | 220 | 46 | 14 | 5 | 7 | 6 | 4 | 11 | 0 | 2 | 82 | 2 | 22 | 10 | 2 |
| | 2016 | 227 | 46 | 14 | 6 | 8 | 6 | 4 | 11 | 0 | 2 | 85 | 2 | 23 | 10 | 2 |
| | 2021 | 233 | 46 | 14 | 6 | 8 | 7 | 4 | 12 | 0 | 2 | 88 | 2 | 23 | 10 | 2 |
| | 2026 | 240 | 47 | 14 | 6 | 9 | 7 | 4 | 12 | 0 | 3 | 91 | 2 | 24 | 11 | 2 |

*Note: Any differences in totals are due to rounding.*

[19] Results are measured at the customer's point-of-use and do not include line losses. This chart presents percentage of electricity consumption by end use for buildings only; the sub sector Non-Buildings is included in the total load, but is not broken down by end use.

# 4. CONSERVATION & DEMAND MANAGEMENT (CDM) MEASURES

## 4.1 INTRODUCTION

This section identifies and assesses the economic attractiveness of the selected energy-efficiency and peak load reduction measures for the Commercial sector. The discussion is organized and presented as follows:

- Methodology for assessment of energy-efficiency measures
- Description of energy-efficiency measures
- Summary of energy-efficiency results
- Peak load reduction measures.

## 4.2 METHODOLOGY FOR ASSESSMENT OF ENERGY-EFFICIENCY MEASURES

The following steps were employed to assess the energy-efficiency measures:

- Select candidate energy-efficiency measures
- Establish technical performance for each option within a range of applicable load sizes and/or service region conditions (e.g., degree days)
- Establish the capital, installation and operating costs for each option
- Calculate the cost of conserved energy (CCE) for each measure.

A brief discussion of each step is outlined below.

***Step 1 Select Candidate Measures***

The candidate measures were selected in close collaboration with the Utilities' personnel and from a literature review and previous study team experience. The selected measures are all considered to be technically proven and commercially available, even if only at an early stage of market entry. Technology costs, which will be addressed in this section, were not a factor in the initial selection of candidate technologies.

***Step 2 Establish Technical Performance***

Information on the performance improvements provided by each measure was compiled from available secondary sources, including the experience and on-going research work of study team members.

***Step 3 Establish Capital, Installation and Operating Costs for Each Measure***

Information on the cost of implementing each measure was also compiled from secondary sources, including the experience and on-going research work of study team members.

The incremental cost is applicable when a measure is installed in a new facility, or at the end of its useful life in an existing facility; in this case, incremental cost is defined as the cost difference for the energy-efficiency measure relative to the "baseline" technology. The full cost is applicable when an operating piece of equipment is replaced with a more efficient model prior to the end of its useful life.

In both cases, the costs and savings are annualized, based on the number of years of equipment life and the discount rate, and the costs incorporate applicable changes in annual O&M costs. All costs are expressed in constant (2007) dollars.

***Step 4 Calculate CCE for Each Measure***

One of the important sets of information provided in this section is the CCE associated with each energy-efficiency measure. The CCE for an energy-efficient measure is defined as the annualized incremental cost of the upgrade measure divided by the annual energy savings achieved, excluding any administrative or program costs required to achieve full use of the technology or measure. All cost information presented in this section and in the accompanying tables (see Appendix B) are expressed in constant (2007) dollars.

The CCE provides a basis for the subsequent selection of measures to be included in the Economic Potential Forecast (see Section 5.0). The CCE is calculated according to the following formula:

$$\frac{C_A + M}{S}$$

Where:

$C_A$ is the annualized installed cost
$M$ is the incremental annual cost of O&M
$S$ is the annual kWh energy savings.

And $A$ is the annualization factor.

Where: $$A = \frac{i(1+i)^n}{(1+i)^n - 1}$$

$i$ is the discount rate
$n$ is the life of the measure.

The detailed CCE tables (see Appendix B) show both "incremental" and "full" installed costs for the energy-efficiency measures, as applicable. If the measure or technology is installed in a new facility, or at the point of natural replacement in an existing facility, then the "incremental" cost of the measure versus the cost of the baseline technology is used.

If, prior to the end of its life, an operating piece of equipment is replaced with a more efficient model, then the "full" cost of the measure is used. In both cases, the costs of the measures are annualized, based on the number of years of equipment life and the discount rate, and the costs incorporate applicable changes in annual O&M costs.

The annual saving associated with the efficiency measure is the difference in annual electricity consumption with and without the measure.

The CCE calculation is sensitive to the chosen discount rate. In the CCE calculations, three discount rates are shown: 4%, 6% and 8%. Based on the Utilities' recommendation, the 6% (net-of-inflation) discount rate was used for the primary CCE calculation[20]. The CCEs were also calculated using the 4% and 8% discount rates to provide the sensitivity analysis.

Selection of the appropriate discount rate for this analysis was guided by the intended use of the study results. This study seeks to identify the economic potential for CDM in Newfoundland and Labrador from a provincial perspective. Therefore, the appropriate discount rate is the social opportunity cost of capital, which is the estimated average pre-tax rate of return on public and private investments in the provincial economy.

## 4.3 DESCRIPTION OF ENERGY-EFFICIENCY MEASURES

The list of energy-efficiency measures and technologies considered in this study is presented in Exhibit 4.1 below.

**Exhibit 4.1: Energy-efficiency Measures and Technologies - Commercial Sector**

**Lighting**
- Standard T8 systems
- Low ballast-factor T8 systems
- High-performance T8 systems
- Fully integrated lighting and control systems
- Lighting redesign
- Occupancy sensors
- Induction lamps
- Compact fluorescents lamps
- White LED lamps
- Halogen infrared lamps
- Ceramic metal halide lamps
- LED exit signs
- Pulse-start metal halide systems
- T5 high-intensity fluorescent systems

**Heating, Ventilating, and Air-Conditioning**
- Low-temperature air source heat pumps
- Ground source heat pumps
- Water loop heat pumps
- Infrared heaters
- High-efficiency chillers
- High-efficiency rooftop AC units
- Adjustable speed drives
- Premium efficiency motors
- Advanced building automation systems
- Building recommissioning
- Advanced building automation systems
- Programmable thermostats

**Refrigeration**
- ENERGY STAR refrigerators & freezers
- High-efficiency supermarket refrigeration

**Domestic Hot Water**
- Low-flow faucet aerators and shower heads
- Grey water heat recovery
- Tankless water heaters
- Heat pump water heaters

**Computer Equipment**
- ENERGY STAR computers
- ENERGY STAR office equipment
- Energy-efficient server technologies

**Building Envelope**
- High-performance glazing systems
- Upgrade wall insulation
- Upgrade roof insulation
- Air curtains

**New Construction**
- New construction - 25% more efficient
- New construction - 40% more efficient

**Street Lighting**
- Electrodeless induction lighting
- Dimming controls

[20] This discount rate allows for analytic consistency with the earlier NERA Marginal Cost Study, which used a nominal discount rate of 8.4% (approximately 6% real, i.e. net of inflation). NLH lowered its nominal discount rate in the summer of 2007 to 7.75%; however, this change has no material impact on the results of this study.

Energy-efficiency improvement opportunities are presented along with a brief description of the technology, savings relative to the baseline, typical installed costs, applicability and co-benefits. A detailed list of the results of the economic assessment of all measures is provided in Exhibit 4.2. The discussion of measures is organized by end use and sub sector.[21]

The following subsections provide a summary of the results of the technical and economic analysis of each measure. The measures are organized and presented according to the format in which they were evaluated. Refer to Appendix B for details and assumptions related to the analyses.

### 4.3.1 Lighting

The discussion of the analysis of lighting measures is organized by major lighting type and presented as follows:

- Fluorescent lighting upgrades
- Incandescent lighting upgrades
- High-intensity discharge (HID) lighting upgrades.

#### ❑ Fluorescent Lighting Upgrades

Fluorescent lighting in the commercial building stock is typically a mix of T12 magnetic and T8 electronic fluorescent lighting systems. The study therefore considered upgrades to both T12 and T8 fluorescent systems.

***T12 Fluorescent Upgrades***

Six energy-efficiency upgrade measures were evaluated for T12 lighting systems:

- Standard T8 lighting systems
- Low ballast factor T8 lighting systems
- High-performance T8 lighting systems
- Redesign with standard T8 lighting systems
- Redesign with high-performance T8 lighting systems
- Redesign with fully integrated lighting and control systems.

These measures are applicable to existing buildings with T12 lighting since new buildings are generally illuminated with T8 systems. Each measure was evaluated at 3,000 hours of operation and on both a full cost and incremental cost basis. The baseline technology used for the analysis is a standard fluorescent fixture equipped with two 34-Watt T12 lamps and magnetic ballast.

[21] Measure inputs not otherwise sourced are based on the consultants' recent work with BC Hydro and other utility clients.

- **Standard T8 Lighting Systems**

| Measure Profile | |
|---|---|
| Applicable Building Types | All |
| Vintage | Existing |
| Costs | Full $41/fixture; incremental $0 |
| Savings | 26% of lighting energy |
| Useful Life | 16 years |

Replacing existing T12 technology with T8 lamps and electronic ballasts reduces the connected lighting load for a two-lamp fixture from 80 Watts to 59 Watts, representing a savings of 26% over the baseline T12 systems. This measure typically results in increased light levels.

- **Low Ballast Factor T8 Lighting Systems**

| Measure Profile | |
|---|---|
| Applicable Building Types | All |
| Vintage | Existing |
| Costs | Full $41/fixture; incremental $0 |
| Savings | 36% of lighting energy |
| Useful Life | 16 years |

Similarly, replacing existing T12s with T8 lamps and low ballast factor electronic ballasts further reduces the connected lighting load for a two-lamp fixture from 80 Watts to 51 Watts, representing a savings of 36% over the baseline T12 systems, while providing an equivalent amount of light.

- **High-performance T8 Lighting Systems**

| Measure Profile | |
|---|---|
| Applicable Building Types | All |
| Vintage | Existing |
| Costs | Full $50/fixture; incremental $9/fixture |
| Savings | 39% of lighting energy |
| Useful Life | 16 years |

High-performance T8 lighting systems operate with an efficacy of 100 lumens per Watt and have a longer lamp life than standard T8 systems. For example, Sylvania's "Xtreme" system, with two high-performance T8 lamps, consumes 49 Watts per fixture, representing a savings of 39% over T12s, while providing the same light output.

- **Redesign with Standard T8 Lighting Systems**

| Measure Profile | |
|---|---|
| Applicable Building Types | All |
| Vintage | Existing |
| Costs | Full $1.58/ft$^2$; incremental $0.62/ft$^2$ |
| Savings | 54% of lighting energy |
| Useful Life | 16 years |

Some existing buildings are over-illuminated compared to current Illuminating Engineering Society of North America (IESNA) guidelines. The combination of lighting redesign to lower light levels and standard T8 lighting systems results in savings of 54% and a lower incremental cost (due to a requirement for fewer fixtures) relative to baseline T12 systems.

- **Redesign with High-performance T8 Lighting Systems**

| Measure Profile | |
|---|---|
| Applicable Building Types | All |
| Vintage | Existing |
| Costs | Full $1.72/ft$^2$; incremental $0.48/ft$^2$ |
| Savings | 62% of lighting energy |
| Useful Life | 16 years |

The combination of lighting redesign to lower light levels and next generation T8 lighting systems results in savings of 62% and a lower incremental cost (due to fewer fixtures) relative to baseline T12 systems.

- **Redesign with Fully Integrated Lighting and Control Systems**

| Measure Profile | |
|---|---|
| Applicable Building Types | Office |
| Vintage | Existing |
| Costs | Full $6.67/ft$^2$; incremental $4.47/ft$^2$ |
| Savings | 65% of lighting energy |
| Useful Life | 16 years |

In a typical configuration, an integrated lighting and control system features a pendant-mounted three-lamp T8 direct/indirect fixture and integrated controls including occupancy, daylight dimming and personal controls. One lamp illuminates the ceiling, while two down lamps illuminate the work surface. Occupancy sensors control the down lamps to reduce their operating hours, while daylight sensors provide dimming. Using a networked computer, individuals can adjust the light levels at their workstation. The system can also be centrally controlled in response to time-of-day schedules and peak load signals.

Fully integrated lighting and control systems can achieve savings of 65% relative to the T12 baseline and are primarily applicable to office environments.

### *T8 Fluorescent Upgrades*

Four energy-efficiency upgrade measures were evaluated for standard T8 lighting systems:

- High-performance T8 lighting systems
- Redesign with high-performance T8 lighting systems
- Redesign with fully integrated lighting and control systems
- Occupancy sensors.

These measures are applicable to both existing buildings and new construction and were evaluated at 3,000 hours of operation and on both a full cost and incremental cost basis. The baseline technology used for the analysis is a standard fluorescent fixture equipped with two 32-Watt T8 lamps and electronic ballast.

#### ❑ High-performance T8 Lighting Systems

| Measure Profile | |
|---|---|
| Applicable Building Types | All |
| Vintage | Existing & new |
| Costs | Full \$50/fixture; incremental \$9/fixture |
| Savings | 17% of lighting energy |
| Useful Life | 16 years |

This upgrade technology is the same as previously described in the T12 upgrades discussion above. In this case, however, the savings are 17% relative to the baseline standard T8 systems.

#### ❑ Redesign with High-performance T8 Lighting Systems

| Measure Profile | |
|---|---|
| Applicable Building Types | All |
| Vintage | Existing & new |
| Costs | Full \$1.73/ft$^2$; incremental \$0.01/ft$^2$ |
| Savings | 48% of lighting energy |
| Useful Life | 16 years |

This technology upgrade is the same as previously described in the T12 upgrades discussion above. In this case, however, the savings are 48% relative to the baseline standard T8 systems.

- **Redesign with Fully Integrated Lighting and Control Systems**

| **Measure Profile** | |
|---|---|
| Applicable Building Types | All |
| Vintage | Existing & new |
| Costs | Full \$6.67/ft$^2$; incremental \$4.95/ft$^2$ |
| Savings | 53% of lighting energy |
| Useful Life | 16 years |

This technology upgrade is the same as previously described in the T12 upgrades discussion above. In this case, however, the savings are 53% relative to the baseline standard T8 systems.

- **Occupancy Sensors**

| **Measure Profile** | |
|---|---|
| Applicable Building Types | All |
| Vintage | Existing & new |
| Costs | Full \$70/switch; incremental \$48/switch |
| Savings | 30% of lighting energy |
| Useful Life | 10 years |

This upgrade consists of replacing a standard wall switch with passive infrared (PIR) sensors. Standard applications include spaces with variable occupancy patterns including offices, corridors, washrooms and utility spaces. There are two general types of occupancy sensors available in the market: ultrasonic sensors, which use an inaudible high frequency sound wave to sense movement, and PIR sensors, which sense heat radiated from the human body. Sensors are generally mounted on walls or ceilings, depending on the desired area of coverage. The full cost is estimated to be \$70 per switch, the savings are estimated to be 30% of lighting energy and the service life is estimated to be 10 years.

### 4.3.2 Incandescent Lighting Upgrades

Incandescent lighting is typically used in architectural, display, task and signage applications and is commonly found in lobbies, corridors, utility spaces, hotel rooms, retail spaces and restaurants.

Six energy-efficiency upgrade measures were evaluated for incandescent lighting:

- Compact fluorescent lamp
- Electrodeless induction lamp
- White LED lamp
- Halogen infrared PAR lamp
- Ceramic metal halide PAR lamp
- LED exit sign.

These upgrade options are applicable to both existing buildings and new construction and were evaluated at 3,000 hours of operation per year and on both a full cost and incremental cost basis (except where noted). The baseline technologies used for the analysis include the following:

- 65 W incandescent reflector lamp
- 75 W halogen PAR 38 lamp
- 30 W incandescent exit sign.

❑ **Compact Fluorescent Lamp**

| **Measure Profile** | |
|---|---|
| Applicable Building Types | All |
| Vintage | Existing & new |
| Costs | Full $22/lamp; incremental $17/lamp |
| Savings | 69% of lighting energy |
| Useful Life | 3 years |

This upgrade is a CFL that displays 785 lumens and has a full cost of $22. Relamping a 65-Watt incandescent reflector flood with this upgrade results in savings of 69% while producing an equivalent amount of light. In addition, CFLs have a life of 10,000 hours compared to the shorter life of incandescent lamps, providing additional benefits in the form of lower maintenance and lamp replacement costs.

❑ **Electrodeless Induction Lamp**

| **Measure Profile** | |
|---|---|
| Applicable Building Types | Office, Retail, Accommodations |
| Vintage | Existing & new |
| Costs | Full $43/lamp; incremental $38/lamp |
| Savings | 65% of lighting energy |
| Useful Life | 5 years |

Electrodeless lamps are discharge lamps like fluorescents, but use magnetic induction to generate an electric field rather than a voltage drop across a pair of electrodes.

This upgrade is 23-Watt electrodeless induction lamp that displays 1,100 lumens and has a full cost of $43. Similar to a CFL and without electrodes, the self-ballasted reflector lamp is a direct replacement for incandescent reflector lamps. It has a high colour rendering index (CRI); however, one limitation is that the lamp cannot be dimmed.

Relamping a 65-Watt incandescent reflector flood with this upgrade results in savings of 65% while producing the equivalent amount of light. In addition, electrodeless induction lamps currently have a life of 15,000 hours compared to the shorter life of incandescent lamps, providing additional benefits in the form of lower maintenance and lamp replacement costs.

- **White LED Lamp**

| Measure Profile | |
|---|---|
| Applicable Building Types | Office, Retail, Accommodations |
| Vintage | Existing & new |
| Costs | Full $43/lamp; incremental $38/lamp |
| Savings | 75% of lighting energy |
| Useful Life | 12 years |

This upgrade is a white light-emitting diode (LED) array that displays 800 lumens at 50 lumens per Watt and has a full cost of $43. Relamping a 65-Watt incandescent reflector lamp with this upgrade results in savings of 75% while producing an equivalent amount of light. In addition, white LEDs currently have a life of 35,000 hours compared to the shorter life of incandescent lamps, providing additional benefits in the form of lower maintenance and lamp replacement costs. However, this technology is in the early stages of market entry and therefore improvements to the technology in terms of cost and efficacy should be expected in the coming years.

- **Halogen IR PAR Lamp**

| Measure Profile | |
|---|---|
| Applicable Building Types | Retail, Office, Accommodations |
| Vintage | Existing & new |
| Costs | Full $15/lamp; incremental $6/lamp |
| Savings | 33% of lighting energy |
| Useful Life | 1.5 years |

This upgrade is a 50-Watt halogen infrared (IR) lamp that displays 970 lumens and has a full cost of $15. Relamping a 75-Watt halogen PAR 38 with this upgrade results in savings of 33% while producing an equivalent amount of light. In addition, halogen IR lamps have a life of 4,200 hours compared to the shorter life of halogen lamps, providing additional benefits in the form of lower maintenance and lamp replacement costs.

- **Ceramic MH PAR Lamp**

| Measure Profile | |
|---|---|
| Applicable Building Types | Retail, Office, Accommodations |
| Vintage | Existing & new |
| Costs | Full $38/lamp; incremental $29/lamp |
| Savings | 53% of lighting energy |
| Useful Life | 3.5 years |

This upgrade is a 25-Watt integrated ceramic metal halide (MH) lamp/ballast that displays 1,200 initial lumens and has a full cost of $38. Relamping a 75-Watt halogen PAR 38 with this technology results in savings of 53% while producing an equivalent amount of light. In addition, ceramic MH lamps have a life of 10,500 hours compared to the shorter life of halogen lamps, providing additional benefits in the form of lower maintenance and lamp replacement costs.

- **LED Exit Sign**

| Measure Profile | |
|---|---|
| Applicable Building Types | All |
| Vintage | Existing |
| Costs | Full $70/fixture |
| Savings | 93% of lighting energy |
| Useful Life | 11 years |

This upgrade is a 2-Watt LED exit sign that has a full cost of $70. Replacing a 30-Watt incandescent exit sign with this upgrade results in savings of 93% while producing an equivalent amount of light. In addition, LED exit signs have a life of 100,000 hours compared to the shorter life of incandescent lamps, providing additional benefits in the form of lower maintenance and lamp replacement costs. This upgrade is applicable to the existing building stock since incandescent exit signs are no longer available for sale in Canada. This measure was therefore evaluated on a full-cost basis at 8,760 hours per year.

### 4.3.3 High-intensity Discharge Lighting Upgrades

High-intensity discharge (HID) lighting such as metal halide is commonly used to illuminate high-ceilinged spaces such as warehouses, retail stores and gymnasiums and in outdoor lighting applications.

Two energy-efficiency upgrade options were evaluated for HID lighting:

- Pulse-start metal halide
- T5 high-intensity fluorescent.

These upgrade options are applicable to both existing buildings and new construction and were evaluated at 3,000 hours of operation and on both a full cost and incremental cost basis. The baseline technology for high-bay lighting is a standard 400-Watt metal halide high-bay fixture.

- **Pulse-start Metal Halide**

| Measure Profile | |
|---|---|
| Applicable Building Types | All buildings, outdoor and roadway lighting |
| Vintage | Existing & new |
| Costs | Full $325/fixture; incremental $10/fixture |
| Savings | 21% of lighting energy |
| Useful Life | 16 years |

This upgrade is a pulse-start metal halide high-bay luminaire featuring a 320-Watt lamp, 40-Watt ballast, 26,000 mean lumens, service life of 20,000 hours and a full cost of $325. Compared to traditional metal halides, a change in the lamp and ballast construction allows pulse-start metal halide lamps to start using a high-voltage ignitor in the ballast instead of a starting electrode in the lamp. The result is high lumen output, less lumen degradation, improved colour uniformity and quick start capabilities.

Replacing a standard 400-Watt metal halide luminaire with this upgrade results in savings of 21% while producing an equivalent amount of light. Pulse-start metal halide systems can be used for all traditional metal halide applications including high-bay, outdoor and roadway lighting.

- **T5 High-intensity Fluorescent**

| **Measure Profile** | |
|---|---|
| Applicable Building Types | Warehouse, Retail, School |
| Vintage | Existing & new |
| Costs | Full $350/fixture; incremental $35/fixture |
| Savings | 53% of lighting energy |
| Useful Life | 16 years |

This upgrade is a high-intensity fluorescent fixture equipped with four F54T5 high-output lamps and an occupancy sensor. This luminaire draws 239 Watts and displays 20,000 initial lumens, has a 20,000-hour lamp life and a full cost of $350.

Improvements in fluorescent lamps and the emergence of high-intensity fluorescent fixtures has made fluorescent lighting the most cost-effective choice for lighting high indoor spaces. These high-intensity fluorescent systems are more energy efficient than traditional HID fixtures and feature lower lumen depreciation, occupancy control, dimming options, instant start-up and better colour rendition.

Replacing a standard 400-Watt metal halide luminaire with this upgrade results in savings of 53% while producing an equivalent amount of light.

### 4.3.3 Heating, Ventilating and Air conditioning

Eleven energy-efficiency upgrade measures were evaluated for building heating, ventilating and air conditioning (HVAC) systems:

- Low-temperature heat pumps
- Ground source heat pumps
- Water loop heat pumps
- Infrared heaters
- High-efficiency chillers
- High-efficiency rooftop AC units
- Adjustable speed drives
- Premium efficiency motors
- Building recommissioning
- Advanced building automation systems
- Programmable thermostats.

As applicable, HVAC upgrade measures were evaluated at both low and high heating/cooling loads to reflect the range of building types and climate regions found in Newfoundland and Labrador.

- **Low-temperature Air Source Heat Pumps**

| Measure Profile | |
|---|---|
| Applicable Building Types | Small Commercial |
| Vintage | Existing and new |
| Costs | $1.80 to $2.50/ft$^2$ incremental cost |
| Savings | 56% to 59% of space heating and cooling energy |
| Useful Life | 15 years |

When outdoor air temperatures drop below freezing, standard air source heat pump systems switch to auxiliary electric resistance heaters to meet the space heating requirements. This limitation has served to minimize the penetration of air source heat pumps in cold climates. However, a low-temperature air source heat pump (LTHP) developed by Hallowell International[22] is capable of operating at 0°F with a coefficient of performance (COP) of greater than 2. At this temperature, standard air source heat pumps operate less efficiently, produce less than half their rated capacity and rely primarily on backup electric resistance heaters to maintain comfort.

The LTHP features a two-speed, two-cylinder compressor for efficient operation, a back-up booster compressor that allows the system to operate efficiently down to 15ºF and a plate heat exchanger called an “economizer” that further extends the performance of the heat pump to well below 0ºF.

This measure involves upgrading a standard HVAC system with an equivalent LTHP system. The target market is both residential and small commercial buildings and the baseline is electric- resistance heating and direct expansion cooling. This technology is applicable to existing buildings (at the end of HVAC life cycle) and new construction. The incremental cost ranges between $1.80 and $2.50 per square foot, the savings range between 56% and 59% of space heating and cooling energy and the service life is 15 years.

Currently, the LTHP is available only as a 3.0 and 3.5 ton split system, however Hallowell International expects to launch an expanded product line targeting the commercial market, including a packaged rooftop heat pump and a packaged terminal heat pump (PTHP) as early as 2008.[23]

[22] http://www.gotohallowell.com.
[23] Conversation with James Bryant of Hallowell International. September 2007.

## ❑ Ground Source Heat Pumps

| Measure Profile | |
|---|---|
| Applicable Building Types | All |
| Vintage | Existing & new |
| Costs | $4.90/ft$^2$ incremental cost |
| Savings | 61% to 64% of heating & cooling energy |
| Useful Life | 20 years |

Ground source heat pump (GSHP) systems are more efficient than conventional heat pump systems, with higher COPs and EERs. GSHPs also replace the need for a boiler in winter by utilizing heat stored in the ground; this heat is upgraded by a vapour-compressor refrigeration cycle. In summer, heat from a building is rejected to the ground, eliminating the need for a cooling tower or a heat rejector. They also lower operating costs because the ground is cooler than the outdoor air.

Water-to-air heat pumps are typically installed throughout a building with duct work serving only the immediate zone; a two-pipe water distribution system conveys water to and from the ground source heat exchanger. The heat exchanger field consists of a grid of vertical boreholes with plastic u-tube heat exchangers connected in parallel.

This measure involves upgrading a standard HVAC system with a GSHP system and is applicable to existing buildings (at the end of HVAC life cycle) and new construction. The baseline is a commercial building with standard electric resistance heating and direct expansion cooling. The incremental cost is $4.90 per square foot, the savings range between 61% and 64% of heating and cooling energy and the service life is 20 years.

## ❑ Water Loop Heat Pumps

Water loop heat pump systems, also known as California heat pump systems, consist of several individual water source heat pumps installed in multiple building zones and connected to a single water loop. Each heat pump adds or removes heat from the circulating water as required. Heat pump loop systems are typically used in large buildings requiring concurrent heating and cooling in different zones, where they are used to recover heat from some zones and deliver it to others. When internal heat gains are insufficient to meet the heating load on the perimeter, an electric boiler would provide the necessary supplementary heating. Disadvantages include a high initial cost and maintenance costs.

Given the heating dominated climate and relatively small internal heat gains in most buildings, and consequently the requirement for supplemental electric heating, water loop heat pumps are unlikely to have significant market uptake in Newfoundland and Labrador and will not be considered any further in this study.

### ❑ Infrared Heaters

| Measure Profile | |
|---|---|
| Applicable Building Types | Warehouse |
| Vintage | Existing & new |
| Costs | Full & incremental cost $750/heater |
| Savings | 14% of space heating energy |
| Useful Life | 10 years |

Radiant infrared heaters can be used as primary heating sources or in applications where supplementary or spot heating is required. Radiant heating systems offer energy savings because building occupants feel comfortable at lower air temperatures in radiantly heated spaces.

This measure involves using infrared heaters to provide supplementary spot heating and maintaining a lower ambient air temperature in the space. It is applicable to both existing buildings and new construction and the baseline is a Warehouse heated with standard electric resistance heating. The cost is estimated to be $750 per heater, the savings are 14% of space heating energy and the service life is 10 years.

### ❑ High-efficiency Chillers

| Measure Profile | |
|---|---|
| Applicable Building Types | Large Commercial/Institutional |
| Vintage | Existing & new |
| Costs | 25% incremental cost |
| Savings | 29% of space cooling |
| Useful Life | 25 years |

High-efficiency chillers feature oil-free centrifugal compressors, magnetic bearings and variable speed drives to deliver better integrated part-load value (IPLV) efficiencies than conventional oil-lubricated centrifugal, scroll and screw compressors.

This measure involves upgrading a standard efficiency chiller with a high-efficiency chiller and is applicable to both existing buildings (at end of chiller life cycle) and new construction. The baseline is a large commercial building cooled with a standard efficiency chiller. The incremental cost is 25%, the savings are 29% of space cooling energy and the service life is 25 years.

### ❑ High-efficiency Rooftop AC Units

| Measure Profile | |
|---|---|
| Applicable Building Types | All |
| Vintage | Existing & new |
| Costs | 20% incremental cost |
| Savings | 24% of space cooling energy |
| Useful Life | 15 years |

Packaged rooftop air conditioning units dominate the market for small and medium low-rise buildings accounting for the majority of the space cooling energy in the Commercial sector. The most common sizes are 5 to 20 ton units. Rooftops are often purchased and installed to minimize first cost, with little consideration of energy and operating costs. High-efficiency rooftop units featuring more efficient compressors, fans, heat exchangers and controls are available on the market with EERs as high as 13.5.

This measure involves upgrading a standard packaged rooftop unit with an equivalent high-efficiency unit. It is applicable to both existing buildings (at end of rooftop life cycle) and new construction. The baseline is a commercial building cooled with standard packaged rooftop air conditioning units with a rated EER of 10.3. The incremental cost is estimated to be 20% more than a conventional rooftop air conditioner and the savings are 24% of space cooling energy. The cost of high-efficiency units is likely to reduce over the coming years as the market matures. The service life is estimated to be 15 years.

- **Adjustable Speed Drives**

| **Measure Profile** | |
|---|---|
| Applicable Building Types | Medium and Large Commercial |
| Vintage | Existing & new |
| Costs | Full cost of $2,750 (10-HP) |
| Savings | 30% of fan energy |
| Useful Life | 10 years |

Adjustable speed drives (ASD) allow induction motor-driven loads such as fans and pumps to operate in response to varying load requirements. ASDs increase efficiency, improve power factor and provide precise control.

This measure involves upgrading a motor-driven centrifugal fan with an ASD and controlling the speed of the fan in response to variable load requirements. It is applicable to both existing buildings and new construction and the baseline is a centrifugal fan equipped with inlet vanes operating at an average of 80% capacity. The full cost is estimated to be $2,750, the savings are 30% of fan motor energy and the service life is estimated to be 10 years.

- **Premium Efficiency Motors**

| **Measure Profile** | |
|---|---|
| Applicable Building Types | All |
| Vintage | Existing & new |
| Costs | 20% incremental cost |
| Savings | 1.4% |
| Useful Life | 10 years |

Premium efficiency motors typically have reduced losses of 10%-40%, thereby increasing motor efficiency by 1% to 10%.[24] In a retrofit situation, it is considered best

[24] BC Hydro. *Power Smart Tips & Practices*.

practice to replace failed motors with new premium efficiency motors rather than rewind them since motor rewinding often degrades motor efficiency by 1% to 3%.

This measure involves upgrading an induction motor with an equivalent premium efficiency motor. It is applicable to both existing buildings (at end of motor life cycle) and new construction. The baseline is a standard efficiency induction motor. The incremental cost is estimated to be 20% relative to a standard efficiency motor, the savings are 1.4% and the service life is 10 years.

- **Building Recommissioning**

| **Measure Profile** | |
|---|---|
| Applicable Building Types | All |
| Vintage | Existing |
| Costs | Full cost of $0.60/ft$^2$ |
| Savings | 20% of HVAC energy use |
| Useful Life | 5 years |

Recommissioning is a quality assurance process for ensuring that a building's complex array of mechanical and electrical systems is operated to perform according to the design intent and current operational needs of the building. The process generally involves monitoring and simulation of building systems to gain a thorough understanding of current operation and possibilities for optimization. Energy savings generally result from equipment repairs, air and water rebalancing and control optimization.

Recommissioning is applicable to existing buildings only. The baseline is a typical Office building with an electricity intensity of 26 kWh/ft$^2$yr. The full cost is estimated to be $0.60/ft$^2$, the savings are 20% of HVAC energy use and the service life is 5 years.

- **Advanced Building Automation Systems**

| **Measure Profile** | |
|---|---|
| Applicable Building Types | All |
| Vintage | Existing |
| Costs | Full cost of $0.90/ft$^2$ |
| Savings | 10% of total energy use |
| Useful Life | 10 years |

Advanced building automation systems (BAS) are able to automatically detect anomalies in building operations and can automate building diagnostics as well. These systems typically take data on how energy systems are performing in a building, analyze them using logic and physical modelling to detect deviations from expected performance and use built-in logic to suggest the cause of the deviation.[25] In addition, advanced BAS have improved predictive, self-tuning control algorithms that help to minimize the need for bypass or override of the BAS. Energy savings generally result from re-instituting

[25] E Source E News. *Automated Building Diagnostics: Improving Electricity Performance and Occupant Comfort.* ER-01. November 18, 2001.

equipment scheduling, expanded control to lighting and VAV boxes, instituting integrated control strategies and improving self-tuning diagnostics.

This measure involves installing an advanced BAS or upgrading an existing BAS with an advanced BAS. It is applicable to existing buildings and the baseline is a typical Office building with an electricity intensity of 26 $kWh/ft^2yr$. The full cost is estimated to be $\$0.90/ft^2$, the savings are 10% of total building energy use and the service life is 10 years.

- **Programmable Thermostats**

| **Measure Profile** | |
|---|---|
| Applicable Building Types | Small Commercial |
| Vintage | Existing & new |
| Costs | Full cost of $400/thermostat |
| Savings | 10% of HVAC energy use |
| Useful Life | 10 years |

The use of programmable thermostats with packaged HVAC equipment provides improved control, scheduling and setpoint reset capability.

This measure involves upgrading standard thermostats with programmable thermostats and scheduling the operation of the equipment based on occupancy requirements. It is applicable to both existing buildings and new construction and the baseline is a Small Commercial building with packaged rooftop units and standard thermostats. The full cost is estimated to be $400 per thermostat, the savings are 10% of HVAC energy use and the service life is 10 years.

### 4.3.5 Refrigeration

Commercial refrigeration generally consists of medium- and low-temperature applications including reach-in refrigerators and freezers, walk-in coolers and freezers, display cases and refrigerated rooms. The energy used by refrigeration systems includes compressors, evaporator and condenser fans, lighting and defrost and anti-sweat heaters.

Two energy-efficiency measures were evaluated for refrigeration:

- ENERGY STAR refrigerators and freezers
- High-efficiency supermarket refrigeration.

- **ENERGY STAR Refrigerators and Freezers**

| **Measure Profile** | |
|---|---|
| Applicable Building Types | Food Retail, Restaurant |
| Vintage | Existing & new |
| Costs | Incremental cost of 20% |
| Savings | 25% of refrigeration energy |
| Useful Life | 10 years |

Commercial self-contained, reach-in refrigerators and freezers are electrically-powered refrigerated cases with shelves and lighting and having up to three opaque or transparent doors. These appliances are used primarily in the retail sector by convenience stores, supermarkets, restaurants, pubs, cafeterias, flower shops, drug stores and others for storing or merchandising refrigerated or frozen products such as cold drinks, ice cube bags, frozen foods, etc. Canada has over 340,000 commercial reach-in refrigerators and freezers, and approximately 38,000 new units sell each year.26 A typical refrigerator consumes 4,300 kWh per year and a freezer 9,800 kWh per year.

On September 1, 2006, ENERGY STAR qualifying criteria for commercial solid door, self-contained refrigerators and freezers came into effect in Canada. ENERGY STAR qualified commercial solid door refrigerators and freezers use electronically commutated motors (ECM) for evaporator and condenser fans, hot gas anti-sweat heaters and high-efficiency compressors. These features make them considerably more energy efficient than standard appliances.

This measure involves upgrading a standard reach-in refrigerator or freezer with an equivalent ENERGY STAR appliance. It is applicable to both existing buildings (at end of refrigeration life cycle) and new construction. The incremental cost is 20%, the savings are 25% and the service life is 10 years.

- **High-efficiency Supermarket Refrigeration**

| **Measure Profile** | |
|---|---|
| Applicable Building Types | Large Food Retail |
| Vintage | Existing & new |
| Costs | Incremental cost of $2.70/ft^2$ |
| Savings | 25% of refrigeration energy |
| Useful Life | 10 years |

Supermarket refrigeration is divided into two distinct segments that have different technologies. The more visible part of these systems is the display cases that hold food for the self-service shopping style of supermarkets. The display cases have their own electric loads and are served by a central refrigeration system. The mechanical equipment, including compressors, condensers, and associated controls, is located in the machine room. The potential for energy consumption reductions associated with machine room equipment is limited to about 5% of overall supermarket refrigeration energy usage. Reduction of 1% of overall usage is possible with increased use of evaporative condensers, a technology which currently has little market penetration. Additional reductions of 4% could be achieved by further use of floating head pressure, mechanical subcooling and heat reclaim, technologies which currently have varying degrees of market penetration.

The potential for energy consumption reductions associated with display cases is about 20% of overall supermarket refrigeration energy usage. Savings of 12% can be achieved with high-efficiency evaporator fan motors and hot-gas defrost. Additional savings of 8%

[26] Natural Resources Canada. www.oee.nrcan.gc.ca/commercial/equipment/selfcontained-refrigerators-freezers.

can be achieved with liquid suction heat exchangers, anti-sweat control and defrost control.

This measure involves upgrading a standard supermarket refrigeration system with an equivalent high-efficiency refrigeration system. It is applicable to existing large Food Retail buildings (at end of refrigeration life cycle) and new construction. The baseline is a Food Retail building with a refrigeration energy intensity of 31 $kWh/ft^2/yr$. The incremental cost is estimated to be $\$2.70/ft^2$, savings are 25% of refrigeration energy use and the service life is 10 years.

### 4.3.6 Domestic Hot Water

Domestic hot water (DHW) is typically used in commercial buildings for hand washing, showers, cleaning and food preparation. Four DHW energy-efficiency upgrades were evaluated:

- Low-flow faucet aerators and shower heads
- Heat pump water heaters
- Grey water heat recovery
- Tankless water heaters.

#### ❑ Low-flow Faucet Aerators and Shower Heads

| Measure Profile | |
|---|---|
| Applicable Building Types | All |
| Vintage | Existing & New |
| Costs | $40/lavatory |
| Savings | 40% of domestic hot water energy use |
| Useful Life | 5 years |

Low-flow faucet aerators lower the water flow to 0.5 to 2 gallons per minute (gpm) by introducing air into the water stream. The aerator creates a fine water spray with a screen that is inserted in the faucet head. Similarly, low-flow shower heads use the same principle as faucet aerators to achieve flow rates in the range of 1.5 to 2.2 gpm.

This measure involves upgrading faucet aerators and shower heads with equivalent water efficient units. It is applicable to existing buildings and new construction. The baseline is a standard shower head with a flow rate of 2.5 to 3 gpm and a standard faucet aerator with a flow rate of 2 to 3 gpm. The cost is estimated to be $40 per lavatory (four sinks and one shower stall), the savings are estimated to be 40% and the service life is 5 years.

#### ❑ Heat Pump Water Heaters

Heat pump water heaters extract heat from the surrounding air to heat hot water. During the heating season the surrounding air will have to be re-heated. Given the 9-month heating season in Newfoundland and Labrador, this technology is not a practical solution and would provide very little economic benefit. Therefore, it is recommended that this technology not be considered any further in this study.

- **Grey Water Heat Recovery**

Grey water heat recovery systems (GWHR) capture energy from warm wastewater to pre-heat incoming water for a DHW tank. GWHR is most effective in buildings with large, sustained DHW requirements such as laundries, gymnasiums and restaurants. As the opportunity for this measure is restricted to niche applications within sub sectors, it will not be considered as an individual measure in the present study. It is recognized, however, that GWHR will be applicable in some new building construction and will, therefore, be considered to be among the family of DHW efficiency measures captured in the measure *New Commercial Building – 40% More Efficient than Current Standards* in Section 4.10 below.

- **Tankless Water Heaters**

| **Measure Profile** | |
|---|---|
| Applicable Building Types | All |
| Vintage | Existing & New |
| Costs | Incremental cost of $5,600 |
| Savings | 7% of domestic hot water energy use |
| Useful Life | 10 years |

Tankless water heaters, also known as instantaneous water heaters, provide hot water without using a storage tank. Like tank water heaters, tankless water heaters use electricity to operate. Cold water travels through a pipe into the unit, and an electric element heats the water. Tankless water heaters can be supplementary units placed at the point of use or can replace conventional tank water heaters. Electric tank water heaters have an energy factor of about 0.91 compared with 0.98 for electric tankless water heaters.

Electric heating elements for tankless water heaters are much larger than for storage water heaters because the heater must be sized for the peak instantaneous. For example, a typical residential electric storage water heater draws at most 7,000 Watts, a whole-house electric tankless heater can draw as much as 19,200 Watts, and may require a larger electrical service.

This measure involves upgrading a central DHW tank heater with multiple point-of-use tankless heaters. It is applicable to existing buildings (at end of tank life cycle) and new construction. The incremental cost is estimated to be $5,600, the savings are 7% and the service life is 10 years.

### 4.3.7 Computer Equipment

Computer equipment typically includes computers, monitors, servers, printers, copiers and fax machines. Three computer equipment energy-efficiency upgrades were evaluated:

- ENERGY STAR computer and monitor
- ENERGY STAR office equipment

- Energy-efficient server technologies.

- **ENERGY STAR Computer and Monitor**

| Measure Profile | |
|---|---|
| Applicable Building Types | All |
| Vintage | Existing & new |
| Costs | Incremental cost of $0/unit |
| Savings | 75% of unit energy consumption |
| Useful Life | 5 years |

Beginning on July 20, 2007, ENERGY STAR's new specifications for computers went into effect. Only the market's most energy-efficient computing products will qualify for the ENERGY STAR label. Qualified products must now meet energy use guidelines in three distinct operating modes: standby, sleep mode and while computers are being used, and will include a more efficient internal power supply.

This measure involves upgrading a standard computer and monitor with an equivalent ENERGY STAR unit. It is applicable to both existing and new buildings at the end of the computer life cycle. The baseline is a standard desktop computer equipped with a 17" liquid crystal display (LCD) monitor and operating under default power management settings. The system is assumed to be on for approximately 40% of the time drawing 93 Watts and 4 Watts while turned off.

The upgrade is a comparable ENERGY STAR rated computer and monitor (17" LCD) operating with ENERGY STAR power management settings. The savings are estimated to be 75%, the incremental cost is zero[27] and the service life is 5 years.

- **ENERGY STAR Office Equipment**

| Measure Profile | |
|---|---|
| Applicable Building Types | All |
| Vintage | Existing & new |
| Costs | Incremental cost $0/unit |
| Savings | 40% of unit energy consumption |
| Useful Life | 5 years |

This measure involves upgrading a standard photocopier with an equivalent ENERGY STAR rated unit. It is applicable to both existing and new buildings at the end of the computer life cycle. The baseline is a standard medium speed copier (21-44 copies per minute) operating under default power management settings. The system is assumed to be on for approximately 50% of the time drawing 177 Watts, on standard for 35% of the time drawings 163 Watts and 14 Watts while turned off. The results of this analysis can be extrapolated to other types of office equipment such as faxes and printers.

The upgrade is a comparable ENERGY STAR rated photocopier featuring reduced standby and off mode consumption as well as enabled ENERGY STAR power

[27] http://www.energystar.gov.

management settings. The savings are estimated to be 40%, the incremental cost is zero[28] and the service life is 5 years.

- **Energy-efficient Server Technologies**

| Measure Profile | |
|---|---|
| Applicable Building Types | All |
| Vintage | Existing & new |
| Costs | $50/server |
| Savings | 40% of server energy |
| Useful Life | 5 years |

This upgrade features two server technologies: server virtualization and energy-efficient servers, however the savings are not additive. The measures apply to both existing and new buildings at the end the server life cycle. The baseline server draws 217 Watts[29] based on the weighted average of the top three servers in the U.S. by shipment volume in 2005.

**Server Virtualization.** Servers are "virtualized" using software that allows a server to run multiple operating systems or instances of the same operating system concurrently. This allows for server consolidation resulting in a reduced number of servers required for operations. Potential energy savings are 40% in applications where many servers are used, such as data centres. Software and installation costs are estimated at $50/unit.[30]

**Energy-efficient Servers.** Servers using "multi-threaded" technology perform multiple parallel operations, achieving a higher performance per Watt than conventional servers. Potential energy savings are 35% and equipment costs are comparable to traditional servers.[31]

### 4.3.8 Building Envelope

Building envelope measures improve the thermal performance of a building's walls, windows and roof.

Four energy-efficiency upgrade options were evaluated for the building envelope:

- High-performance glazing systems
- Upgrade wall insulation
- Upgrade roof insulation
- Air curtains.

Each measure is evaluated at a low- and high-heating load to reflect the range of climate conditions found in Newfoundland and Labrador.

[28] http://www.energystar.gov.
[29] J.G. Koomey. *Estimating Total Power Consumption by Servers in the U.S. and the World*. 2007.
[30] http://www.microsoft.com.
[31] http://www.sun.com.

- **High-performance Glazing Systems**

| Measure Profile | |
|---|---|
| Applicable Building Types | All |
| Vintage | Existing and new |
| Costs | $2.00/ft^2$ (floor area) incremental cost |
| Savings | 28% to 34% of heating and cooling energy |
| Useful Life | 20 years |

High-performance glazing systems consist of low-e coated films suspended inside an insulating glass unit. These units can be incorporated into both window and curtain wall systems. In addition to superior insulating performance and lower energy costs, the co-benefits include enhanced comfort, noise reduction, the elimination of perimeter heating and reduced HVAC equipment costs.

Visionwall window and curtain wall systems manufactured by Visionwall Corporation[32] have thermal resistance R-values ranging from 3 to 7 hr.ft$^2$.$^o$F/Btu, low shading coefficients and high visible light transmission. The highest performing product on the market is Superglass Quad (R-value 12.5 hr.ft$^2$.$^o$F/Btu) manufactured by Southwall Technologies.[33] It features two films suspended inside an insulating glass unit creating three krypton-filled air spaces. A tape system is used for gas retention and a thermally broken insolating spacer stops the conduction through the edge of the glass.

This upgrade is a high-performance glazing system with an overall U-value of 0.25 Btu/hr.ft$^2$.$^o$F (R-4). It is applicable to both existing buildings (at end of window life cycle) and new construction. The baseline is an electrically-heated commercial building with standard double-glazed windows with an overall U-value of 0.45 Btu/hr.ft$^2$.$^o$F (R-2.2). The incremental cost is $2 per square foot of floor area, the savings range from 28% to 34% of the heating and cooling energy and the service life is 20 years.

- **Upgrade Wall Insulation**

| Measure Profile | |
|---|---|
| Applicable Building Types | All |
| Vintage | Existing and new |
| Costs | $1.38/ft^2$ (floor area) incremental cost |
| Savings | 18% of heating energy |
| Useful Life | 25 years |

Various insulating materials and methods can be used to upgrade wall insulation including applying rigid polystyrene board to the exterior of a building or installing fibreglass batts between interior wall studs.

This measure involves upgrading wall insulation to R-24. It is applicable to both existing buildings (at time of recladding) and new construction. The baseline is an electrically-

[32] http://www.visionwall.com.
[33] http://www.southwall.com.

heated commercial building with R-12 wall insulation. The incremental cost is $1.38 per square foot of floor area, the savings are 18% of heating energy and the service life is 25 years.

- **Upgrade Roof Insulation**

| **Measure Profile** | |
|---|---|
| Applicable Building Types | All |
| Vintage | Existing and new |
| Costs | $\$1/ft^2$ (floor area) incremental cost |
| Savings | 13% of heating energy |
| Useful Life | 25 years |

Upgrading insulation on a built-up roofing system typically involves adding additional layers of rigid insulation at the time of re-roofing.

This measure involves upgrading roof insulation to R-30. It is applicable to both existing buildings (at time of re-roofing) and new construction. The baseline is an electrically-heated commercial building with R-20 roof insulation. The incremental cost is $1 per square foot of floor area, the savings are 13% of heating energy and the service life is 25 years.

- **Air Curtains**

| **Measure Profile** | |
|---|---|
| Applicable Building Types | Retail, Warehouse |
| Vintage | Existing & new |
| Costs | Full $2,150 per double door |
| Savings | 9% of space heating energy |
| Useful Life | 15 years |

Air curtain systems use a fan to generate a laminar air flow across an open doorway. This mass flow of air acts as a barrier, reducing outside air infiltration by approximately 90%, thus preventing unwanted heat transfer both at the building envelope and between rooms within buildings. Typical applications include entrances to buildings in the Retail sub sector, overhead garage doors, loading docks and refrigerated rooms. The co-benefits include protecting employees from adverse environmental conditions such as cold drafts and dust.

This upgrade involves the installation of an air curtain to a double door entrance. It is applicable to both existing buildings and new construction and the baseline is a Non-food Retail building with a double door entrance. The full cost is $2,150 per double door, the savings are 9% of the space heating energy and the service life is estimated to be 15 years.

### 4.3.9 New Construction

New construction refers to new high-efficiency buildings designed using the integrated design process that achieve substantial improvements over conventional new buildings through the application and integration of energy-efficiency technologies and design approaches.

Baseline new construction is assumed to follow the MNECB and ASHRAE 90.1 - 1999 standards.

Two energy-efficiency upgrade options were evaluated for new construction:

- New Commercial Building - 25% more efficient than current standards
- New Commercial Building - 40% more efficient than current standards.

- **New Commercial Building - 25% More Efficient than Current Standards**

| **Measure Profile** | |
|---|---|
| Applicable Building Types | All |
| Vintage | New |
| Costs | $\$1/ft^2$ incremental cost |
| Savings | 25% |
| Useful Life | 30 years |

The integrated design approach (IDA) to new building design is predicated on a systematic application of energy measures to all end uses at the design stage. This includes targeting the building envelope, lighting, HVAC equipment (fans and pumps) and, finally, the heating and cooling plants. Savings of 25% are achievable at an average incremental cost of $\$1/ft^2$.

- **New Commercial Building - 40% More Efficient than Current Standards**

| **Measure Profile** | |
|---|---|
| Applicable Building Types | All |
| Vintage | New |
| Costs | $\$4.50/ft^2$ incremental cost |
| Savings | 40% |
| Useful Life | 30 years |

A new commercial building that is 40% more efficient than current design practice will require a very high-performance design, equivalent to C-2000 levels. This requires a full IDA that takes advantage of costs trade-offs from equipment downsizing. The design will require the most energy-efficient technologies, extremely efficient lighting designs and heating/cooling plants with very high part-load efficiencies. Savings of 40% are achievable at an average incremental cost of $\$4.50/ft^2$.

### 4.3.10 Street Lighting

Street lighting refers to all outdoor and roadway lighting intended to illuminate municipal streets and highways. Street lighting is dominated by high-pressure sodium lamps at approximately 85%, followed by metal halide at approximately 15%.

Two energy-efficiency upgrade options were evaluated for this end use:

- Electrodeless induction lighting
- Dimming controls.

### Electrodeless Induction Lighting

| Measure Profile | |
|---|---|
| Applicable Building Types | Street Lighting |
| Vintage | Existing and new |
| Costs | $300/fixture incremental cost |
| Savings | 25% |
| Useful Life | 16 years |

Induction lighting uses a magnetic field instead of electrodes to produce the electric field that excites the gas to emit light. This technology was first introduced in Europe in 1991 but has been slow to catch on in North America. Induction lighting has numerous benefits, the most important being an exceptionally long life, rated at 100,000 hours. Other benefits include instant-on capabilities, a high colour rendering index (CRI) of approximately 80 and an efficacy of 60-80 lumens per Watt. The drawbacks to this technology are that the capital cost is high, the technology does not work with dimmers, the lamps are large and not compatible with existing fixtures and the lamps do not work in temperatures above 35ºC to 40ºC.

Currently, Philips and OSRAM/Sylvania are the only manufacturers that have available products. The Philips Quality Light (QL) product line includes 55-, 85- and 165-Watt systems. OSRAM/Sylvania has a 100- and 150-Watt version called the Icetron.

Experts are mixed on the future of this technology. However, at a minimum, it is expected that these lamps will find a niche in areas where long life is a critical factor, such as in hard to reach areas and areas where maintenance costs would be high, e.g., in tunnels and over bridges.

This upgrade involves retrofitting of a 175-Watt metal halide with an equivalent 150-Watt induction luminaire. The incremental cost is $300 per luminaire,[34] the savings are 25% and the service life is 16 years.

[34] Bonneville Power Administration. http://www.bpa.gov/Energy/N.

- **Dimming Controls**

| **Measure Profile** | |
|---|---|
| Applicable Building Types | Street Lighting |
| Vintage | Existing and new |
| Costs | Full $220/fixture |
| Savings | 30% |
| Useful Life | 16 years |

Dimming controls (sometimes called adaptive lighting) have the potential to reduce annual energy use by 20% to 40% by lowering light levels during periods of low activity. Several companies are currently investigating different approaches to the application of this technology. In one configuration, the controls are incorporated as an add-on device to an existing magnetic ballast. In a second configuration, the technology is combined with advanced monitoring and wireless, computer enabled controls to further increase savings.

Currently, there is very little dimming being used in outdoor lighting in Canada. Issues related to safety and possible liability arising from the lower light levels, have made lighting designers and policy makers reluctant change the status quo. However, many industry experts believe that this technology could have a significant impact on the market if the issues of safety and liability can be adequately addressed.

This upgrade involves adding dimming controls to street lighting to reduce or shut off lighting during silent periods. The savings are estimated to be 30%, the full cost is $220[35] per luminaire and the service life is 16 years.

## 4.4 SUMMARY OF ENERGY-EFFICIENCY RESULTS

The energy-efficiency measures and their associated CCEs are summarized in Exhibit 4.2. Note that the negative values shown for selected lighting upgrades indicate that the annualized capital cost of the energy-efficiency measure is less expensive than the baseline technology.

[35] Average cost including hardware, controls and estimated installation costs. Streetlight Intelligence Ltd.

## Exhibit 4.2: Commercial Energy-efficiency Technologies and Measures – Cost of Conserved Energy

| Measure/Technology | | | Sub Sector | Vintage | CCEs (¢/kWh) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 4.0% DR | | 6.0% DR | | 8.0% DR | |
| | | | | | Full | Incr. | Full | Incr. | Full | Incr. |
| Lighting | T12 | Standard T8s | All | Existing | 5.4 | 0.0 | 6.3 | 0.0 | 7.2 | 0.0 |
| | | Low BF T8s | All | Existing | 3.9 | 0.0 | 4.6 | 0.0 | 5.2 | 0.0 |
| | | High-performance T8s | All | Existing | 4.2 | 0.5 | 4.9 | 0.7 | 5.7 | 0.8 |
| | | Redesign with standard T8s | All | Existing | 5.1 | -2.0 | 5.9 | -2.3 | 6.8 | -2.6 |
| | | Redesign with high-performance T8s | All | Existing | 4.9 | -1.3 | 5.6 | -1.6 | 6.4 | -1.8 |
| | | Fully integrated lighting and controls | All | Existing | 17.7 | 11.9 | 20.5 | 13.7 | 23.5 | 15.8 |
| | T8 | High-performance T8s | All | Existing & New | 13.1 | 1.7 | 15.3 | 2.1 | 17.6 | 2.5 |
| | | Redesign with high-performance T8s | All | Existing & New | 8.4 | 0.0 | 9.8 | 0.0 | 11.2 | 0.0 |
| | | Fully integrated lighting and controls | All | Existing & New | 29.6 | 22.0 | 34.3 | 25.4 | 39.3 | 29.2 |
| | | Occupancy sensors | All | Existing & New | 6.0 | 4.3 | 6.6 | 4.7 | 7.2 | 5.1 |
| | Inc | Compact fluorescent lamps | All | Existing & New | 2.7 | -1.1 | 2.9 | -1.0 | 3.2 | -0.8 |
| | | Induction lighting | Retail | Existing & New | 4.5 | 0.4 | 4.9 | 0.7 | 5.4 | 1.1 |
| | | White LEDs | All | Existing & New | 0.1 | -3.5 | 0.4 | -3.2 | 0.8 | -2.8 |
| | | Halogen IR | All | Existing & New | 10.1 | -4.8 | 10.5 | -4.7 | 10.8 | -4.6 |
| | | Ceramic metal halide | Retail | Existing & New | 4.7 | -4.6 | 5.1 | -4.4 | 5.6 | -4.1 |
| | | LED exit signs | All | Existing | 1.7 | na | 2.0 | na | 2.4 | na |
| | HID | Pulse-start metal halide | All, outdoor, roadway | Existing & New | 9.5 | 0.3 | 10.9 | 0.3 | 12.5 | 0.4 |
| | | High intensity fluorescents | Warehouse, retail, school | Existing & New | 4.1 | 0.4 | 4.8 | 0.5 | 5.4 | 0.5 |
| HVAC | | Low temperature heat pumps - Island | Small commercial | Existing & New | na | 5.5 | na | 6.0 | na | 6.6 |
| | | Low temperature heat pumps - Labrador | Small commercial | Existing & New | na | 4.8 | na | 5.3 | na | 5.8 |
| | | Ground source heat pumps - Island | All | Existing & New | na | 6.2 | na | 7.3 | na | 8.6 |
| | | Ground source heat pumps - Labrador | All | Existing & New | na | 4.5 | na | 5.4 | na | 6.3 |
| | | Infrared heaters - Island | Retail, warehouse | Existing & New | 6.7 | 6.7 | 7.4 | 7.4 | 8.1 | 8.1 |
| | | Infrared heaters - Labrador | Retail, warehouse | Existing & New | 4.8 | 4.8 | 5.3 | 5.3 | 5.8 | 5.8 |
| | | High-efficiency chillers - Island | Large commercial | Existing & New | na | 6.1 | na | 7.4 | na | 8.9 |
| | | High-efficiency chillers - Labrador | Large commercial | Existing & New | na | 8.1 | na | 9.9 | na | 11.8 |
| | | High-efficiency AC units - Island | All | Existing & New | na | 11.3 | na | 12.9 | na | 14.7 |
| | | High-efficiency AC units - Labrador | All | Existing & New | na | 18.7 | na | 21.5 | na | 24.3 |
| | | Adjustable speed drives | All | Existing & New | 5.0 | 5.0 | 5.6 | 5.6 | 6.1 | 6.1 |
| | | Premium efficiency motors | All | Existing & New | 19.5 | 2.9 | 21.5 | 3.2 | 23.5 | 3.6 |
| | | Building recommissioning | All | Existing | 4.0 | na | 4.3 | na | 4.5 | na |
| | | Advanced BAS | All | Existing & New | 4.3 | na | 4.7 | na | 5.1 | na |
| | | Programmable thermostats - Island | Small commercial | Existing & New | 1.8 | 0.9 | 2.0 | 1.0 | 2.2 | 1.1 |
| | | Programmable thermostats - Labrador | Small commercial | Existing & New | 1.6 | 0.8 | 1.8 | 0.9 | 1.9 | 1.0 |
| Refrigeration | | ENERGY STAR refrigerators & freezers | Food retail, restaurant | Existing & New | na | 6.7 | na | 7.3 | na | 8.0 |
| | | HE supermarket refrigeration | Food retail | Existing & New | na | 4.3 | na | 4.7 | na | 5.2 |
| DHW | | Low-flow aerators & shower heads | All | Existing & New | 2.6 | na | 2.8 | na | 2.9 | na |
| | | Tankless water heaters | All | Existing & New | na | 37.4 | na | 41.2 | na | 45.2 |
| Computer Equipment | | ENERGY STAR computers | All | Existing & New | na | 0.0 | na | 0.0 | na | 0.0 |
| | | ENERGY STAR office equipment | All | Existing & New | na | 0.0 | na | 0.0 | na | 0.0 |
| | | High-efficiency servers | All | Existing & New | na | 1.5 | na | 1.6 | na | 1.7 |
| Building Envelope | | High-performance glazings - Island | All | Existing & New | na | 5.5 | na | 6.5 | na | 7.5 |
| | | High-performance glazings - Labrador | All | Existing & New | na | 3.3 | na | 4.0 | na | 4.6 |
| | | Wall insulation - Island | All | Existing & New | na | 6.0 | na | 7.4 | na | 8.8 |
| | | Wall insulation - Labrador | All | Existing & New | na | 4.2 | na | 5.1 | na | 6.1 |
| | | Roof insulation - Island | All | Existing & New | na | 6.9 | na | 8.5 | na | 10.1 |
| | | Roof insulation - Labrador | All | Existing & New | na | 4.4 | na | 5.3 | na | 6.4 |
| | | Air curtains - Island | Warehouse, retail | Existing & New | 5.1 | 5.1 | 5.8 | 5.8 | 6.6 | 6.6 |
| | | Air curtains - Labrador | Warehouse, retail | Existing & New | 3.3 | 3.3 | 3.8 | 3.8 | 4.3 | 4.3 |
| New Construction | | New buildings - 25% more efficient | All | New | na | 0.9 | na | 1.1 | na | 1.4 |
| | | New buildings - 40% more efficient | All | New | na | 2.5 | na | 3.1 | na | 3.8 |
| Streetlighting | | Induction lighting | | Existing & New | na | 10.4 | na | 12.3 | na | 14.4 |
| | | Dimming controls | | Existing & New | 5.0 | 5.0 | 5.8 | 5.8 | 6.6 | 6.6 |

## 4.5 PEAK LOAD REDUCTION MEASURES

### 4.5.1 Overview

Electric utilities are typically interested in peak load reduction measures as a means to avoid or defer the costs of capacity expansion. Capacity costs refer to a wide range of capital-based investments, including generating stations (new and upgraded), transmission lines, distribution lines, substations, transformers and other infrastructure required to deliver power.

From the customer's perspective, adoption of peak load reduction measures is typically dependent on the overall benefits to them, such as direct incentive payments or rate benefits. Although most medium and large commercial customers do pay a monthly demand charge that reflects their monthly peak, small commercial customers with a monthly demand of less than 10 kW are billed only for electricity (kWh) regardless of when it is used.

The current trend throughout much of the North American utility industry is towards more specific pricing such as time-of-use and even hourly pricing, or peak incentives that pass along some of the utility benefits to customers on a performance basis. These new pricing structures provide added incentive to larger commercial customers (who already pay a demand charge); they also provide an incentive for small commercial customers to implement measures or to participate in utility peak load reduction programs, as long as the differential between peak and off-peak prices is sufficient to provide a noticeable financial benefit to the customer.

Currently, several Canadian jurisdictions[36] are in the early stages of implementing pilot load reduction initiatives targeted to both commercial and residential customers. These initiatives are designed to test:

- New metering technologies, such as advanced meters (also referred to as "smart meters")
- New rate structures, such as real-time feedback, pay-as-you-go billing and critical peak pricing
- Direct load control.

Most conventional meters used in small commercial facilities monitor electricity consumption (kWh) but do not track *when* the electricity is used. Instead, conventional meters are occasionally read and reported to electric utilities, which then bill customers every one or two months. As a result, customers only find out their electricity usage after the fact.

In contrast, *advanced meters* (known in some industry circles as "smart meters") record how much electricity is used and when. Advanced meters, through their interval metering and two-way communications, allow the implementation of numerous utility programs

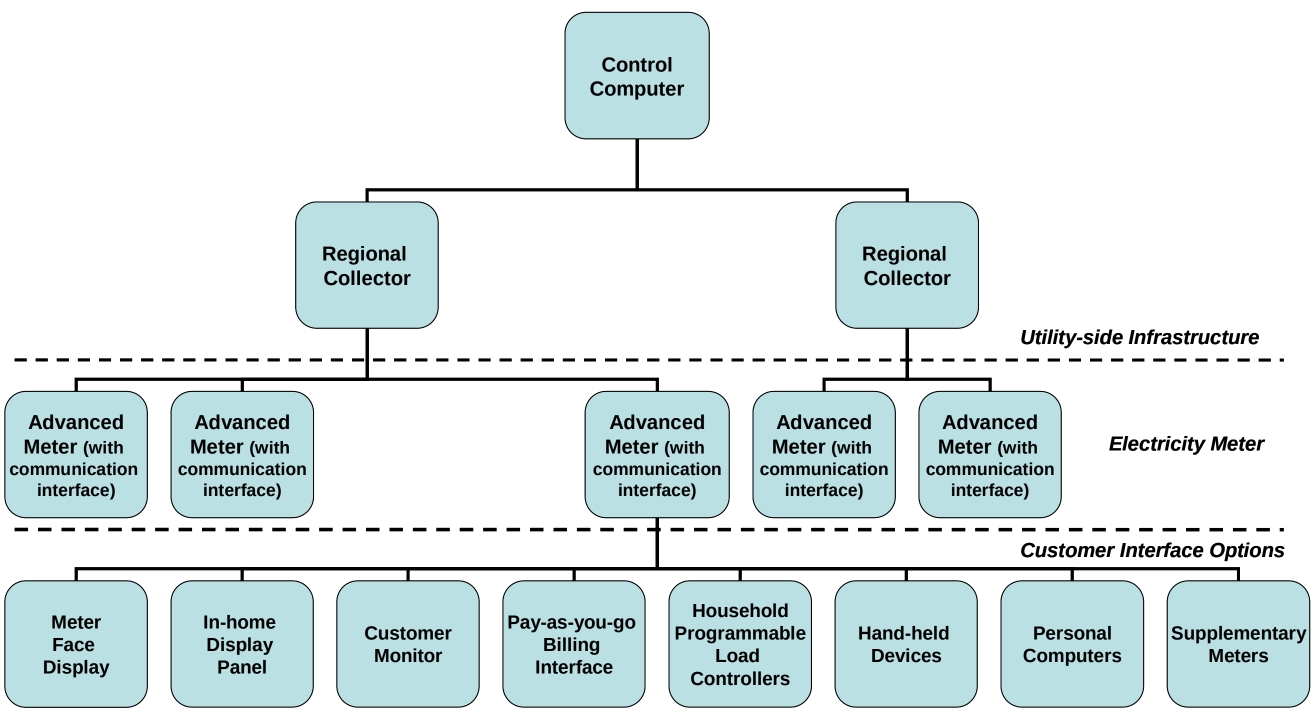
[36] Marbek Resource Consultants, *Technology & Market Assessment of Residential Electricity Advanced Metering In Canada*. Prepared for Natural Resources Canada, November 2006.

and services that encourage customers to reduce or shift (i.e., change the time of) their electricity consumption, particularly away from peak times when the cost of supply is becoming increasingly more expensive.

Exhibit 4.3 presents an illustrative schematic of an advanced metering system. As illustrated there are three major levels of system components:

- **Customer Interface Options** — The hardware interfaces that can be used for the advanced meter to communicate with the customer and, to a certain extent, any applicable electrical load controllers in the customer's household.
- **Electricity Meter** — The advanced meter itself, equipped with a communication interface to facilitate communication to other devices and the utility.
- **Utility-side Infrastructure** — The infrastructure required for two-way communication between the utility and the advanced meter.[37]

**Exhibit 4.3**
**Illustrative Schematic of an Advanced Metering System**




As illustrated in Exhibit 4.3, there is wide range of technical options available at each level in a typical advanced metering system. This is particularly the case at the customer interface level where there is a growing number of devices that can be used to provide real-time feedback to customers in a convenient and understandable manner. Typically, these devices provide a numerical or graphical display that is either wired into the same

[37] Ibid.

room as the meter, wired next to the main thermostat or is a wireless panel that can be placed anywhere in the home or commercial facility. However, alone, none of these devices save energy *per se*.

In summary, new electric metering and customer interface technologies, when combined with the applicable utility infrastructure, have the potential to support a wide range of utility-sponsored peak load reduction and load shifting initiatives via pricing and promotional initiatives. Within the agreed study scope, it is not feasible to provide further specific rate design or system infrastructure specifications. However, further information is provided below on selected direct load control options.

### 4.5.2 Peak Load Reduction Measures – Direct Load Control

Consistent with the agreed study scope, the information provided below is based on existing secondary data sources and does not include a detailed analysis of specific NLH/NP peak load conditions. Much of the information provided draws from work that the consultant team is currently undertaking for BC Hydro.[38] To that end, the material presented is intended to be indicative of general trends and costs but would need to be adjusted for specific application to NLH/NP peak load conditions.[39]

The remainder of this subsection provides an overview of the following Commercial sector peak load reduction measures:

- Utility-based control of space heating (HVAC) equipment using remote thermostat
- Utility-based control of space heating (HVAC) equipment using remote switch
- Utility-based control of hot water heater using remote switch.

❑ **Utility-Based Control of Space Heating (HVAC) Equipment Using Remote Thermostat[40]**

Thermostat-based load control is accomplished by the installation of a remote communicating thermostat that facilitates utility remote control of the thermostat (for space heating and/or, in some cases, space cooling). Utility control would occur under specific, pre-arranged, capacity-constrained conditions that would typically occur during a limited number of pre-specified hours during winter peak months.

The control options typically include thermostat setback (specific number of degrees) or cycling, whereby the units are limited to a fixed percentage of operating time per hour. These systems typically provide capability for local override by participants and are either one-way or two-way communicating systems. Two-way communicating systems also enable access by participants to their thermostats via the Internet, utility

[38] Marbek Resource Consultants and Applied Energy Group. *BC Hydro Conservation Potential Review – 2007*. Prepared for BC Hydro. In process, 2007.
[39] As both BC Hydro and NLH/NP are winter peaking utilities and both are hydro-based with fossil fuel plants serving peak load conditions, the information provided is expected to be generally applicable to the NLH/NP context.
[40] Op. cit., *BC Hydro Conservation Potential Review – 2007*, p. 109.

confirmation of communication during curtailments and collection of data on runtime[41] and temperature from the individual units.

Two-way communicating technology is commercially available and implemented in over 100,000 sites in the U.S. However, to date it has been primarily applied to central air conditioning equipment.

This measure is most applicable in buildings that have thermostat control of specific heating units (e.g., packaged rooftop units) rather than central heating systems such as those found in large buildings. In some cases, where multiple package systems are used in a single building, multiple thermostats, each controlling one package unit, could be accessed through a single data communications point or gateway and redistributed to the individual thermostats, rather than directly accessing each individual thermostat from the utility.

Experience in space heating load control is more limited than for air conditioning control. The BC Hydro study concluded that the potential peak load reductions for this measure are likely to vary widely depending on the type and size of commercial facility. Some of the particularly influential site-specific considerations include:

- Heating unit capacity (i.e., ability to restore temperature at the end of the control period)
- Facility thermal insulation levels (i.e., ability to maintain temperature during a control cycle)
- Occupancy patterns (i.e., are there periods of low occupancy that overlap with control periods such as the 4 to 8 pm period)
- Occupant comfort needs.

It was also noted that where occupants are not owners, they might not have access to the thermostats (which are often locked); this would preclude easy access to overrides if comfort is affected and would, consequently, adversely affect participation rates.

Subject to the preceding caveats, the BC Hydro study estimated that the potential peak load reduction (during the 8 am to 1 pm period on a typical BC winter peak day) would range between about 1.07 kW and 1.43 kW for a range of “typical” small (under 20,000 $ft^2$) commercial facilities such as Small Offices, Food Retail and Non-food Retail.

Large commercial facilities that have an existing building automation system (e.g., Large Offices) may offer a more attractive opportunity for this type of control option than smaller facilities. In some cases, it may be relatively easy for the utility to link into to existing building automation system and to cycle key HVAC loads such as heating equipment, fans, pumps, etc., during the control period. A typical load reduction for this type of site was not estimated. However, it was noted that this opportunity is increasingly attractive if load control is desired in the early evening winter period hours (e.g., 4 to 8 pm), which is typical in many Canadian jurisdictions. At this time of day, many large

[41] Runtime data typically represents number of minutes that the unit operates each hour for a period of time (e.g., one week) that can be stored in the unit.

buildings are at, or near, the end of their daily full occupancy period but typically have not yet reduced their HVAC loads.

Based on a one-time cost of approximately $315 (one-way communication) to $500 (two-way communication), ongoing maintenance of 5% (about $12) for one-way systems to $25 (two-way systems) per year and estimated annual impacts of 1.07 kW-1.43 kW per site, the BC Hydro study estimated that the cost would be in the range of about $45-$60 per kW/year when applied to a small commercial facility with 100% electric fuel use.

Utility infrastructure costs as well as program administration, promotion and incentive costs are in addition. Additional costs would also include maintenance of a call centre to handle participant calls, including off-hours support and referrals to "on-call" installers.

***Caveats***

Although some pilot space heat control projects have been tested in the U.S., the experience with this technology has primarily been with central air conditioning loads. Because space heating is much less discretionary, customer acceptance of this type of measure remains uncertain.

- **Utility-Based Control of Space Heating (HVAC) Equipment Using Remote Switch[42]**

Switch-based heating unit load control is similar to the preceding measure except that a remote control switch is installed on the heating unit itself or on the circuits controlling the heating unit. As with the preceding measure, utility control would occur under specific, pre-arranged, capacity-constrained conditions that typically would occur during a limited number of pre-specified hours during winter peak months. Typically, units are not shut off for the entire control period but rather "cycled" to limit their on-time to a pre-determined number of minutes per control cycle. The technology is commercially available and has been implemented in millions of sites in the U.S. (primarily for central air conditioning and water heating).

This measure primarily addresses units where temperature control is on each room unit, without a central thermostat capability. Typically, this would include baseboard units with individual controls or where one or more units are controlled from an electrical circuit.

Costs are similar to one-way thermostat control presented in the preceding discussion. The installation cost is higher for the switch because it involves a high voltage connection and thus a higher skilled installer (in many locales a licensed electrician). Installation costs are the same in both new and existing buildings.

Electric peak load reduction would be comparable to the thermostat control systems. However, without two-way access or thermostats, it would be more difficult to predict the effect on comfort and there would be a higher risk of over-control and adverse comfort impacts.

[42] Op. cit., *BC Hydro Conservation Potential Review – 2007*, p. 114.

Unlike thermostat-based systems, a control switch would not provide customers with any ancillary benefits (e.g., a programmable thermostats for comfort and energy savings and remote/Internet access to the thermostat) and thus the only incentive for participation would be monetary in nature, adding to recurring program costs.

- **Utility Control of Domestic Hot Water Heater Using Remote Switch**[43]

Switch-based water heating load control is accomplished by the installation of a remote control switch on either the water heater itself or on the circuits controlling the water heater. In older systems, this type of control has been accomplished via radio frequency (RF) control. In the systems that are currently offered, pager-based communications is used.

Costs are reduced if a communications system already exists. For example, if space heat control already exists, water heat control can be added via a hard-wired or wireless connection. This can reduce the total cost of the water heat control by up to 40%.

Depending upon the length of the control period and the size of the water heater tank, units can be shut off for the entire control period or "cycled" to limit their operating time to a predetermined number of minutes per control cycle. Water heat control technology is commercially available and implemented in hundreds of thousands of sites in the U.S.

This measure is applicable to small commercial buildings that have an electric water heater with a minimum 40-gallon capacity. The size of the tank is important because it provides hot water during times when the control is in effect. The larger the water heater tank, the longer the control can be in place without disrupting the customer's service.

Switches cost about $100 per unit, plus $150 for installation, plus maintenance. Costs are reduced to $150 (i.e., $50 incremental installation) if the control switch can be added to an existing control system at the same time, including one-way/two-way thermostats and switches for space heating. There is no savings in installation costs for a new facility.

Based on a one-time cost of approximately $250, ongoing maintenance of 5% (about $12/year) and estimated annual impacts of 0.39 kW to 0.46 kW per small commercial facility, the BC Hydro study estimated that the cost would be in the range of $75 - $88[44] per kW/year when applied to small commercial buildings with 4,000 annual kWh for electric DHW. Utility infrastructure costs as well as program administration, promotion and incentive costs are in addition.

[43] Op. cit., *BC Hydro Conservation Potential Review – 2007*, p. 120.
[44] Assumes 10-year life, 6% discount rate.

***Caveats***

This technology has a long history, going back at least 30 years on various types of equipment, including central air conditioners, water heaters and pool pumps.

Since the water heater switch uses a one-way communications-based system, it will require support analyses including the need for signal propagation studies and periodic sampling and re-estimation of reliability levels, accompanied by sufficient maintenance, to maintain an adequate level and accurate estimate of losses.

Experience in the utility industry has shown that performance is likely to erode significantly over time[45] if the system is not properly maintained.

The water heater control switch would not provide customers with any ancillary benefits and thus the only incentive for participation would be monetary in nature, likely on a per annum or per control event basis.

[45] Switch communications failures ranged from 10% to nearly 40% in utility reported data (Energy Pulse article by C. King – December 2005).

# 5. ECONOMIC POTENTIAL ELECTRICITY FORECAST

## 5.1 INTRODUCTION

This section presents the Commercial sector Economic Potential Forecast for the study period 2006 to 2026. The Economic Potential Forecast estimates the level of electricity consumption that would occur if all equipment and building envelopes were upgraded to the level that is cost effective against the long-run avoided cost of electricity in the Newfoundland and Labrador service area. In this study, "cost effective" means that the technology upgrade cost, referred to as the cost of conserved energy (CCE) in the preceding section, is equal to, or less than, the economic screen.[46]

The discussion in this section is organized according to the following subsections:

- Avoided Cost Used for Screening
- Major Modelling Tasks
- Technologies Included in Economic Potential Forecast
- Summary of Results
- CDM Measure Supply Curves.

## 5.2 AVOIDED COST USED FOR SCREENING

NLH has determined that the primary avoided costs of new electricity supply to be used for this analysis are $0.0980/kWh for the Island and Isolated service region and $0.0432/kWh for the Labrador Interconnected service region. These avoided costs represent a future in which the Lower Churchill project is not built and there is no DC link from Labrador to the Island.[47]

Therefore, the Economic Potential Forecast incorporates all the CDM measures reviewed in the preceding Section 4 that have a CCE equal to or less than the avoided costs.

NLH is currently studying the Lower Churchill/DC Link project. However, a decision on whether to proceed is not expected until 2009 and, even if the project proceeds, the earliest completion date would be in late 2014. This means that, regardless of the decision, the avoided cost values shown above will be in effect until the approximate mid point of the study period. If the Lower Churchill/DC Link project does proceed, the avoided costs presented above are expected to change. To provide insight into the potential impacts of the Lower Churchill/DC Link project on this study, it was agreed that the consultants would provide a high-level sensitivity analysis.

[46] Costs related to program design and implementation are not yet included.

[47] The avoided costs draw on the results of the earlier study conducted by NERA Economic Consulting, which is entitled: Newfoundland and Labrador Hydro. *Marginal Costs of Generation and Transmission*. May 2006. The avoided costs used in this study include generation, transmission and distribution.

## 5.3 MAJOR MODELLING TASKS

By comparing the results of the Commercial sector Economic Potential Electricity Forecast with the Reference Case, it is possible to determine the aggregate level of potential electricity savings within the Commercial sector, as well as identify which specific building types and end uses provide the most significant opportunities for savings.

To develop the Commercial sector Economic Potential Forecast, the following tasks were completed:

- The CCE for each of the energy-efficient upgrades presented in Exhibit 4.2 were reviewed, using the 6% (real) discount rate.[48]

- Technology upgrades that had a CCE equal to, or less than, the avoided cost threshold were selected for inclusion in the economic potential scenario, either on a "full cost" or "incremental" basis. It is assumed that technical upgrades having a "full cost" CCE that met the cost threshold were implemented in the first milestone year. It is assumed that those upgrades that only met the cost threshold on an "incremental" basis are being introduced more slowly as the existing stock reaches the end of its useful life.

- Electricity use within each of the building types was modelled with the same energy models that were used to generate the Reference Case. However, for this forecast, the remaining "baseline" technologies included in the Reference Case forecast were replaced with the most efficient "technology upgrade option" and associated performance efficiency that met the cost threshold of $0.0980/kWh for the Island and Isolated service region and $0.0432/kWh for the Labrador Interconnected service region.

- When more than one upgrade option was applied to a given end use, upgrades were applied in sequence. The general approach was to first reduce total end-use load, then to meet the remaining load with the most efficient technology that passed the economic screen. For example, measures to reduce the overall space heating load (e.g., envelope insulation) were applied before efficient heating plant measures (e.g., ground source heat pump).

- A sensitivity analysis was conducted using preliminary avoided cost values that assume development of the Lower Churchill/DC Link.

## 5.4 TECHNOLOGIES INCLUDED IN ECONOMIC POTENTIAL FORECAST

Exhibits 5.1 and 5.2 provide a list of the technologies selected for inclusion in this forecast for, respectively, the Island and Isolated and Labrador Interconnected service regions. In each case, the exhibits show the following:

- End use affected
- Upgrade option(s) selected

[48] See Section 4.2.

- Building types to which the upgrade options were applied
- Rate at which the upgrade options were introduced into the stock.

### Exhibit 5.1: Technologies Included in Economic Potential Forecast for the Island and Isolated Service Region

| Category | Upgrade Technology/Measures | Applicability of Upgrade Options by Building Type | Vintage | Rate of Stock Introduction |
|---|---|---|---|---|
| Lighting | T12 baseline: Redesign with high-performance T8s | All | Existing | Immediate |
| | T8 baseline: Redesign with high-performance T8s | All | Existing | Immediate |
| | Occupancy sensors | All | Existing | Immediate |
| | Compact fluorescent lamps | All | Existing | Immediate |
| | Pulse-start metal halide | All | Existing | Rate of turnover |
| | High-intensity fluorescent | Retail, warehouse, school | Existing | Immediate |
| HVAC | Ground source heat pump | All | Existing | Rate of turnover |
| | High-efficiency chillers | Large commercial/institutional | Existing | Rate of turnover |
| | Adjustable speed drives | All | Existing | Immediate |
| | Premium efficiency motors | All | Existing | Rate of turnover |
| | Advanced BAS/Building recommissioning | All | Existing | Immediate |
| Refrigeration | ENERGY STAR Refrigerators and Freezers | All | Existing | Rate of turnover |
| | High-efficiency supermarket refrigeration | Food retail | Existing | Rate of turnover |
| DHW | Low-flow aerators & shower heads | All | Existing | Immediate |
| Computer Equipment | ENERGY STAR computers | All | Existing | Rate of turnover |
| | ENERGY STAR office equipment | All | Existing | Rate of turnover |
| | High-efficiency servers | All | Existing | Rate of turnover |
| Building Envelope | High-performance glazings | All | Existing | Rate of turnover |
| | Wall insulation | All | Existing | Rate of turnover |
| | Roof insulation | All | Existing | Rate of turnover |
| | Air curtains | Retail,warehouse | Existing | Immediate |
| New Construction | New buildings - 40% more efficient | All | New | Rate of construction |
| Streetlighting | Dimming controls | Streetlighting | Existing & New | Immediate |

### Exhibit 5.2: Technologies Included in Economic Potential Forecast for the Labrador Interconnected Service Region

| Category | Upgrade Technology/Measures | Applicability of Upgrade Options by Building Type | Vintage | Rate of Stock Introduction |
|---|---|---|---|---|
| Lighting | T12 baseline: Redesign with high-performance T8s | All | Existing | Rate of turnover |
| | T8 baseline: Redesign with high-performance T8s | All | Existing | Rate of turnover |
| | Compact fluorescent lamps | All | Existing | Immediate |
| | High-intensity fluorescent | Retail, warehouse, school | Existing | Rate of turnover |
| HVAC | Premium efficiency motors | All | Existing | Rate of turnover |
| | Advanced BAS/Building recommissioning | All | Existing | Immediate |
| DHW | Low-flow aerators & shower heads | All | Existing | Immediate |
| Computer Equipment | ENERGY STAR computers | All | Existing | Rate of turnover |
| | ENERGY STAR office equipment | All | Existing | Rate of turnover |
| | High-efficiency servers | All | Existing | Rate of turnover |
| Building Envelope | High-performance glazings | All | Existing | Rate of turnover |
| | Air curtains | Retail,warehouse | Existing | Immediate |
| New Construction | New buildings - 40% more efficient | All | New | Rate of construction |

*Note: Individually, advanced BAS fails the economic screen for the Labrador Interconnected service region, while building recommissioning passes. The combined measure, advanced BAS/building recommissioning has a CCE below the Labrador threshold of $0.0432 and is, therefore, included in the Economic Potential Forecast.*

## 5.5 SUMMARY OF RESULTS[49]

This section compares the Reference Case and Economic Potential Electricity Forecast levels of commercial electricity consumption for the two service regions. In each case, the results are presented as electricity savings that would occur at the customer's point-of-use. The results are presented in the following exhibits:

- Exhibit 5.3 shows the electricity savings for the Island and Isolated service region over the study period. As illustrated, under the Reference Case commercial electricity use would grow from the Base Year level of 1,881 GWh/yr. to approximately 2,233 GWh/yr. by 2026. This contrasts with the Economic Potential Forecast in which electricity use would increase to approximately 1,541 GWh/yr. by 2026, approximately 692 GWh/yr. (31%) below the Reference Case consumption.

- Exhibit 5.4 shows the electricity savings for the Labrador Interconnected service region over the study period. As illustrated, under the Reference Case commercial electricity use would grow from the Base Year level of 201 GWh/yr. to approximately 240 GWh/yr. by 2026. This contrasts with the Economic Potential Forecast in which electricity use would increase to approximately 197 GWh/yr. for the same period, approximately 43 GWh/yr. (18%) below the Reference Case consumption.

- Exhibits 5.5 and 5.6 present the results by end use, building type and milestone year for, respectively, the Island and Isolated and Labrador Interconnected service regions.

- Exhibits 5.7 and 5.8 show the 2026 savings by major end use and building type for, respectively, the Island and Isolated and Labrador Interconnected service regions.

- Exhibits 5.9 and 5.10 show 2026 savings by major end use and vintage for, respectively, the Island and Isolated and Labrador Interconnected service regions.

[49] All results are reported at the customer's point-of-use and do not include line losses.

**Exhibit 5.3: Reference Case versus Economic Potential Electricity Consumption in Commercial Sector, (GWh/yr.) for the Island and Isolated Service Region**

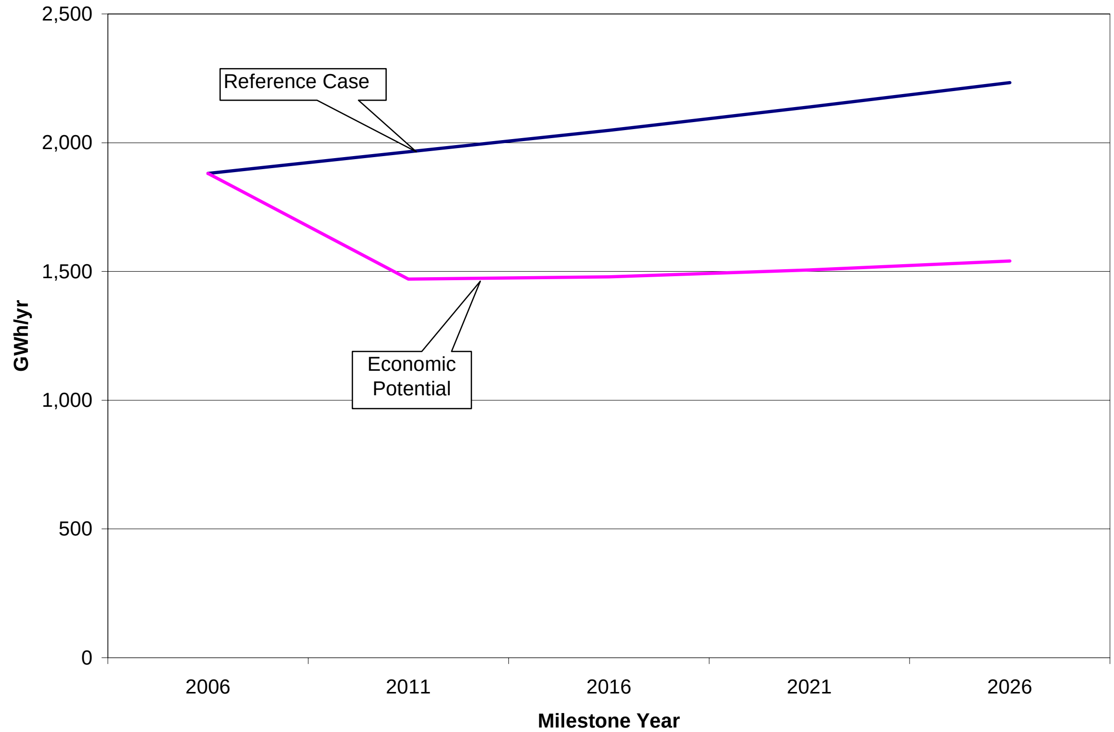
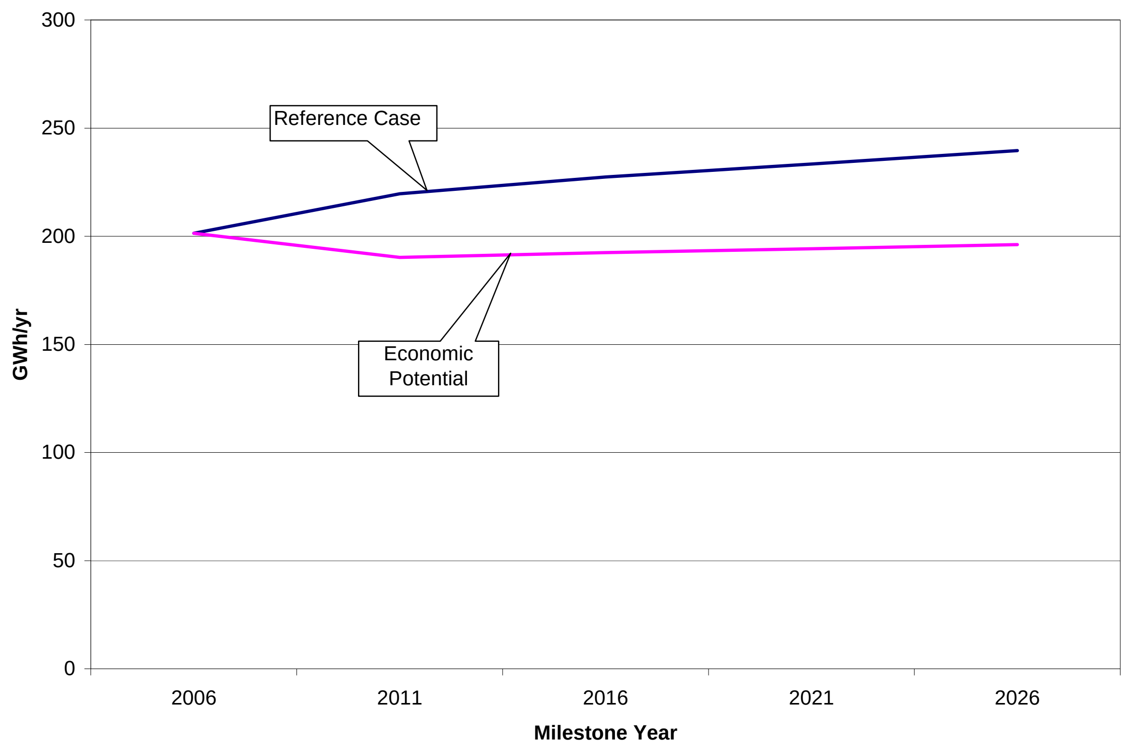



**Exhibit 5.4: Reference Case versus Economic Potential Electricity Consumption in Commercial Sector, (GWh/yr.) for the Labrador Interconnected Service Region**



## Exhibit 5.5: Total Potential Electricity Savings by End Use, Building Type and Milestone Year for the Island and Isolated Service Region (GWh/yr.)

| Building Type | Milestone Year | Total | General Lighting | Secondary Lighting | Outdoor Lighting | Computer Equipment | Other Plug Loads | Food Service Equipment | Refrigeration | Elevators | Miscellaneous | Space Heating | Space Cooling | HVAC Fans and Pumps | Domestic Hot Water | Street Lighting |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Office | 2011 | 122.9 | 40.6 | 11.0 | 0.7 | 21.9 | 0.0 | 0.0 | 0.2 | 0.0 | 0.1 | 14.2 | 5.0 | 26.7 | 2.7 | |
| | 2016 | 146.4 | 41.1 | 11.1 | 1.0 | 23.7 | 0.0 | 0.0 | 0.3 | 0.0 | 0.1 | 32.8 | 5.6 | 27.7 | 2.9 | |
| | 2021 | 169.0 | 41.8 | 11.3 | 1.3 | 25.8 | 0.0 | 0.0 | 0.4 | 0.0 | 0.2 | 49.7 | 6.3 | 28.9 | 3.2 | |
| | 2026 | 190.1 | 42.5 | 11.5 | 1.7 | 28.1 | 0.0 | 0.1 | 0.4 | 0.0 | 0.3 | 64.9 | 6.9 | 30.2 | 3.5 | |
| Non-food Retail | 2011 | 48.1 | 27.5 | 2.7 | 0.5 | 2.0 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 3.9 | 3.3 | 7.3 | 0.7 | |
| | 2016 | 53.8 | 27.6 | 2.7 | 0.7 | 2.2 | 0.0 | 0.0 | 0.3 | 0.0 | 0.0 | 8.3 | 3.5 | 7.6 | 0.8 | |
| | 2021 | 59.2 | 27.9 | 2.8 | 0.9 | 2.4 | 0.0 | 0.0 | 0.3 | 0.0 | 0.0 | 12.3 | 3.6 | 8.0 | 0.8 | |
| | 2026 | 64.2 | 28.2 | 2.9 | 1.1 | 2.6 | 0.0 | 0.0 | 0.3 | 0.0 | 0.0 | 15.9 | 3.8 | 8.5 | 0.9 | |
| Food Retail | 2011 | 26.9 | 10.0 | 1.1 | 0.2 | 1.1 | 0.0 | 0.0 | 10.3 | 0.0 | 0.0 | 0.0 | 0.6 | 2.8 | 0.8 | |
| | 2016 | 40.1 | 10.1 | 1.2 | 0.4 | 1.1 | 0.0 | 0.1 | 20.6 | 0.0 | 0.0 | 2.1 | 0.6 | 3.0 | 0.9 | |
| | 2021 | 44.3 | 10.4 | 1.2 | 0.5 | 1.2 | 0.1 | 0.1 | 22.0 | 0.0 | 0.0 | 3.9 | 0.7 | 3.2 | 1.0 | |
| | 2026 | 48.3 | 10.6 | 1.3 | 0.6 | 1.4 | 0.1 | 0.1 | 23.5 | 0.0 | 0.0 | 5.4 | 0.8 | 3.4 | 1.1 | |
| Healthcare | 2011 | 28.4 | 2.1 | 9.0 | 0.5 | 2.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 5.4 | 0.6 | 7.0 | 1.5 | |
| | 2016 | 31.0 | 2.1 | 8.9 | 0.6 | 2.5 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 7.3 | 0.8 | 7.2 | 1.6 | |
| | 2021 | 33.7 | 2.0 | 8.8 | 0.7 | 2.6 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 9.2 | 1.0 | 7.4 | 1.7 | |
| | 2026 | 36.5 | 2.0 | 8.7 | 0.8 | 2.7 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 11.3 | 1.2 | 7.6 | 1.9 | |
| Schools | 2011 | 30.1 | 8.9 | 1.5 | 0.5 | 4.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 11.2 | 0.0 | 2.5 | 1.4 | |
| | 2016 | 39.3 | 9.4 | 2.6 | 0.7 | 4.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 18.0 | 0.0 | 2.7 | 1.5 | |
| | 2021 | 48.6 | 9.9 | 3.7 | 0.9 | 4.7 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 24.7 | 0.0 | 2.9 | 1.7 | |
| | 2026 | 57.5 | 10.5 | 4.7 | 1.1 | 5.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 31.0 | 0.0 | 3.0 | 1.8 | |
| Accomodations | 2011 | 33.9 | 8.4 | 10.3 | 0.2 | 1.5 | 0.0 | 0.0 | 0.5 | 0.0 | 0.0 | -0.2 | 0.7 | 2.9 | 9.6 | |
| | 2016 | 41.5 | 8.4 | 10.4 | 0.3 | 1.6 | 0.0 | 0.1 | 1.0 | 0.0 | 0.0 | 5.5 | 0.8 | 3.1 | 10.4 | |
| | 2021 | 48.5 | 8.4 | 10.5 | 0.4 | 1.7 | 0.0 | 0.1 | 1.0 | 0.0 | 0.0 | 10.8 | 1.0 | 3.3 | 11.4 | |
| | 2026 | 55.3 | 8.5 | 10.6 | 0.5 | 1.9 | 0.0 | 0.1 | 1.0 | 0.0 | 0.1 | 15.6 | 1.1 | 3.5 | 12.4 | |
| University/College | 2011 | 34.7 | 11.2 | 2.8 | 0.2 | 6.1 | 0.0 | 0.0 | 0.5 | 0.0 | 0.0 | 0.4 | 0.3 | 12.4 | 0.9 | |
| | 2016 | 36.9 | 11.1 | 2.7 | 0.4 | 6.4 | 0.0 | 0.0 | 1.0 | 0.0 | 0.0 | 1.6 | 0.4 | 12.4 | 0.9 | |
| | 2021 | 38.7 | 10.9 | 2.7 | 0.5 | 6.7 | 0.0 | 0.0 | 1.0 | 0.0 | 0.0 | 3.0 | 0.5 | 12.5 | 0.9 | |
| | 2026 | 40.6 | 10.8 | 2.6 | 0.6 | 7.0 | 0.0 | 0.0 | 1.0 | 0.0 | 0.0 | 4.4 | 0.6 | 12.6 | 1.0 | |
| Warehouse/Wholesale | 2011 | 13.6 | 8.4 | 1.1 | 0.2 | 1.1 | 0.0 | 0.0 | 0.8 | 0.0 | 0.0 | -0.1 | 0.1 | 1.5 | 0.5 | |
| | 2016 | 17.2 | 8.5 | 1.1 | 0.3 | 1.2 | 0.0 | 0.0 | 1.6 | 0.0 | 0.0 | 2.3 | 0.1 | 1.5 | 0.6 | |
| | 2021 | 20.0 | 8.7 | 1.1 | 0.4 | 1.2 | 0.0 | 0.0 | 1.6 | 0.0 | 0.0 | 4.6 | 0.1 | 1.6 | 0.6 | |
| | 2026 | 22.7 | 8.9 | 1.1 | 0.5 | 1.3 | 0.0 | 0.0 | 1.7 | 0.0 | 0.0 | 6.8 | 0.1 | 1.6 | 0.7 | |
| Small Commercial | 2011 | 120.1 | | | | | | | | | | | | | | |
| | 2016 | 126.6 | | | | | | | | | | | | | | |
| | 2021 | 133.3 | | | | | | | | | | | | | | |
| | 2026 | 139.2 | | | | | | | | | | | | | | |
| Other Buildings | 2011 | 21.4 | | | | | | | | | | | | | | |
| | 2016 | 22.2 | | | | | | | | | | | | | | |
| | 2021 | 22.9 | | | | | | | | | | | | | | |
| | 2026 | 23.8 | | | | | | | | | | | | | | |
| Non Buildings | 2011 | 0.0 | | | | | | | | | | | | | | |
| | 2016 | 0.0 | | | | | | | | | | | | | | |
| | 2021 | 0.0 | | | | | | | | | | | | | | |
| | 2026 | 0.0 | | | | | | | | | | | | | | |
| Isolated Buildings | 2011 | 1.9 | | | | | | | | | | | | | | |
| | 2016 | 2.2 | | | | | | | | | | | | | | |
| | 2021 | 2.4 | | | | | | | | | | | | | | |
| | 2026 | 2.5 | | | | | | | | | | | | | | |
| Streetlighting | 2011 | 11.8 | | | | | | | | | | | | | | 11.8 |
| | 2016 | 11.8 | | | | | | | | | | | | | | 11.8 |
| | 2021 | 11.8 | | | | | | | | | | | | | | 11.8 |
| | 2026 | 11.9 | | | | | | | | | | | | | | 11.9 |
| Total | 2011 | 493.9 | 117.0 | 39.4 | 3.0 | 40.0 | 0.0 | 0.1 | 12.4 | 0.0 | 0.1 | 34.7 | 10.6 | 63.1 | 18.2 | 11.8 |
| | 2016 | 569.0 | 118.3 | 40.7 | 4.2 | 43.0 | 0.0 | 0.3 | 24.7 | 0.0 | 0.2 | 77.9 | 11.8 | 65.3 | 19.6 | 11.8 |
| | 2021 | 632.4 | 120.1 | 42.1 | 5.5 | 46.5 | 0.1 | 0.4 | 26.3 | 0.0 | 0.4 | 118.2 | 13.2 | 67.8 | 21.4 | 11.8 |
| | 2026 | 692.5 | 121.9 | 43.4 | 6.9 | 50.1 | 0.1 | 0.6 | 28.0 | 0.0 | 0.5 | 155.2 | 14.7 | 70.5 | 23.2 | 11.9 |

*Notes: 1) Savings are at customer's point-of-use. 2) Any differences in totals are due to rounding.*

## Exhibit 5.6: Total Potential Electricity Savings by End Use, Building Type and Milestone Year for the Labrador Interconnected Service Region (GWh/yr.)

| Building Type | Milestone Year | Total | General Lighting | Secondary Lighting | Outdoor Lighting | Computer Equipment | Other Plug Loads | Food Service Equipment | Refrigeration | Elevators | Miscellaneous | Space Heating | Space Cooling | HVAC Fans and Pumps | Domestic Hot Water | Street Lighting |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Office | 2011 | 1.2 | 0.2 | 0.0 | 0.0 | 0.6 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.3 | 0.1 | |
| | 2016 | 1.9 | 0.3 | 0.0 | 0.0 | 0.7 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.4 | 0.0 | 0.3 | 0.1 | |
| | 2021 | 2.6 | 0.5 | 0.0 | 0.0 | 0.7 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.9 | 0.1 | 0.3 | 0.1 | |
| | 2026 | 3.3 | 0.6 | 0.0 | 0.0 | 0.8 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.4 | 0.1 | 0.3 | 0.1 | |
| Non-food Retail | 2011 | 6.4 | 4.3 | 0.1 | 0.1 | 0.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | 0.2 | 0.7 | 0.2 | |
| | 2016 | 7.6 | 4.7 | 0.1 | 0.2 | 0.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.8 | 0.3 | 0.8 | 0.2 | |
| | 2021 | 8.8 | 5.0 | 0.1 | 0.2 | 0.6 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.5 | 0.3 | 0.9 | 0.2 | |
| | 2026 | 10.0 | 5.4 | 0.1 | 0.2 | 0.6 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 2.1 | 0.4 | 0.9 | 0.2 | |
| Food Retail | 2011 | 1.5 | 0.4 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.2 | 0.0 | 0.0 | 0.5 | 0.0 | 0.1 | 0.1 | |
| | 2016 | 1.9 | 0.5 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.3 | 0.0 | 0.0 | 0.6 | 0.0 | 0.1 | 0.1 | |
| | 2021 | 2.2 | 0.6 | 0.1 | 0.0 | 0.1 | 0.0 | 0.0 | 0.4 | 0.0 | 0.0 | 0.6 | 0.0 | 0.2 | 0.1 | |
| | 2026 | 2.5 | 0.8 | 0.1 | 0.1 | 0.1 | 0.0 | 0.0 | 0.5 | 0.0 | 0.0 | 0.6 | 0.0 | 0.2 | 0.1 | |
| Healthcare | 2011 | 3.3 | 0.2 | 0.9 | 0.1 | 0.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | 0.0 | 0.5 | 0.9 | |
| | 2016 | 4.2 | 0.2 | 1.1 | 0.1 | 0.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.6 | 0.1 | 0.6 | 0.9 | |
| | 2021 | 4.7 | 0.3 | 1.2 | 0.1 | 0.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.9 | 0.1 | 0.6 | 0.9 | |
| | 2026 | 5.1 | 0.3 | 1.3 | 0.2 | 0.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.2 | 0.1 | 0.6 | 0.9 | |
| Schools | 2011 | 1.3 | 0.2 | 0.1 | 0.0 | 0.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.3 | 0.0 | 0.3 | 0.1 | |
| | 2016 | 1.8 | 0.4 | 0.1 | 0.0 | 0.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.5 | 0.0 | 0.3 | 0.1 | |
| | 2021 | 2.1 | 0.5 | 0.1 | 0.1 | 0.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.6 | 0.0 | 0.3 | 0.1 | |
| | 2026 | 2.3 | 0.6 | 0.2 | 0.1 | 0.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.7 | 0.0 | 0.3 | 0.1 | |
| Accomodations | 2011 | 1.0 | 0.3 | 0.3 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | -0.1 | 0.0 | 0.1 | 0.4 | |
| | 2016 | 1.3 | 0.3 | 0.3 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 | 0.1 | 0.4 | |
| | 2021 | 1.5 | 0.3 | 0.3 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.3 | 0.0 | 0.1 | 0.5 | |
| | 2026 | 1.8 | 0.3 | 0.3 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.5 | 0.0 | 0.1 | 0.5 | |
| University/College | 2011 | 0.7 | 0.1 | 0.0 | 0.0 | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | -0.1 | 0.0 | 0.3 | 0.1 | |
| | 2016 | 1.1 | 0.2 | 0.0 | 0.0 | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 | 0.3 | 0.1 | |
| | 2021 | 1.3 | 0.3 | 0.0 | 0.0 | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.3 | 0.0 | 0.3 | 0.1 | |
| | 2026 | 1.5 | 0.3 | 0.0 | 0.0 | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.4 | 0.0 | 0.3 | 0.1 | |
| Warehouse/Wholesale | 2011 | 0.8 | 0.3 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | -0.1 | 0.0 | 0.2 | 0.1 | |
| | 2016 | 1.2 | 0.6 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | 0.1 | |
| | 2021 | 1.6 | 0.9 | 0.0 | 0.1 | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 | 0.2 | 0.1 | |
| | 2026 | 2.0 | 1.1 | 0.1 | 0.1 | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | 0.0 | 0.2 | 0.1 | |
| Small Commercial | 2011 | 5.3 | | | | | | | | | | | | | | |
| | 2016 | 5.9 | | | | | | | | | | | | | | |
| | 2021 | 6.2 | | | | | | | | | | | | | | |
| | 2026 | 6.5 | | | | | | | | | | | | | | |
| Other Buildings | 2011 | 2.2 | | | | | | | | | | | | | | |
| | 2016 | 2.3 | | | | | | | | | | | | | | |
| | 2021 | 2.4 | | | | | | | | | | | | | | |
| | 2026 | 2.5 | | | | | | | | | | | | | | |
| Non Buildings | 2011 | 0.0 | | | | | | | | | | | | | | |
| | 2016 | 0.0 | | | | | | | | | | | | | | |
| | 2021 | 0.0 | | | | | | | | | | | | | | |
| | 2026 | 0.0 | | | | | | | | | | | | | | |
| Other Institutional | 2011 | 5.7 | | | | | | | | | | | | | | |
| | 2016 | 5.7 | | | | | | | | | | | | | | |
| | 2021 | 5.8 | | | | | | | | | | | | | | |
| | 2026 | 5.8 | | | | | | | | | | | | | | |
| Streetlighting | 2011 | 0.0 | | | | | | | | | | | | | | 0.0 |
| | 2016 | 0.0 | | | | | | | | | | | | | | 0.0 |
| | 2021 | 0.0 | | | | | | | | | | | | | | 0.0 |
| | 2026 | 0.0 | | | | | | | | | | | | | | 0.0 |
| Total | 2011 | 29.4 | 6.0 | 1.4 | 0.4 | 2.4 | 0.0 | 0.1 | 0.3 | 0.0 | 0.0 | 1.0 | 0.4 | 2.5 | 1.9 | 0.0 |
| | 2016 | 34.9 | 7.3 | 1.7 | 0.5 | 2.6 | 0.0 | 0.1 | 0.4 | 0.0 | 0.0 | 3.2 | 0.4 | 2.7 | 2.0 | 0.0 |
| | 2021 | 39.2 | 8.3 | 1.9 | 0.6 | 2.7 | 0.0 | 0.1 | 0.5 | 0.0 | 0.0 | 5.2 | 0.5 | 2.9 | 2.1 | 0.0 |
| | 2026 | 43.4 | 9.3 | 2.1 | 0.7 | 2.9 | 0.0 | 0.1 | 0.6 | 0.0 | 0.0 | 7.2 | 0.6 | 3.0 | 2.1 | 0.0 |

*Notes: 1) Savings are at customer's point-of-use. 2) Any differences in totals are due to rounding.*

**Exhibit 5.7: Savings by Major End Use and Building Type for the Island and Isolated Service Region, 2026**

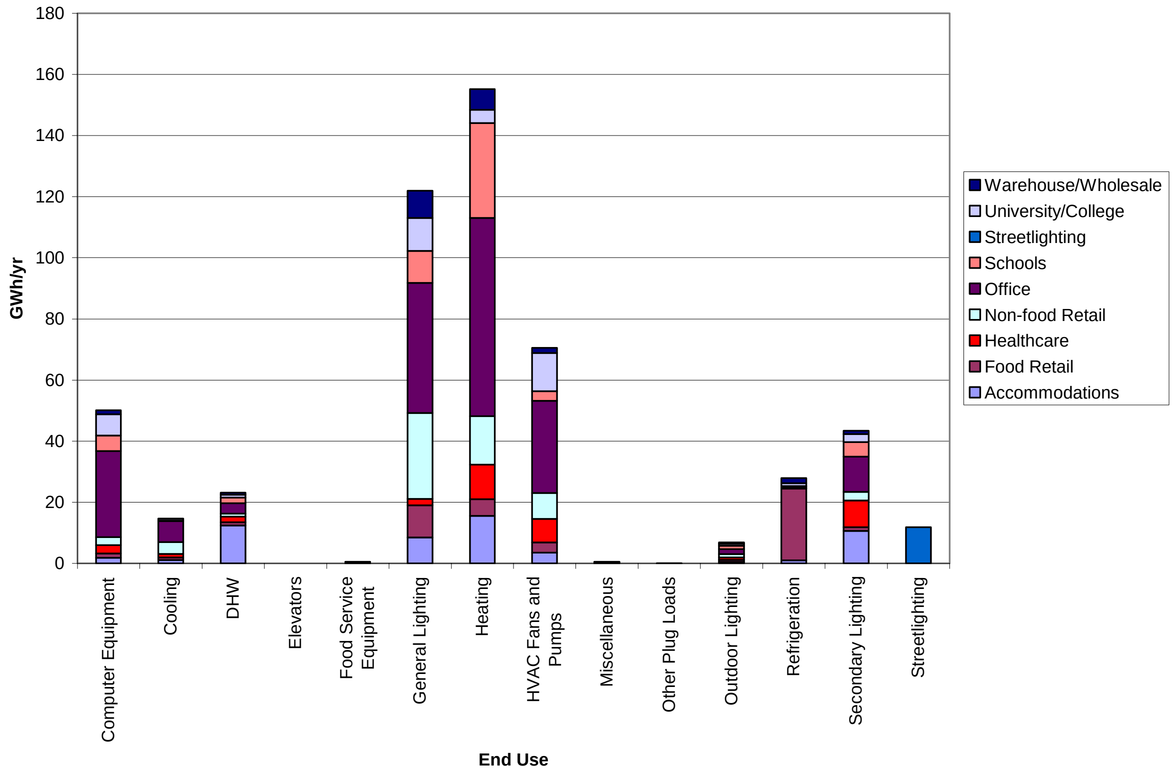



**Exhibit 5.8: Savings by Major End Use and Building Type for the Labrador Interconnected Service Region, 2026**

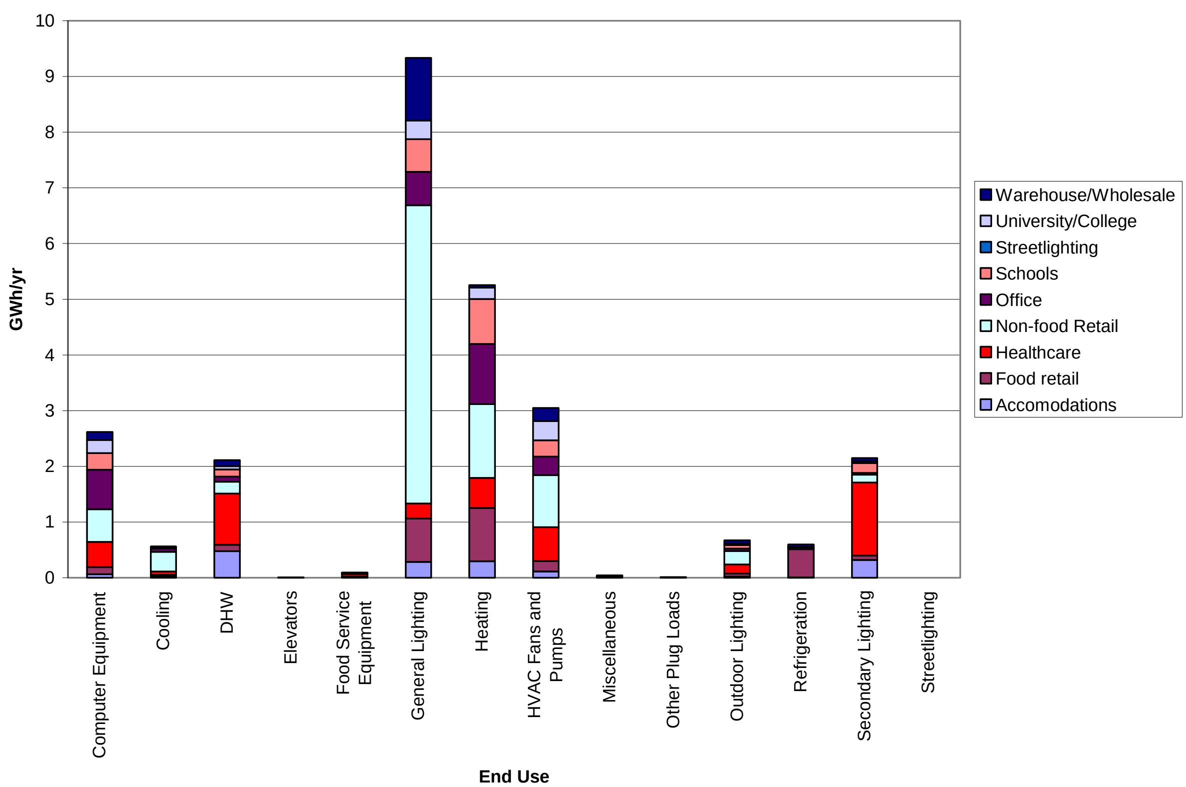


**Exhibit 5.9: Savings by Major End Use and Vintage for the Island and Isolated Service Region, 2026**

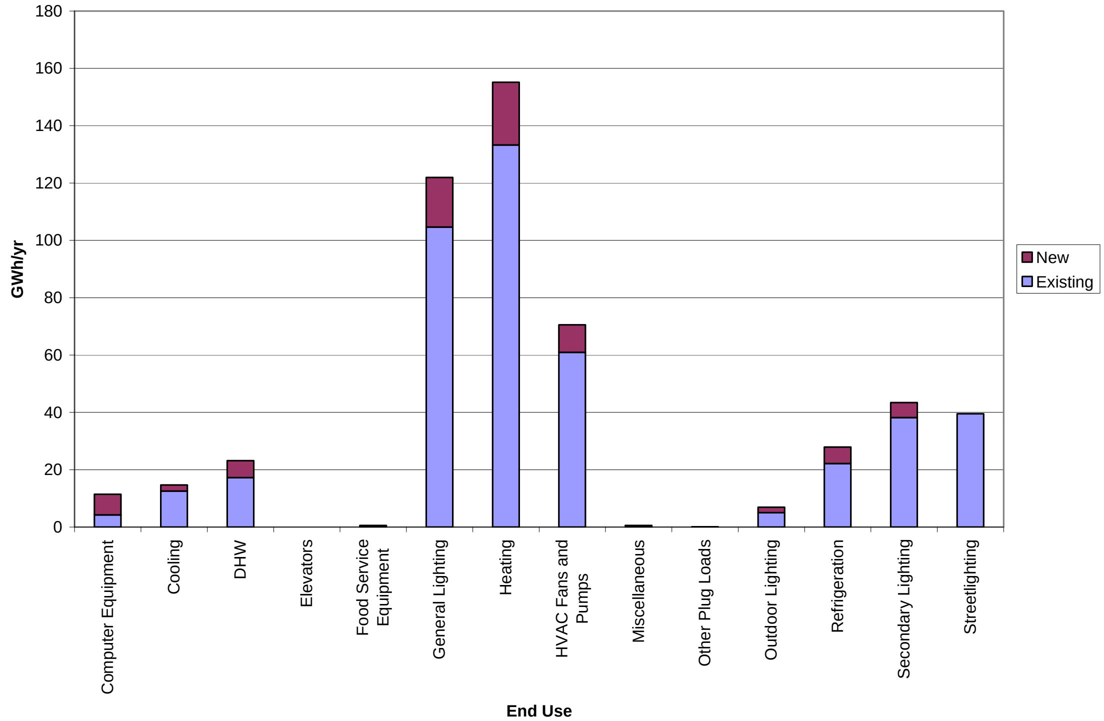
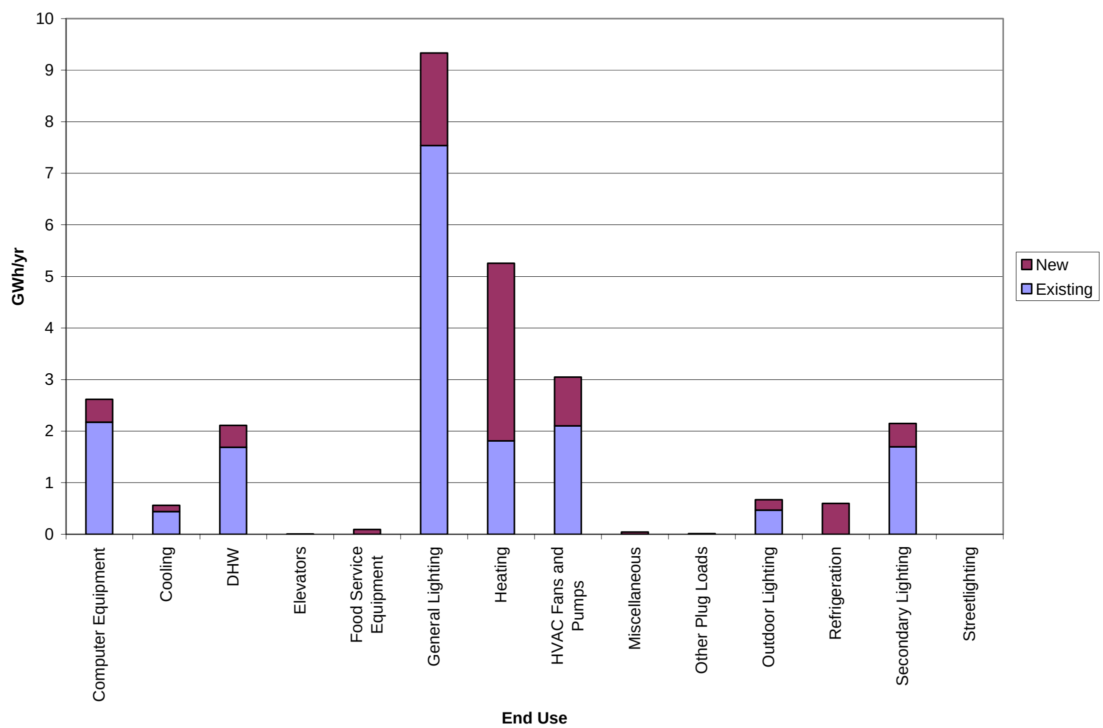



**Exhibit 5.10: Savings by Major End Use and Vintage for the Labrador Interconnected Service Region, 2026**



### 5.5.1 Interpretation of Results

Highlights:

- **Electricity Savings by Service Region**

The Island and Isolated service region has the largest economic potential savings at approximately 94% of the total, followed by the Labrador Interconnected service region at 6% in 2026.

- **Electricity Savings by Sub Sector**

In the Island and Isolated service region, the Office sub sector has the largest economic potential at approximately 27% of the total in 2026, followed by Small Commercial at 20%, Non-food Retail at 9% and Schools and Accommodations at 8%.

In the Labrador Interconnected service region, the Non-food Retail sub sector has the largest economic potential at 22% of the total in 2026, followed by Small Commercial at 16%, Other Institutional at 14% and Healthcare at 11%.

- **Electricity Savings by End Use**

In the Island and Isolated service region, the space heating end use has the largest economic potential at approximately 29% of the total in 2026, followed by general lighting at 23%, HVAC fans and pumps at 12% and computer equipment at 10%.

In the Labrador Interconnected service region, the general lighting end use has the largest economic potential at approximately 35% of the total in 2026, followed by space heating at 20%, HVAC fans and pumps at 13% and computer equipment at 10%.

*Note 1: In some cases, the space heating savings are negative due to a reduction in internal heat gains associated with lighting, computer equipment and HVAC efficiency measures.*

*Note 2: As shown in Exhibit 5.10, in the Labrador Interconnected service region, space heating savings in existing buildings represent a small proportion of the total space heating savings. This is due to the fact that few space heating measures for existing buildings pass the economic screen.*

### 5.5.2 Caveats

A systems approach was used to model the energy impacts of the CDM measures presented in the preceding section. In the absence of a systems approach, there would be double counting of savings and an accurate assessment of the total contribution of the energy-efficient upgrades would not be possible. More specifically, there are two particularly important considerations:

- **More than one upgrade may affect a given end use**. For example, improved insulation reduces space heating electricity use, as does the installation of a heat pump. On their own, each measure will reduce overall space heating electricity use. However, the two savings are not additive. The order in which some upgrades are introduced is also important. In this study, the approach has been to select and model the impact of "bundles of measures" that reduce the load for a given end use (e.g., wall insulation and window upgrades that reduce the space heating load) and then to introduce measures that meet the remaining load more efficiently (e.g., a high-efficiency space heating system).

- **There are interactive effects among end uses**. For example, the electricity savings from more efficient lighting results in reduced heat generation. During the space heating season, internal heat gains lower the amount of heat that must be provided by the space heating system and, conversely, increase the amount of heat that must be removed by the space cooling system. For instance, in a typical commercial building, a measure with a 25% reduction in lighting energy would result in a 2% to 4% increase in space heating energy. Interactive effects have been analyzed using CEEAM for each measure and are included in the Economic and Achievable Forecasts.

### 5.5.3 Sensitivity Analysis – Alternative Avoided Costs

A sensitivity analysis was conducted using preliminary avoided cost values that assume development of the Lower Churchill/DC link. The analysis reviewed the scope of measures that would pass or fail the economic screen under the changed avoided costs. Based on the preliminary avoided cost values assessed, the analysis concluded that any impacts would be modest.

## 5.6 CDM MEASURE SUPPLY CURVES

A supply curve was constructed for each of the service regions based on the economic potential savings associated with the above measures. The following approach was followed:

- Measures are introduced in sequence to see incremental impact and cost
- Sequence is determined by principle of 1) reduce load, then 2) meeting residual load with most efficient technology
- Is organized by CCE levels.

Exhibits 5.11 and 5.12 show the supply curves for, respectively, the Island and Isolated and the Labrador Interconnected service regions. Exhibits 5.13 and 5.14 show the measures included in each of the supply curves.

*Note: The average CCE is the weighted average of all sub sector CCEs for a particular measure. It is calculated by adding measure costs for all sub sectors and dividing the result by total electricity saving, inclusive of interactive effects across all sub sectors. The following exhibits may include measures with a CCE that exceeds the study's avoided cost threshold. This increased CCE is due to the impact of interactive effects. The measures shown maintain consistency with previous exhibits.*

**Exhibit 5.11: Supply Curve for Commercial Sector, Island and Isolated Service Region, 2026**

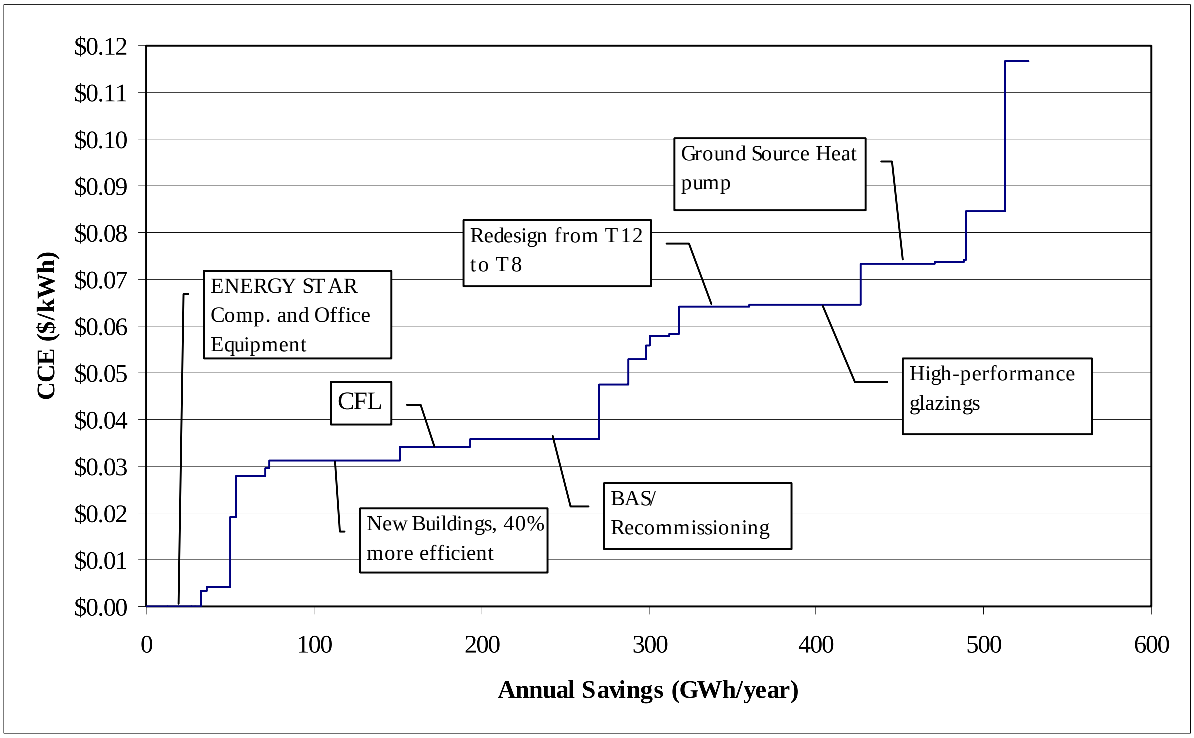
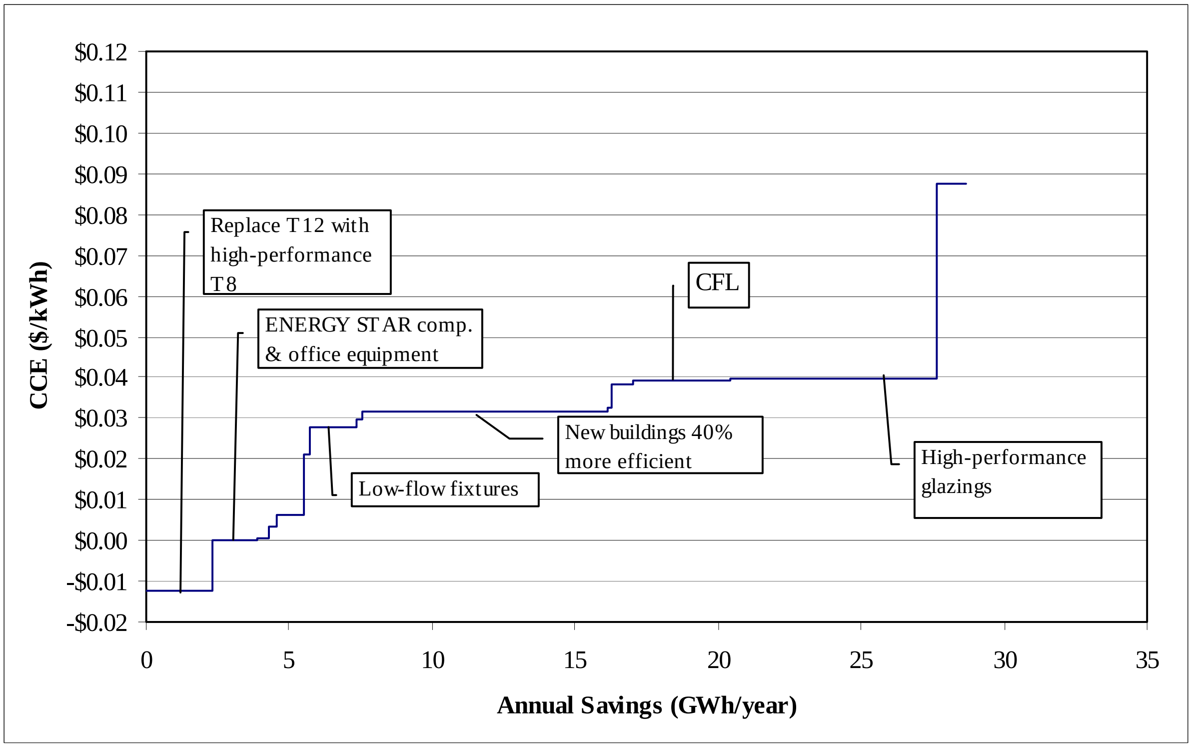


**Exhibit 5.12: Supply Curve for Commercial Sector, Labrador Interconnected Service Region, 2026**



## Exhibit 5.13: Summary of Commercial Sector Energy-efficiency Measures, Island and Isolated Service Region 2026

| Measure | Average* CCE ($/kWh) | Annual Savings (GWh/yr) |
|---|---|---|
| ENERGY STAR computers | $0.000 | 26 |
| ENERGY STAR office equipment | $0.000 | 6 |
| Pulse-start metal halide | $0.003 | 3 |
| High-intensity fluorescent | $0.004 | 15 |
| High-efficiency servers | $0.019 | 4 |
| Low-flow aerators & shower heads | $0.028 | 17 |
| Compact fluorescent lamps (Outdoor) | $0.029 | 2 |
| New buildings - 40% more efficient | $0.031 | 78 |
| Compact fluorescent lamps | $0.034 | 42 |
| Advanced BAS/Recommissioning | $0.036 | 76 |
| HE supermarket refrigeration | $0.047 | 18 |
| Occupancy sensors | $0.053 | 10 |
| Adjustable speed drives | $0.056 | 2 |
| Dimming controls | $0.058 | 12 |
| Air curtains | $0.058 | 6 |
| T12 Baseline - Redesign with high-performance T8s | $0.064 | 42 |
| High-performance glazings | $0.065 | 66 |
| ENERGY STAR refrigerators & freezers | $0.073 | 4 |
| Ground source heat pumps | $0.073 | 40 |
| Wall insulation | $0.074 | 17 |
| High-efficiency chillers | $0.074 | 1 |
| Roof insulation | $0.085 | 24 |
| T8 Baseline - Redesign with high-performance T8s | $0.117 | 14 |

## Exhibit 5.14: Summary of Commercial Sector Energy-efficiency Measures, Labrador Interconnected Service Region 2026

| Measure | Average* CCE ($/kWh) | Annual Savings (GWh/yr) |
|---|---|---|
| T12 baseline - redesign with high-performance T8s | -$0.012 | 2.3 |
| ENERGY STAR computers | $0.000 | 1.3 |
| ENERGY STAR office equipment | $0.000 | 0.3 |
| T8 baseline - redesign with high-performance T8s | $0.000 | 0.4 |
| Pulse-start metal halide | $0.003 | 0.3 |
| High-intensity fluorescents | $0.006 | 0.9 |
| High-efficiency servers | $0.021 | 0.2 |
| Low-flow aerators & shower heads | $0.028 | 1.7 |
| Compact fluorescent lamps (Outdoor) | $0.029 | 0.2 |
| New buildings - 40% more efficient | $0.031 | 8.6 |
| Premium efficiency motors | $0.032 | 0.1 |
| Air curtains | $0.038 | 0.7 |
| Compact fluorescent lamps | $0.039 | 3.4 |
| High-performance glazings | $0.040 | 7.2 |
| Advanced BAS/Recommissioning | $0.088 | 1.0 |

# 6. ACHIEVABLE POTENTIAL

## 6.1 INTRODUCTION

This section presents the Commercial sector Achievable Potential electricity savings for the study period. The Achievable Potential is defined as the proportion of the savings identified in the Economic Potential Forecast that could realistically be achieved within the study period.

The remainder of this discussion is organized into the following subsections:

- Description of Achievable Potential
- Approach to the estimation of Achievable Potential
- Workshop results
- Summary of Achievable electricity savings
- Peak load impacts.

## 6.2 DESCRIPTION OF ACHIEVABLE POTENTIAL

Achievable Potential recognizes that it is difficult to induce all customers to purchase and install all the electrical efficiency technologies that meet the criteria defined by the Economic Potential Forecast. For example, customer decisions to implement energy-efficient measures can be constrained by important factors such as:

- Higher first cost of efficient product(s)
- Need to recover investment costs in a short period (payback)
- Lack of product performance information
- Lack of product availability
- Consumer awareness.

The rate at which customers accept and purchase energy-efficient products can be influenced by a variety of factors including, the level of financial incentives, information and other measures put in place by the utilities, governments and the private sector to remove barriers such as those noted above.

Exhibit 6.1 presents the level of electricity consumption that is estimated in the Achievable Potential scenarios. As illustrated, the Achievable Potential scenarios are "banded" by the two forecasts presented in previous sections, namely the Economic Potential Forecast and the Reference Case.

Electricity savings under Achievable Potential are typically less than in the Economic Potential Forecast. In the Economic Potential Forecast, efficient new technologies are assumed to fully penetrate the market as soon as it is financially attractive to do so. However, the Achievable Potential recognizes that under "real world" conditions, the rate at which customers are likely to implement new technologies will be influenced by additional practical considerations and will, therefore, occur more slowly than under the assumptions employed in the Economic Potential Forecast. Exhibit 6.1 also shows that future electricity consumption under the Reference Case is greater than in either of the two Achievable Potential Forecasts. This is because the Reference

Case represents a "worst case" situation in which there are no additional utility market interventions and hence no additional electricity savings beyond those that occur "naturally."

Exhibit 6.1 presents the achievable results as a band of possibilities, rather than a single line. This recognizes that any estimate of Achievable Potential over a 20-year period is necessarily subject to uncertainty and that there are different levels of potential CDM program intervention.

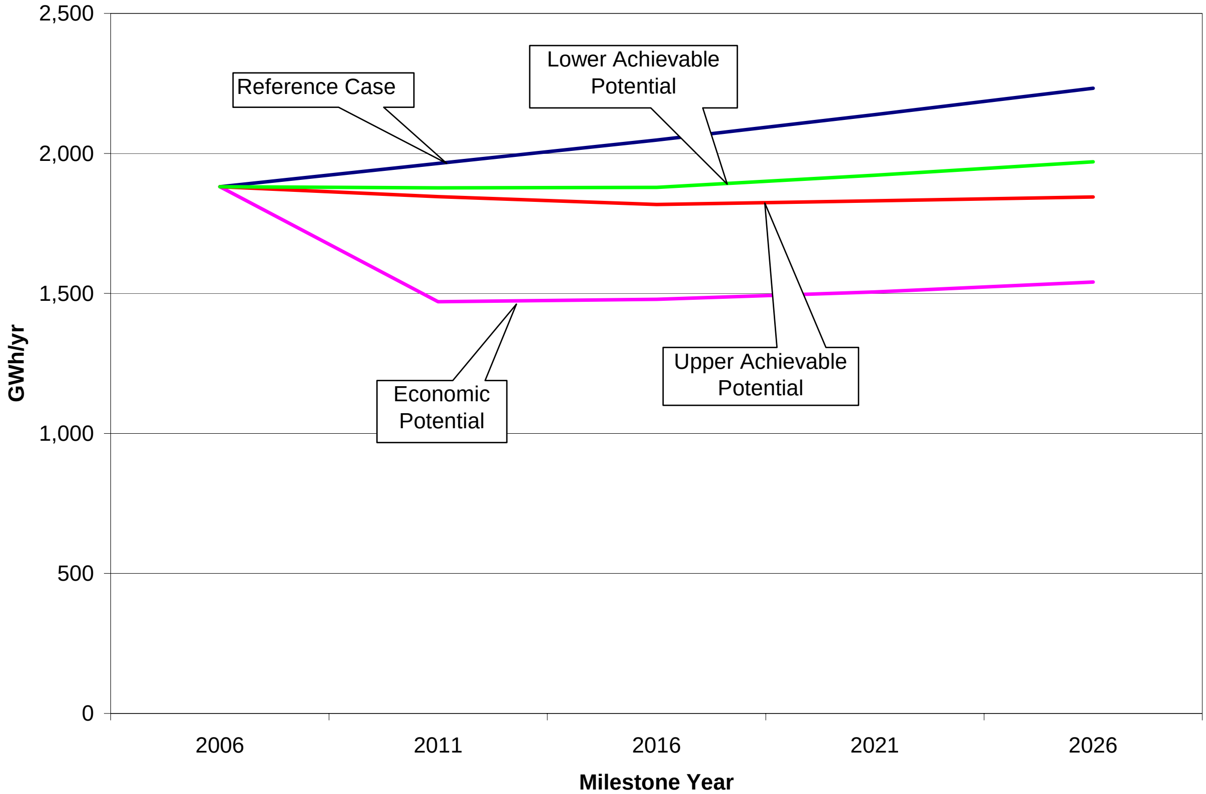
- **The Upper Achievable Potential** assumes both an aggressive program approach and a very supportive context, e.g., healthy economy, very strong public commitment to climate change mitigation, etc.

  However, the Upper Achievable Potential scenario also recognizes that there are limits to the scope of influence of any electric utility. It recognizes that some markets or submarkets may be so price sensitive or constrained by market barriers beyond the influence of CDM programs that they will only fully act if forced to by legal or other legislative means. It also recognizes that there are practical constraints related to the pace that existing inefficient equipment can be replaced by new, more efficient models or that existing building stock can be retrofitted to new energy performance levels.

  For the purposes of this study, the Upper Achievable Potential can, informally, be described as: *"Economic Potential less those customers that "can't" or "won't" participate."*

- **The Lower Achievable Potential** assumes that existing CDM programs and the scope of technologies addressed are expanded, but at a more modest level than in the Upper Achievable Potential. Market interest and customer commitment to energy efficiency and sustainable environmental practices remain approximately as current. Similarly, federal, provincial and municipal government energy-efficiency and GHG mitigation efforts remain similar to the present.

**Exhibit 6.1: Annual Electricity Consumption – Illustration of Achievable Potential Relative to Reference Case and Economic Potential Forecast for the Commercial Sector (GWh/yr.)**



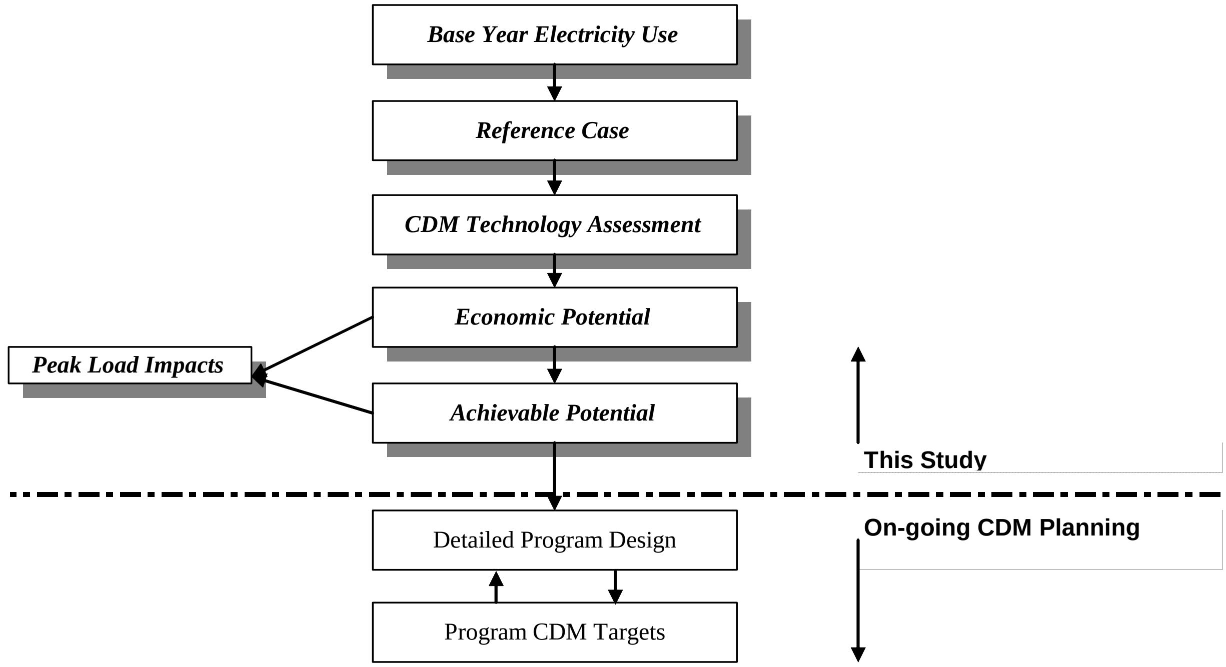

## Achievable Potential versus Detailed Program Design

It should be emphasized that the estimation of Achievable Potential is not synonymous with either the setting of specific program targets or with program design. While both are closely linked to the discussion of Achievable Potential, they involve more detailed analysis that is beyond the scope of this study.[50]

Exhibit 6.2 illustrates the relationship between Achievable Potential and the more detailed program design.

[50] The Achievable Potential savings assume program start-up in 2007. Consequently, electricity savings in the first milestone year of 2011 will need to be adjusted to reflect actual program initiation dates. This step will occur during the detailed program design phase, which will follows this study.

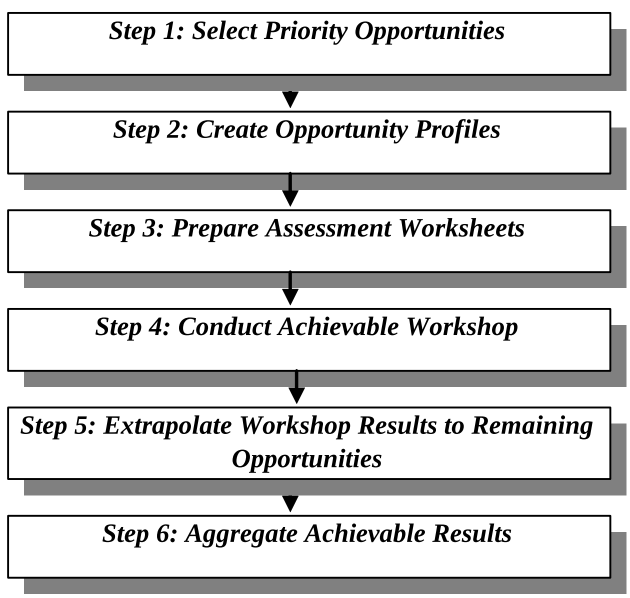
**Exhibit 6.2: Achievable Potential versus Detailed Program Design**




## 6.3 APPROACH TO THE ESTIMATION OF ACHIEVABLE POTENTIAL

Achievable Potential was estimated in a six-step approach. A schematic showing the major steps is shown in Exhibit 6.3 and each step is discussed below.

**Exhibit 6.3: Approach to Estimating Achievable Potential**



### Step 1: Select Priority Opportunities

The first step in developing the Achievable Potential estimates required that the energy-saving opportunities identified in the Economic Potential Forecasts be "bundled" into a set of opportunity areas that would facilitate the subsequent assessment of their potential market penetration.

The amount of time available in the Achievable Potential workshop for the discussion of energy-efficiency opportunities was limited. Consequently, the energy-efficiency opportunity areas shown in Exhibit 6.4 were selected based primarily on the basis that they represent a significant portion of the energy savings potential identified in the Economic Potential Forecast. Where two or more opportunities offered similar levels of potential energy savings, consideration was also given to whether discussion of the selected opportunity area in the workshop would provide insights into the participation rates to be used for related opportunities that could not be covered during the workshop.

Eight energy-efficiency opportunity areas were selected for discussion in the Commercial sector workshop that was held on October 31, 2007. Exhibit 6.4 identifies the opportunity areas and shows the approximate percentage that each represents of the total Commercial sector potential contained in the Economic Potential Forecast.

**Exhibit 6.4: Commercial Sector Opportunity Areas**

| Opportunity Area | Title | Approximate % of Economic Potential Savings |
|---|---|---|
| **C1** | T8 Fluorescent Upgrades (T12 Baseline) | 8% |
| **C2** | T8 Fluorescent Upgrades (T8 Baseline) | 3% |
| **C3** | Incandescent Upgrades | 8% |
| **C4** | Building Envelope Measures | 20% |
| **C5** | Building Recommissioning & Advanced BAS | 14% |
| **C6** | Ground Source Heat Pumps | 8% |
| **C7** | Advanced New Commercial Building Construction | 15% |
| **C8** | ENERGY STAR Computer Equipment | 7% |
| | **Total** | 83% |

### Step 2: Create Opportunity Profiles

The next step involved the development of brief profiles for the priority opportunity areas noted in Exhibit 6.4. A sample profile for Opportunity C1: T8 Fluorescent Upgrade (T12 baseline) is presented in Exhibit 6.5; the remaining Opportunity Profiles are provided in Appendix C.

The purpose of the Opportunity Profiles was to provide a "high-level" logic framework that would serve as a guide for participant discussions in the workshop. The intent was to define a broad rationale and direction without getting into the much greater detail required of program design, which, as noted previously, is beyond the scope of this project.

## Exhibit 6.5: Sample Opportunity Profile

**Opportunity Profile**

### C1 – T8 Fluorescent Upgrades (T12 Baseline)

***Overview:***

- General lighting in the commercial building stock is typically a mix of fluorescent T12 and T8 lighting systems.
- This Opportunity Profile covers the replacement of T12 lighting systems with advanced T8 technologies in commercial buildings.
- Our discussion will be based on Office buildings and will focus on the three standard approaches to achieving lighting energy savings:
  - Redesign with advanced T8s (new layout, fewer fixtures, lower light levels)
  - Retrofit with advanced T8s (relamp/reballast)
  - Occupancy controls (occupancy sensors, time-of day scheduling, etc.)
- The target market is the remaining stock of T12 lighting

***Target Technologies and Building Types:***

- The target technologies include: redesign with advanced T8s, retrofit with advanced T8s and controls as outlined above.
- The target market includes all existing commercial buildings with T12 lighting; however, the focus of our discussion is Office buildings (> 40,000 ft$^2$) in Newfoundland.
- The penetration of T12 lighting is estimated to be 60%

***Opportunity Costs and Savings Profile:***

- Redesign with advanced T8s: full cost $1.7/ft$^2$; savings 62%; CCE $0.056/kWh; simple payback 6 years.
- Retrofit with advanced T8s: full cost $1.0/ft$^2$; savings 39%; CCE $0.049/kWh; simple payback 6 years.
- Occupancy controls: full cost $0.5/ft$^2$; savings 30%; CCE $0.066 cents/kWh; simple payback 5 years.

***Target Audience(s) & Potential Delivery Allies:***

- Owners, developers, facility managers, BOMA members
- Lighting manufacturers and suppliers
- Lighting designers, IESNA
- Electrical maintenance contractors
- NRCan and Ministry of Energy re: lighting standards and regulations
- Performance contractors
- Commercial renovation contractors

***Constraints & Challenges:***

- The most significant barriers are:
  - Lack of customer awareness, e.g., energy savings, improved light quality, productivity, longer life
  - Split incentive, e.g., lease arrangements – commercial “triple net lease” discourages owner participation
  - High paybacks, particularly for the redesign upgrades
  - Financing, e.g., access to capital
  - Lack of standards to differentiate “advanced” T8, manufacturer sets own protocol

***Opportunities & Synergies:***

- Phasing out of T12s through regulations
- Trade ally alliances, tying trade “partners” to qualified leads
- Opportunities for work environment improvements, customized to work function needs
- Link to renovation upgrades, building sales

As illustrated in Exhibit 6.5, each Opportunity Profile addresses the following areas:

- ***Overview*** – provides a summary statement of the broad goal and rationale for the opportunity.

- ***Target Technologies and Building Types –*** highlights the major technologies and the sub sectors where the most significant opportunities have been identified in the Economic Potential Forecast.

- ***Opportunity Costs and Savings Profile*** – provides information on the financial attractiveness of the opportunity from the perspective of both the customer and NLH or NP.

- ***Target Audiences and Potential Delivery Allies*** – identifies key market players that would be expected to be involved in the actual delivery of services. The list of stakeholders shown is intended to be "indicative" and is by no means comprehensive.

- ***Constraints and Challenges –*** identifies key market barriers that are currently constraining the increased penetration of energy-efficient technologies or measures. Interventions for addressing the identified barriers are noted. Again, it is recognized that the interventions are not necessarily comprehensive; rather, their primary purpose was to help guide the workshop discussions.

- ***Opportunities and Synergies –*** identifies information or possible synergies with other opportunities that may affect workshop participant views on possible customer participation rates.

**Step 3: Prepare Draft Opportunity Assessment Worksheets**

A draft Assessment Worksheet was prepared for each Opportunity Profile in advance of the workshop. The Assessment Worksheets complemented the information contained in the Opportunity Profiles by providing quantitative data on the potential energy savings for each opportunity, as well as providing information on the size and composition of the eligible population of potential participants. Energy impacts and population data were taken from the detailed modelling results contained in the Economic Potential Forecast.

A sample Assessment Worksheet for Opportunity C3 – Incandescent Upgrades is presented in Exhibit 6.6 (worksheets for the remaining opportunity areas are provided in Appendix D). As illustrated in Exhibit 6.6, each Assessment Worksheet addresses the following areas:

- ***Total Economic Savings Potential –*** shows the yearly total of economically attractive potential for electricity savings, by milestone period, for the measures included in the opportunity area.

- ***Market Size –*** shows the total population of potential participants that could theoretically take part in the opportunity area. Numbers shown are from the eligible populations used in the Economic Potential Forecasts. The definition of "participant" varies by opportunity area. In the example shown, a participant is defined as an equivalent 40,000 $ft^2$ Office building.

- ***Major Technologies and Contribution to Savings –*** shows the technical components of each opportunity area and its approximate contribution to the economic potential savings of the opportunity area as a whole.

- ***Approximate CCE*** – shows the approximate CCE for the measure(s) included within each opportunity area. Where multiple measures are included, a weighted average value is presented. The CCE provides an indication of the relative economic attractiveness of the energy-efficiency measures from the utility's perspective. For the purposes of the workshop, this information provided participants with an indication of the scope for using financial incentives to influence customer participation rates. The CCE value, combined with the preceding customer payback information, provided an important reference point for the workshop participants when considering potential participation rates. The combined information enabled participants to "roughly" estimate the level of financial incentives that could be employed to increase the opportunity's attractiveness to customers without making the measures economically unattractive to NLH or NP.

- ***Approximate Payback*** – shows the simple payback from the customer's perspective for the package of energy-efficiency measures included in the opportunity area. This information provided an indication of the level of attractiveness that the opportunity measures would present to customers.

- ***Participation Rates, By Year –*** show the percentage of economic savings that workshop participants concluded could be achievable in each milestone period. As noted in the introduction to this section, two Achievable scenarios are shown: Lower and Upper. For example, Exhibit 6.6 shows a participation rate of 90% (Lower) and 98% (Upper) for the measure "Relamp incandescent with CFL" in existing offices by the year 2026. This means that, by 2026, between 90% and 98% of the potential savings contained in the Economic Potential Forecast could be achieved.

- ***Savings, By Year –*** shows the calculated electricity savings in each milestone period based on the savings and participation rates presented in the preceding columns of the Assessment Worksheet.

## Exhibit 6.6: Sample Commercial Sector Opportunity Assessment Worksheet

## Commercial Sector -- C3 -- Incandescent Upgrades

| **Sub Sector** | | **Office - Existing** | | | |
|---|---|---|---|---|---|
| **Total Economic Savings Potential (GWh/yr) in 2026** | General and Secondary Lighting | 10 | | | |
| **Market Size** | # of sites (approx.) | 381 | | | |
| | ft2 (approx.) | 15,250,000 | | | |
| | % eligible | 50% | Approx. 60% for LED exit sign | | |
| | # eligible sites | 191 | | | |
| **Major Technologies & Approx. Contribution to Economic Potential Savings** | CFL | 100% | | | |
| | LED Exit Sign | 0% | | | |
| | Other Technologies | 0% | | | |
| | *Sub total:* | 100% | | | |
| **Approx CCE (c/kWh)** | CFL | 2.9 | Full Cost | | |
| | LED Exit Sign | 2.0 | Full Cost | | |
| | Other Technologies | 0.5 - 5.0 | Full Cost | | |
| **Approx payback (years)** | CFL | 1.4 | | | |
| | LED Exit Sign | 3 | | | |
| | Other Technologies | 1 - 3 | | | |
| **Participation Rates, by Year (% of Eligible Sites)** | | ***2011*** | ***2016*** | ***2021*** | ***2026*** |
| ***Relamp Incandescent with CFL*** | *Lower* | | | | 90% |
| | *Upper* | | | | 98% |
| ***Incandescent to LED Exit Sign*** | *Lower* | | | | 95% |
| | *Upper* | | | | 98% |
| **Savings, by Year (GWh/yr)** | | ***2011*** | ***2016*** | ***2021*** | ***2026*** |
| ***Relamp Incandescent with CFL*** | *Lower* | | | | 8 |
| | *Upper* | | | | 9 |
| ***Incandescent to LED Exit Sign*** | *Lower* | | | | 1 |
| | *Upper* | | | | 1 |
| ***Total*** | *Lower* | | | | 9 |
| | *Upper* | | | | 10 |

**Step 4: Achievable Potential Workshop**

The most critical step in developing the estimates of Achievable Potential was the one-day workshop held October 31, 2007. Workshop participants consisted of core members of the consultant team, program personnel from NP and NLH and local trade allies.

The purpose of this workshop was twofold:

- Promote discussion regarding the technical and market conditions confronting the identified energy-efficiency opportunities

- Compile participant views related to how much of the identified economic savings could realistically be achieved over the study period.

The discussion of each opportunity area began with a brief consultant presentation. The floor was then opened to participant discussion. Key areas that were explored for each opportunity area included:

- Target audiences and potential delivery allies
- Constraints, barriers and challenges
- Potential opportunities and synergies
- Estimates of Lower Achievable and Upper Achievable for milestone years
- Guidelines for consultants for extrapolating to related sub sectors.

Following discussion of the broad market and intervention conditions affecting the opportunity areas, workshop participant views were recorded on Lower and Upper customer participation rates. To facilitate this portion, the discussion of the Commercial sector opportunity areas focused initially on Office buildings in the Island and Isolated service region. The following four-step process was employed:[51]

- The participation rate for the Upper Potential in 2026 was estimated. As noted previously, this participation rate was “roughly” defined as 100% of the Economic Potential minus the market share represented by the “can’t” or ‘won’t” population.

- The shape of the adoption curve was selected for the Upper scenario. Rather than seek consensus on the specific values to be employed in each of the intervening milestone years, workshop participants selected one of four curve shapes that best matched their view of the appropriate “ramp-up” rate for each opportunity.

- The preceding process was repeated for the Lower scenario.

[51] Some minor variations on these steps occurred, depending on the specific opportunity area; however, the general approach was applied across the range of opportunity areas.

Exhibit 6.7 shows the four curves that were used in the workshop discussions.

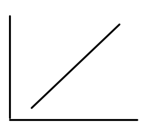
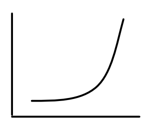
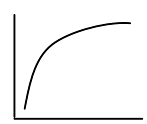
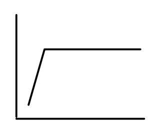
- **Curve A** represents a steady increase in the expected participation rate over the 20-year study period

- **Curve B** represents a relatively slow participation rate during the first half of the 20-year study period followed by a rapid growth in participation during the second half of the 20-year study period

- **Curve C** represents a rapid initial participation rate followed by a relatively slow growth in participation during the remainder of the 20-year study period

- **Curve D** represents a very rapid initial participation rate that results in virtual full saturation of the applicable market during the first milestone period of the 20-year study period.

**Exhibit 6.7: Adoption Curve Shapes (2006 to 2026)**

| Curve A | Curve B | Curve C | Curve D |
|---|---|---|---|
|  |  |  |  |

Finally, as applicable, workshop participants provided guidelines to the consultants for extrapolating the results of the workshop discussion to the remaining sub sectors and service regions.

**Step 5: Extrapolate Workshop Results to Remaining Opportunities**

As noted earlier, it was not possible to fully address all opportunities in the one-day workshop. Consequently, the workshop focused on the “big ticket” opportunities. Participation rates for the remaining opportunities were completed by the consultants, guided by the workshop results and discussions. The values shown in the summary tables and attached appendices incorporate the results of the two sets of inputs.

**Step 6: Aggregate Achievable Potential Results**

The final step involved aggregating the results of the individual opportunity areas to provide a view of the potential Achievable savings for the total Commercial sector.

## 6.4 WORKSHOP RESULTS

The following subsection provides a summary of the participation rates established by the workshop participants for each of the opportunity areas that were discussed during the workshop. As noted previously, the Commercial sector opportunity areas were:

- C1 - T8 Fluorescent Upgrades (T12 Baseline)
- C2 - T8 Fluorescent Upgrades (T8 Baseline)
- C3 - Incandescent Upgrades
- C4 - Building Envelope Measures
- C5 - Building Recommissioning & Advanced BAS
- C6 - Ground Source Heat Pumps
- C7 - Advanced New Building Construction
- C8 - ENERGY STAR Computer Equipment

Further detail on each of the above opportunity areas is provided below and, as applicable, the following information is provided for each:

- Summary of Upper and Lower Achievable participation rates
- Shape of Adoption Curve selected by the workshop participants
- Highlights of key issues arising during the workshop discussions
- Summary of major assumptions employed by the consultants for extrapolating the workshop results to other sub sectors.

### 6.4.1 C1 - T8 Fluorescent Upgrades (T12 Baseline)

Workshop participants concluded that, under the conditions represented by the Upper Achievable scenario, participation rates up to 74%[52] could be achieved in Office buildings in the Island and Isolated service region by 2026. Workshop participants agreed that Adoption Curve A represented the best fit with the pace of participation in the intervening years from 2007 to 2026 under this Upper Achievable scenario.

Under the more modest market conditions represented by the Lower Achievable scenario, participation rates up to 64% could be achieved in Office buildings in the Island and Isolated service region by 2026. Workshop participants agreed that Adoption Curve A represented the best fit with the pace of participation in the intervening years from 2007 to 2026 under this Lower Achievable scenario.

Based on the workshop discussions, it was assumed that participation rates would be directionally higher in institutional sub sectors (Health, Schools and University/College) and directionally lower in the primarily private sub sectors (Non-food Retail, Food Retail, Accommodations and Warehouse/Wholesale) when compared to the above values. Participation rates in the Labrador Interconnected service region were assumed to be similar to those for the Island and Isolated service region.

Selected highlights:

- Possible barriers discussed included limited capital resources for energy retrofits, increased space heating loads due to reduced internal heat gain and increased cost due to asbestos removal when undertaking redesign work in buildings older than approximately 30 years.

[52] Participation rates cited in this section are a weighted average of participation rates discussed for two separate but related measures during the workshop; “Redesign with high-performance T8” and “Retrofit with high-performance T8.”

- Potential positive influences on participation rates discussed included previous experience with fluorescent lighting program design and implementation in the early 1990's, co-benefits of increased chargeable rental rates in offices as a result of lighting retrofits and more attractive economics in buildings with high hours of use such as hospitals.
- Schools are presently undertaking T8 retrofits as part of ongoing electrical upgrades and repairs started in 2006.
- Labrador participation rates may be substantially lower if not driven by participation in government buildings.

The preceding results were used as a reference point for estimating participation rates related to other lighting opportunities in the Commercial sector.

Selected highlights:

- Participation rates for T8 upgrades from both T8 and T 12 baselines were taken into account when estimating rates for both pulse-start metal halide and high-intensity fluorescent lamps and fixtures.

### 6.4.2 C2 - T8 Fluorescent Upgrades (T8 Baseline)

Unlike opportunity C1, measures discussed within this opportunity were evaluated at incremental cost and applied at the rate of natural stock turnover.[53]

Workshop participants concluded that, under the conditions represented by the Upper Achievable scenario, participation rates up to 100%[54] could be achieved in Office buildings in the Island and Isolated service region in the year 2026. Workshop participants agreed that Adoption Curve C represented the best fit with the pace of participation in the intervening years from 2007 to 2026 under this Upper Achievable scenario. Occupancy sensors were also considered as part of this discussion. Upper Achievable participation rates were estimated at 98%.

Under the more modest market conditions represented by the Lower Achievable scenario, participation rates up to 82% could be achieved in Office buildings in the Island and Isolated service region in the year 2026. Workshop participants agreed that Adoption Curve C represented the best fit with the pace of participation in the intervening years from 2007 to 2026 under this Lower Achievable scenario. For occupancy sensors, Lower Achievable participation rates were estimated at 80%.

Since measures contained within this opportunity are applicable only at the time of stock turnover, lower participation rates in early milestone periods represent a lost savings opportunity that persists for the duration of the replaced equipment's service life. C2

[53] Fluorescent upgrades (T8 baseline) were evaluated at full cost with a CCE of $0.0979/kWh in the Economic Potential analysis. Because of unattractive customer paybacks and virtually zero opportunity for utility incentive under the CCE cutoff of $0.098/kWh, these measures are evaluated at incremental cost in the Achievable analysis.

[54] Participation rates cited in this section are a weighted average of participation rates discussed for two separate but related measures during the workshop: "Redesign with high-performance T8" and "Retrofit with high-performance T8."

participation rates, shown in Exhibits 6.8 and 6.9, represent the percentage of the *total stock* that would turn over to the evaluated technologies by 2026, under the two participation scenarios described above.

Based on the workshop discussions, it was assumed that participation rates would be directionally higher in institutional sub sectors (Health, Schools and University/College) and directionally lower in the primarily private sub sectors (Non-food Retail, Food Retail, Accommodations and Warehouse/Wholesale) when compared to the above values. Participation rates in the Labrador Interconnected service region were assumed to be similar those for the Island and Isolated service region.

Workshop participants identified potential barriers and positive influences on participation rates very similar to those listed in opportunity C1, above. In addition, workshop participants felt that customers with T8 fixtures already installed have been market leaders in the past and would likely continue to employ cutting-edge technology. There were also some concerns voiced about the present availability and consumer awareness of high-performance T8 systems.

The preceding results were used as a reference point for estimating participation rates related to other lighting opportunities in the Commercial sector.

Selected highlights:

- Participation rates for T8 upgrades from both T8 and T 12 baselines were taken into account when estimating rates for both pulse-start metal halide and high-intensity fluorescent lamps and fixtures.

### 6.4.4 C3 - Incandescent Upgrades

Workshop participants concluded that, under the conditions represented by the Upper Achievable scenario, participation rates up to 98% could be achieved in Office buildings in the Island and Isolated service region by 2026 for the measure “Relamp incandescent with CFL.” Workshop participants agreed that Adoption Curve D (reaching a maximum in 2016) represented the best fit with the pace of participation in the intervening years from 2007 to 2026 under this Upper Achievable scenario. LED exit signs were also considered as part of this discussion. Upper Achievable participation rates were estimated at 98%, following adoption curve C. A weighted average participation rate for these two measures is reported in Exhibit 6.8 below

Under the more modest market conditions represented by the Lower Achievable scenario, participation rates up to 90% could be achieved in Office buildings in the Island and Isolated service region by 2026 for “Relamp incandescent with CFL.” Workshop participants agreed that Adoption Curve D (reaching a maximum at 2016) represented the best fit with the pace of participation in the intervening years from 2007 to 2026 under this Lower Achievable scenario. For LED exit signs, Lower Achievable participation rates were estimated at 95% following adoption curve C. A weighted average participation rate for these two measures is reported in Exhibit 6.9 below.

Based on the workshop discussions, it was assumed that participation rates would be directionally higher in institutional sub sectors (Health, Schools and University/College) and directionally lower in the primarily private sub sectors (Non-food Retail, Food Retail, Accommodations and Warehouse/Wholesale) when compared to the above values. Participation rates in the Labrador Interconnected service region were assumed to be similar those for the Island and Isolated service region.

Selected highlights:

- Real and perceived issues regarding light quality and technical shortcomings may act as a barrier to uptake for CFL technologies.
- Increased consumer awareness (especially as it pertains to residential applications) and a possible phase-out of incandescent light bulbs by manufacturers or legislation may facilitate uptake.

### 6.4.5 C4 - Building Envelope Measures

This opportunity considered achievable participation rates for three building envelope measures: high-performance glazings, wall insulation and roof insulation. All of the measures discussed within this opportunity were evaluated at incremental cost and applied at the rate of natural stock turnover.

Workshop participants concluded that, under the conditions represented by the Upper Achievable scenario, participation rates of up to 13%, 13% and 21% for the respective measures listed above could be achieved in Office buildings in the Island and Isolated service region in the year 2026. Workshop participants agreed that Adoption Curve A represented the best fit for all three measures in the intervening years from 2007 to 2026 under this Upper Achievable scenario.

Under the more modest market conditions represented by the Lower Achievable scenario, participation rates up to 4%, 4% and 13% respectively could be achieved in Office buildings in the Island and Isolated service region in the year 2026. Workshop participants agreed that Adoption Curve A represented the best fit with the pace of participation in the intervening years from 2007 to 2026 under this Lower Achievable scenario.

Based on the workshop discussions, it was assumed that participation rates would be directionally higher in institutional sub sectors (Health, Schools and University/College) and directionally lower in the primarily private sub sectors (Non-food Retail, Food Retail, Accommodations and Warehouse/Wholesale) when compared to the above values. Participation rates in the Labrador Interconnected service region were assumed to be similar those for the Island and Isolated service region.

Since measures contained within this opportunity are applicable only at the time of stock turnover, lower participation rates in early milestone periods represent a lost savings opportunity that persists for the duration of the replaced equipment’s service life. C4 participation rates shown in Exhibits 6.8 and 6.9 represent the percentage of the *total* *stock* that would turn over to the evaluated technologies by 2026, under the two participation scenarios described above.

Selected highlights:

- Technical issues and lack of physical space as they pertain to wall insulation upgrades may act as a barrier to building envelope measure participation.
- Conversely, the relative technical simplicity of upgrading roof insulation may facilitate uptake.
- Predictable savings levels may lead to a relatively low perceived risk and increased uptake.
- Co-benefits, such as increased occupant comfort, may facilitate uptake.
- Workshop participants noted that there is an ongoing roof insulation improvement program in Newfoundland and Labrador schools, that there have been few insulation retrofits in Labrador to date, and that in addition to insulation, air infiltration issues must be considered, especially with respect to preventing moisture damage.

The preceding results were used as a reference point for estimating participation rates related to other building envelope opportunities in the Commercial sector. Specifically, participation rates for the measure “Roof insulation” were taken into account when estimating participation rates for the measure “Air curtains.”

### 6.4.6 C5 - Building Recommissioning & Advanced BAS

Workshop participants concluded that, under the conditions represented by the Upper Achievable scenario, participation rates up to 85% could be achieved in Office buildings in the Island and Isolated service region by 2026 for the measure “Building Recommissioning.” Workshop participants agreed that a “flattened” Adoption Curve B (essentially a hybrid between curves A and B) represented the best fit with the pace of participation in the intervening years from 2007 to 2026 under this Upper Achievable scenario. Advanced BAS were also considered as part of this discussion. Upper Achievable participation rates were estimated at 65%, following adoption curve A. A weighted average participation rate for these two measures is reported in Exhibit 6.8 below.

Under the more modest market conditions represented by the Lower Achievable scenario, participation rates up to 40% could be achieved in Office buildings in the Island and Isolated service region by 2026 for the measure “Building Recommissioning.” Workshop participants agreed that Adoption Curve B represented the best fit with the pace of participation in the intervening years from 2007 to 2026 under this Lower Achievable scenario. For Advanced BAS, Upper Achievable participation rates were estimated at 25%, following adoption curve B. A weighted average participation rate for these two measures is reported in Exhibit 6.9 below.

Based on the workshop discussions, it was assumed that participation rates would be directionally higher in institutional sub sectors (Health, Schools and University/College) and directionally lower in the primarily private sub sectors (Non-food Retail, Food Retail, Accommodations and Warehouse/Wholesale) when compared to the above values.

Participation rates in the Labrador Interconnected service region were assumed to be similar those for the Island and Isolated service region.

Selected highlights:

- Workshop participants felt that this was a particularly large opportunity in buildings of all ages, especially buildings older than 15 years
- Participants stressed the importance of maintaining savings over time by training building managers and through service contracts
- Possible roles identified for the Utilities included assistance with training programs for building owners and operators, producing and providing technical information or specific case studies and financial incentives for pre-audits or to lower cost the cost of building "tuning."

The preceding participation rates were also applied to the HVAC measure "adjustable speed drives," which was not discussed during the workshop.

### 6.4.7 C6 – Ground Source Heat Pumps

This opportunity considered achievable participation rates for the measure "Ground Source Heat Pumps." This measure was evaluated at incremental cost and applied at the rate of natural stock turnover.

Workshop participants concluded that, under the conditions represented by the Upper Achievable scenario, participation rates of up to 20% could be achieved in Office buildings in the Island and Isolated service region in the year 2026. Workshop participants agreed that Adoption Curve B represented the best fit in the intervening years from 2007 to 2026 under this Upper Achievable scenario.

Under the more modest market conditions represented by the Lower Achievable scenario, participation rates up to 2% could be achieved in Office buildings in the Island and Isolated service region in the year 2026. Workshop participants agreed that Adoption Curve B represented the best fit with the pace of participation in the intervening years from 2007 to 2026 under this Lower Achievable scenario.

Based on the workshop discussions, it was assumed that participation rates would be directionally higher in institutional sub sectors (Health, Schools and University/College) and directionally lower in the primarily private sub sectors (Non-food Retail, Food Retail, Accommodations and Warehouse/Wholesale) when compared to the above values. Participation rates in the Labrador Interconnected service region were assumed to be similar those for the Island and Isolated service region.

Since measures contained within this opportunity are applicable only at the time of stock turnover, lower participation rates in early milestone periods represent a lost savings opportunity that persists for the duration of the replaced equipment's service life. C6 participation rates shown in Exhibits 6.8 and 6.9 represent the percentage of the *total stock* that would turn over to the evaluated technologies by 2026, under the two participation scenarios described above.

Selected highlights:

- This measure was seen to be much more attractive for new construction than for retrofits
- In addition to the limited opportunity for uptake of ground source heat pumps, participants felt that there may be some additional opportunity for installation of air source heat pumps and low-temperature heat pumps
- Public and institutional buildings were expected to have slightly higher participation rates
- A commitment by the provincial government to build efficient new public buildings, which could include heat pump systems, may facilitate uptake in retrofit applications.

### 6.4.6 C7 – Advanced New Building Construction

This opportunity considered achievable participation rates for the measures "New buildings – 40% more efficient" and "New buildings – 25% more efficient." These measures were evaluated at incremental cost and applied at the time of construction.

Workshop participants drew a distinction between likely participation rates within the private and public/institutional sectors. Consequently, participation rates were discussed separately for these two sector groups, and combined in a weighted average in Exhibits 6.8 and 6.9.

Workshop participants concluded that, under the conditions represented by the Upper Achievable scenario, participation rates of up to 100% for public Office buildings and 25% in private buildings for the measure "New buildings – 40% more efficient" could be achieved in Office buildings in the Island and Isolated service region in the year 2026. In addition, participation rates of up to 50% in private buildings for the measure "New buildings – 25% more efficient" could be achieved in Office buildings in 2026. No curve shape was applied to the estimated participation rates. Instead, participation rates were discussed for earlier milestone years. It was estimated that private offices would achieve participation rates of 30%, and publicly owned offices would achieve participation rates of 100% for the measure "New buildings – 25% more efficient" in 2011. It was assumed that no new buildings would be built to a 40% more efficient standard by the 2011 milestone year.

Lower Achievable participation rates were not discussed for this opportunity during the workshop. Discussion during the workshop, data from other jurisdictions and the prior experience of the consulting team were used to estimate the Lower Achievable participation rates presented in Exhibit 6.9.

Based on the workshop discussions, it was assumed that participation rates would be similar to the rates discussed for publicly-owned Office buildings in institutional sub sectors (Health, Schools and University/College) and similar to those discussed for private Office buildings in the primarily private sub sectors (Non-food Retail, Food Retail, Accommodations and Warehouse/Wholesale) when compared to the above values. Participation rates in the Labrador Interconnected service region were assumed to be similar those for the Island and Isolated service region.

Selected highlights:

- Participants noted that as part of its recent Energy Plan, the Government of Newfoundland and Labrador will implement a policy requiring construction of all buildings receiving provincial funding to exceed the Model National Energy Code by 25%
- Participants estimated that new office construction will be split 50-50 between the public and private sectors.

Since measures contained within this opportunity are applicable only at the time of stock turnover, lower participation rates in early milestone periods represent a lost savings opportunity that persists for the duration of the replaced equipment's service life. C4 participation rates shown in Exhibits 6.8 and 6.9 represent the percentage of the *total stock* that would turn over to the evaluated technologies by 2026, under the two participation scenarios described above.

### 6.4.7 C8 – ENERGY STAR Computer Equipment

This opportunity considered achievable participation rates for three computer equipment measures: ENERGY STAR computers, ENERGY STAR office equipment and high-efficiency servers. All of the measures discussed within this opportunity were evaluated at incremental cost and applied at the rate of natural stock turnover.

Due to time constraints and the fact that this opportunity was outside of the expertise of most workshop participants, this measure was not discussed during the workshop. Estimates made for participation rates for the residential measure "ENERGY STAR computer" (residential workshop opportunity R8) were used to estimate participation rates for this opportunity.

### 6.4.8 Extrapolated Participation Rates – Remaining Energy-efficiency Opportunities

As noted previously, the workshop results and follow-up email responses were used as a reference point, combined with consultant experience, to estimate participation rates for the remaining energy-efficiency opportunities that are contained in the Economic Potential Forecast.

Exhibits 6.8 and 6.9 provide, respectively, a summary of the estimated Upper and Lower participation rates for the remaining energy-efficiency opportunities. As illustrated, each exhibit shows:

- Workshop reference number, which refers to the package of Opportunity Profiles that were provided to workshop participants
- The affected technology
- The participation rates by 2026 (or in 2026, in the case of measures implemented at time of existing stock turnover).

- Notes that illustrate sources and rationale used by the consultant when estimating the participation rates shown.

## Exhibit 6.8: Participation Rates – Upper Achievable Potential

| Workshop Reference # | Upgrade Technology/Measures | Participation Rate 2026 | Adoption Curve Shape | Notes |
|---|---|---|---|---|
| C1 | T12 baseline: Redesign with high-performance T8s | 74% | A | Workshop measure C1 |
| C2 | T8 baseline: Redesign with high-performance T8s | 90% | C | Workshop measure C2 |
| C2 | Occupancy sensors | 98% | C | Workshop measure C2 |
| C3 | Compact fluorescent lamps | 98% | D | Curve D in 2016, Workshop measure C3 |
| | Pulse-start metal halide | 85% | C | Based on Measures C1 & C2 |
| | High-intensity fluorescent | 85% | C | Based on Measures C1 & C2 |
| C6 | Ground source heat pump | 9% | B | Workshop measure C6 |
| | High-efficiency chillers | 38% | A | Based on workshop results, consultant experience |
| | Adjustable speed drives | 73% | B/A | Flattened curve B, based on measure C5 |
| | Premium efficiency motors | 78% | C | Based on workshop results, consultant experience, Industrial workshop measure I6 |
| C5 | Advanced BAS/Building recommissioning | 73% | B/A | Flattened curve B. Workshop measure C5 |
| | ENERGY STAR Refrigerators and Freezers | 47% | B | Based on consultant experience |
| | High-efficiency supermarket refrigeration | 63% | B | Based on consultant experience |
| | Low-flow aerators & shower heads | 90% | C | Based on workshop results, consultant experience |
| | ENERGY STAR computers | 80% | B | Based on residential workshop measure R8 |
| | ENERGY STAR office equipment | 80% | B | Based on residential workshop measure R8 |
| | High-efficiency servers | 80% | B | Based on residential workshop measure R8 |
| C4 | High-performance glazings | 13% | A | Workshop measure C4 |
| C4 | Wall insulation | 13% | A | Workshop measure C4 |
| C4 | Roof insulation | 21% | A | Workshop measure C4 |
| | Air curtains | 33% | A | Based on workshop measure C4 |
| C7 | New buildings - 40% more efficient | 60% | * | Based on input from workshop measure C7 |
| | Dimming controls | 20% | A | Based on consultant experience, barriers to significant uptake |

* An adoption curve was not assigned to the measure "New buildings - 40% more efficient". Participation rates and trends were discussed for multiple milestone periods, as well as for public and private buildings. The participation rates approximate a flattened curve B.

## Exhibit 6.9: Participation Rates – Lower Achievable Potential

| Workshop Reference # | Upgrade Technology/Measures | Participation Rate 2026 | Adoption Curve Shape | Notes |
|---|---|---|---|---|
| C1 | T12 baseline: Redesign with high-performance T8s | 64% | A | Workshop measure C1 |
| C2 | T8 baseline: Redesign with high-performance T8s | 73% | C | Workshop measure C2 |
| C2 | Occupancy sensors | 80% | C | Workshop measure C2 |
| C3 | Compact fluorescent lamps | 90% | D | Curve D in 2016, Workshop measure C3 |
| | Pulse-start metal halide | 75% | C | Based on Measures C1 & C2 |
| | High-intensity fluorescent | 75% | C | Based on Measures C1 & C2 |
| C6 | Ground source heat pump | 1% | B | Workshop measure C6 |
| | High-efficiency chillers | 28% | A | Based on workshop results, consultant experience |
| | Adjustable speed drives | 31% | B | Based on measure C5 |
| | Premium efficiency motors | 68% | C | Based on workshop results, consultant experience, Industrial workshop measure I6 |
| C5 | Advanced BAS/Building recommissioning | 31% | B | Workshop measure C5 |
| | ENERGY STAR Refrigerators and Freezers | 35% | B | Based on consultant experience |
| | High-efficiency supermarket refrigeration | 47% | B | Based on consultant experience |
| | Low-flow aerators & shower heads | 75% | C | Based on workshop results, consultant experience |
| | ENERGY STAR computers | 15% | B | Based on residential workshop measure R8 |
| | ENERGY STAR office equipment | 15% | B | Based on residential workshop measure R8 |
| | High-efficiency servers | 15% | B | Based on residential workshop measure R8 |
| C4 | High-performance glazings | 4% | A | Workshop measure C4 |
| C4 | Wall insulation | 4% | A | Workshop measure C4 |
| C4 | Roof insulation | 13% | A | Workshop measure C4 |
| | Air curtains | 27% | A | Based on workshop measure C4 |
| C7 | New buildings - 40% more efficient | 40% | * | Based on input from workshop measure C7 |
| | Dimming controls | 10% | A | Based on consultant experience, barriers to significant uptake |

* An adoption curve was not assigned to the measure "New buildings - 40% more efficient". Participation rates and trends were discussed for multiple milestone periods, as well as for public and private buildings. The participation rates approximate a flattened curve B.

## 6.5 SUMMARY OF ACHIEVABLE ELECTRICITY SAVINGS

Exhibits 6.10 and 6.11 provide a summary of the achievable electricity savings under both the Lower and Upper scenarios for the Island and Isolated and Labrador Interconnected service regions respectively.

Under the Reference Case for the Island and Isolated service region, commercial electricity use would grow from the Base Year level of 1,881GWh/yr. to approximately 2,233 GWh/yr. by 2026. This contrasts with the Upper Achievable scenario in which electricity use would increase to approximately 1,846 GWh/yr. for the same period, a difference of approximately 387 GWh/yr., or about 17%. Under the Lower Achievable scenario, electricity use would increase to approximately 1,972 GWh/yr. for the same period, a difference of approximately 261 GWh/yr., or about 12%.

Under the Reference Case for the Labrador Interconnected service region, commercial electricity use would grow from the Base Year level of 201GWh/yr. to approximately 240 GWh/yr. by 2026. This contrasts with the Upper Achievable scenario in which electricity use would increase to approximately 212 GWh/yr. for the same period, a difference of approximately 28 GWh/yr., or about 12%. Under the Lower Achievable scenario, electricity use would increase to approximately 221 GWh/yr. for the same period, a difference of approximately 19 GWh/yr., or about 8%.

**Exhibit 6.10: Reference Case versus Upper and Lower Achievable Potential Electricity Consumption in Commercial Sector for the Island and Isolated Service Region (GWh/yr.)**

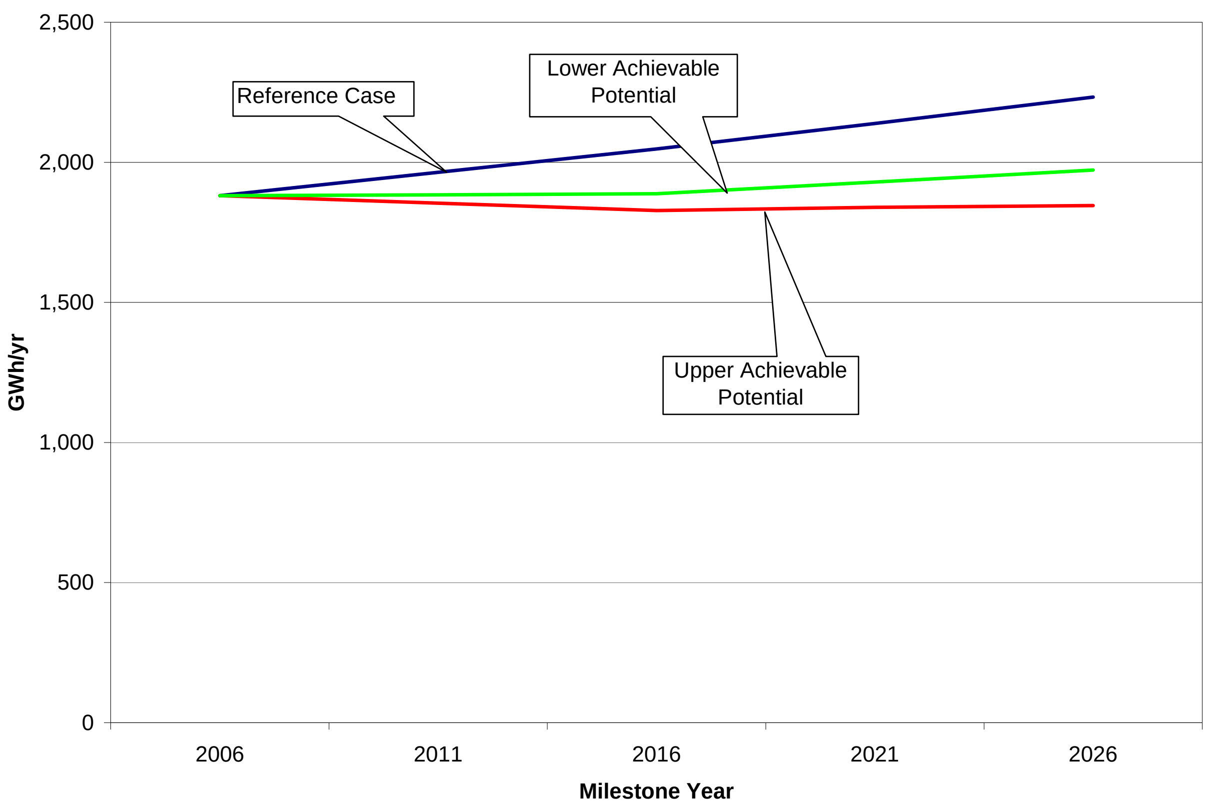
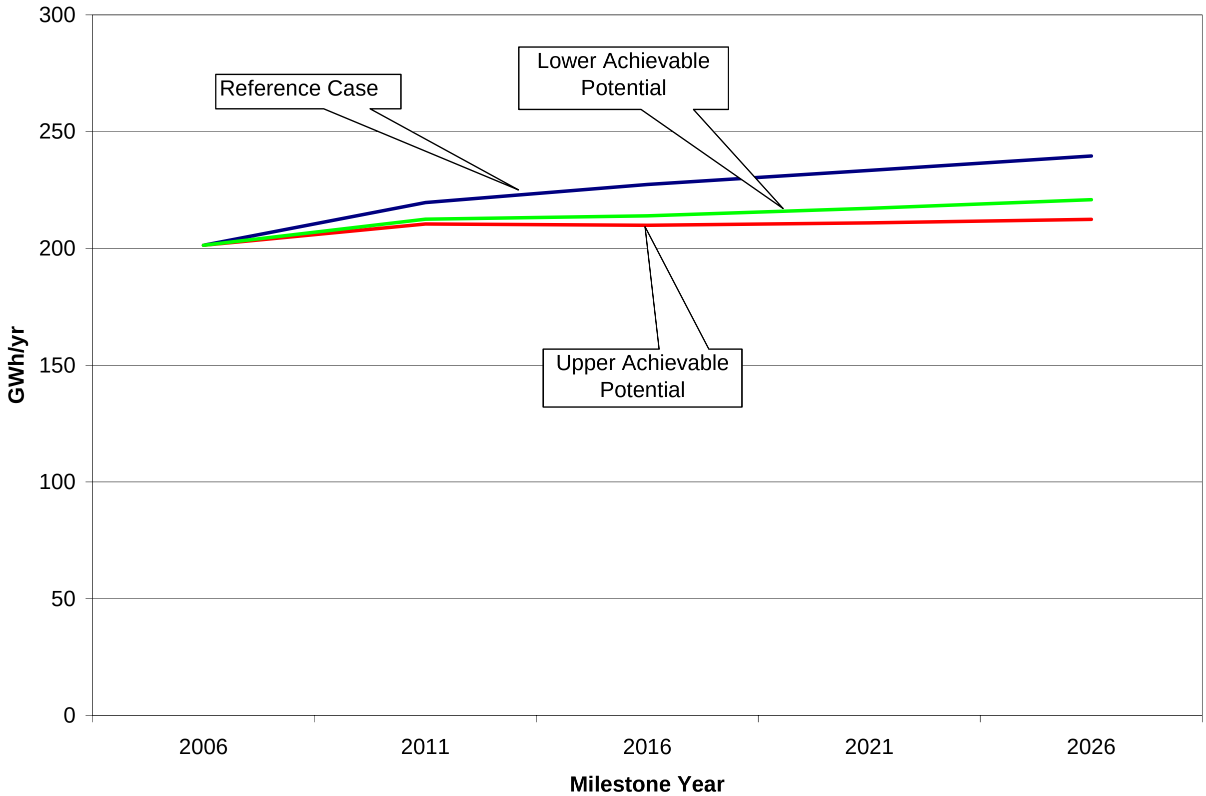


**Exhibit 6.11: Reference Case versus Upper and Lower Achievable Potential Electricity Consumption in Commercial Sector for the Island and Isolated Service Region (GWh/yr.)**




Further detail on the total potential electricity savings provided by the Achievable Potential Forecasts is provided in the following exhibits:

- Exhibits 6.12 and 6.13 present, respectively, the Upper and Lower Achievable results by end use, sub sector and milestone year for the Island and Isolated service region.

- Exhibits 6.14 and 6.15 present, respectively, the Upper and Lower Achievable results by end use, sub sector and milestone year for the Labrador Interconnected service region.

- Exhibits 6.16 and 6.17 present, respectively, Upper and Lower Achievable savings in 2026 by major end use and sub sector for the Island and Isolated service region.

- Exhibits 6.18 and 6.19, respectively, present Upper and Lower Achievable savings in 2026 by major end use and sub sector for the Labrador Interconnected service region.

- Exhibit 6.20 presents Upper and Lower Achievable savings by scenario, milestone year and service region.

## Exhibit 6.12: Summary of Annual Electricity Savings for the Island and Isolated Service Region by End Use and Sub Sector, Upper Achievable Potential (GWh/yr.)

| Building Type | Milestone Year | Total | General Lighting | Secondary Lighting | Outdoor Lighting | Computer Equipment | Other Plug Loads | Food Service Equipment | Refrigeration | Elevators | Miscellaneous | Space Heating | Space Cooling | HVAC Fans and Pumps | Domestic Hot Water | Street Lighting |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Office | 2011 | 22.7 | 10.8 | 5.3 | 0.2 | 1.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.8 | 1.1 | 2.1 | 1.1 | |
| | 2016 | 48.4 | 19.7 | 10.5 | 0.6 | 4.7 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 1.8 | 2.4 | 6.7 | 1.9 | |
| | 2021 | 72.1 | 26.8 | 10.5 | 0.8 | 11.1 | 0.0 | 0.0 | 0.1 | 0.0 | 0.1 | 3.3 | 3.5 | 13.3 | 2.5 | |
| | 2026 | 103.7 | 33.1 | 10.6 | 1.1 | 20.5 | 0.0 | 0.0 | 0.2 | 0.0 | 0.2 | 8.6 | 4.9 | 21.6 | 2.8 | |
| Non-food Retail | 2011 | 14.4 | 11.4 | 1.1 | 0.2 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.7 | 0.5 | 0.2 | |
| | 2016 | 27.9 | 21.0 | 2.2 | 0.4 | 0.4 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.2 | 1.6 | 1.6 | 0.4 | |
| | 2021 | 32.1 | 21.9 | 2.2 | 0.6 | 0.9 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.4 | 2.1 | 3.3 | 0.6 | |
| | 2026 | 36.7 | 22.3 | 2.2 | 0.7 | 1.7 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.8 | 2.8 | 5.4 | 0.6 | |
| Food Retail | 2011 | 5.4 | 3.2 | 0.3 | 0.1 | 0.1 | 0.0 | 0.0 | 1.2 | 0.0 | 0.0 | -0.1 | 0.2 | 0.2 | 0.3 | |
| | 2016 | 12.3 | 5.4 | 0.6 | 0.2 | 0.2 | 0.0 | 0.0 | 4.3 | 0.0 | 0.0 | 0.1 | 0.3 | 0.7 | 0.5 | |
| | 2021 | 17.6 | 6.8 | 0.7 | 0.3 | 0.5 | 0.0 | 0.0 | 6.7 | 0.0 | 0.0 | 0.2 | 0.4 | 1.3 | 0.7 | |
| | 2026 | 22.4 | 7.3 | 0.8 | 0.4 | 0.9 | 0.0 | 0.1 | 9.2 | 0.0 | 0.0 | 0.3 | 0.5 | 2.2 | 0.7 | |
| Healthcare | 2011 | 7.3 | 1.0 | 4.1 | 0.2 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.4 | 0.2 | 0.6 | 0.6 | |
| | 2016 | 14.5 | 1.7 | 7.0 | 0.5 | 0.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.4 | 0.3 | 1.9 | 1.2 | |
| | 2021 | 20.5 | 1.9 | 7.9 | 0.6 | 1.3 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 3.0 | 0.5 | 3.7 | 1.5 | |
| | 2026 | 27.2 | 1.9 | 8.2 | 0.7 | 2.3 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 5.3 | 0.7 | 6.1 | 1.8 | |
| Schools | 2011 | 6.0 | 3.3 | 0.6 | 0.2 | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.8 | 0.0 | 0.2 | 0.6 | |
| | 2016 | 13.6 | 5.8 | 1.8 | 0.5 | 1.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 2.7 | 0.0 | 0.7 | 1.1 | |
| | 2021 | 22.7 | 7.7 | 3.1 | 0.7 | 2.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 5.8 | 0.0 | 1.4 | 1.5 | |
| | 2026 | 33.2 | 9.2 | 4.3 | 0.9 | 4.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 10.4 | 0.0 | 2.4 | 1.7 | |
| Accomodations | 2011 | 10.4 | 3.2 | 4.2 | 0.1 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | -0.6 | 0.2 | 0.2 | 3.0 | |
| | 2016 | 21.1 | 6.3 | 7.5 | 0.2 | 0.3 | 0.0 | 0.0 | 0.2 | 0.0 | 0.0 | 0.3 | 0.5 | 0.6 | 5.2 | |
| | 2021 | 24.4 | 6.3 | 7.8 | 0.3 | 0.6 | 0.0 | 0.0 | 0.3 | 0.0 | 0.0 | 0.5 | 0.6 | 1.2 | 6.8 | |
| | 2026 | 27.2 | 6.2 | 7.9 | 0.3 | 1.1 | 0.0 | 0.0 | 0.4 | 0.0 | 0.0 | 0.8 | 0.7 | 2.0 | 7.7 | |
| University/College | 2011 | 7.8 | 4.6 | 1.3 | 0.1 | 0.3 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.1 | 0.9 | 0.4 | |
| | 2016 | 15.8 | 7.6 | 2.4 | 0.3 | 1.4 | 0.0 | 0.0 | 0.2 | 0.0 | 0.0 | 0.1 | 0.2 | 3.0 | 0.7 | |
| | 2021 | 23.1 | 9.2 | 2.5 | 0.4 | 3.3 | 0.0 | 0.0 | 0.3 | 0.0 | 0.0 | 0.2 | 0.3 | 6.1 | 0.8 | |
| | 2026 | 30.8 | 9.4 | 2.5 | 0.6 | 6.0 | 0.0 | 0.0 | 0.4 | 0.0 | 0.0 | 0.3 | 0.4 | 10.1 | 0.9 | |
| Warehouse/Wholesale | 2011 | 3.3 | 2.8 | 0.4 | 0.1 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | -0.3 | 0.0 | 0.1 | 0.2 | |
| | 2016 | 6.8 | 4.6 | 0.6 | 0.2 | 0.2 | 0.0 | 0.0 | 0.3 | 0.0 | 0.0 | 0.1 | 0.0 | 0.3 | 0.3 | |
| | 2021 | 9.1 | 5.8 | 0.7 | 0.3 | 0.5 | 0.0 | 0.0 | 0.5 | 0.0 | 0.0 | 0.3 | 0.0 | 0.6 | 0.4 | |
| | 2026 | 10.9 | 6.2 | 0.8 | 0.4 | 0.9 | 0.0 | 0.0 | 0.7 | 0.0 | 0.0 | 0.4 | 0.1 | 1.1 | 0.5 | |
| Small Commercial | 2011 | 26.7 | | | | | | | | | | | | | | |
| | 2016 | 48.9 | | | | | | | | | | | | | | |
| | 2021 | 62.8 | | | | | | | | | | | | | | |
| | 2026 | 77.8 | | | | | | | | | | | | | | |
| Other Buildings | 2011 | 4.8 | | | | | | | | | | | | | | |
| | 2016 | 8.6 | | | | | | | | | | | | | | |
| | 2021 | 10.8 | | | | | | | | | | | | | | |
| | 2026 | 13.3 | | | | | | | | | | | | | | |
| Non Buildings | 2011 | 0.0 | | | | | | | | | | | | | | |
| | 2016 | 0.0 | | | | | | | | | | | | | | |
| | 2021 | 0.0 | | | | | | | | | | | | | | |
| | 2026 | 0.0 | | | | | | | | | | | | | | |
| Isolated Buildings | 2011 | 0.5 | | | | | | | | | | | | | | |
| | 2016 | 1.0 | | | | | | | | | | | | | | |
| | 2021 | 1.4 | | | | | | | | | | | | | | |
| | 2026 | 1.8 | | | | | | | | | | | | | | |
| Streetlighting | 2011 | 0.6 | | | | | | | | | | | | | | 0.6 |
| | 2016 | 1.2 | | | | | | | | | | | | | | 1.2 |
| | 2021 | 1.8 | | | | | | | | | | | | | | 1.8 |
| | 2026 | 2.4 | | | | | | | | | | | | | | 2.4 |
| Total | 2011 | 110.0 | 40.3 | 17.3 | 1.2 | 2.1 | 0.0 | 0.0 | 1.4 | 0.0 | 0.0 | 1.2 | 2.4 | 4.9 | 6.4 | 0.6 |
| | 2016 | 220.1 | 72.1 | 32.4 | 2.9 | 8.7 | 0.0 | 0.1 | 5.1 | 0.0 | 0.1 | 6.7 | 5.3 | 15.5 | 11.3 | 1.2 |
| | 2021 | 298.4 | 86.2 | 35.4 | 4.0 | 20.4 | 0.0 | 0.2 | 8.0 | 0.0 | 0.2 | 13.8 | 7.5 | 31.0 | 14.8 | 1.8 |
| | 2026 | 387.4 | 95.6 | 37.4 | 5.2 | 37.7 | 0.0 | 0.3 | 11.0 | 0.0 | 0.3 | 27.0 | 10.1 | 50.7 | 16.8 | 2.4 |

*Notes: 1) Results are measured at the customer's point-of-use and do not include line losses. 2) Any differences in totals are due to rounding. 3) In the above Exhibit, a value displays as 0 if it is between 0 and 0.5. Totals are calculated using the actual numerical value. 4) Negative values in the space heating end use are a result of the reduction in internal heat gains due to lighting and appliance measures being greater than any savings from space heating measures.*

## Exhibit 6.13: Summary of Annual Electricity Savings for the Island and Isolated Service Region by End Use and Sub Sector, Lower Achievable Potential (GWh/yr.)

| Building Type | Milestone Year | Total | General Lighting | Secondary Lighting | Outdoor Lighting | Computer Equipment | Other Plug Loads | Food Service Equipment | Refrigeration | Elevators | Miscellaneous | Space Heating | Space Cooling | HVAC Fans and Pumps | Domestic Hot Water | Street Lighting |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Office | 2011 | 14.6 | 6.3 | 4.9 | 0.2 | 0.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.5 | 0.7 | 0.8 | 0.9 | |
| | 2016 | 31.3 | 13.0 | 9.5 | 0.5 | 1.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.2 | 1.6 | 2.7 | 1.5 | |
| | 2021 | 45.4 | 19.7 | 9.5 | 0.8 | 2.9 | 0.0 | 0.0 | 0.1 | 0.0 | 0.1 | 2.2 | 2.4 | 5.7 | 2.0 | |
| | 2026 | 62.8 | 27.4 | 9.5 | 1.0 | 5.4 | 0.0 | 0.0 | 0.1 | 0.0 | 0.1 | 3.5 | 3.4 | 10.0 | 2.3 | |
| Non-food Retail | 2011 | 12.0 | 9.8 | 1.0 | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.5 | 0.2 | 0.2 | |
| | 2016 | 23.4 | 18.4 | 1.9 | 0.4 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.2 | 1.2 | 0.7 | 0.4 | |
| | 2021 | 26.1 | 19.4 | 2.0 | 0.5 | 0.3 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.4 | 1.5 | 1.4 | 0.5 | |
| | 2026 | 29.2 | 20.3 | 2.0 | 0.7 | 0.5 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.7 | 1.9 | 2.5 | 0.5 | |
| Food Retail | 2011 | 4.5 | 2.6 | 0.2 | 0.1 | 0.0 | 0.0 | 0.0 | 1.2 | 0.0 | 0.0 | -0.1 | 0.1 | 0.1 | 0.2 | |
| | 2016 | 10.5 | 4.5 | 0.4 | 0.2 | 0.1 | 0.0 | 0.0 | 4.3 | 0.0 | 0.0 | 0.1 | 0.2 | 0.3 | 0.4 | |
| | 2021 | 15.1 | 5.7 | 0.6 | 0.3 | 0.1 | 0.0 | 0.0 | 6.7 | 0.0 | 0.0 | 0.2 | 0.3 | 0.6 | 0.6 | |
| | 2026 | 19.5 | 6.4 | 0.7 | 0.4 | 0.2 | 0.0 | 0.1 | 9.2 | 0.0 | 0.0 | 0.3 | 0.4 | 1.0 | 0.6 | |
| Healthcare | 2011 | 5.2 | 0.8 | 3.2 | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.1 | 0.2 | 0.5 | |
| | 2016 | 10.2 | 1.4 | 5.8 | 0.5 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.4 | 0.2 | 0.7 | 0.9 | |
| | 2021 | 13.5 | 1.6 | 6.7 | 0.6 | 0.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.1 | 0.4 | 1.6 | 1.2 | |
| | 2026 | 17.1 | 1.7 | 7.4 | 0.7 | 0.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 2.1 | 0.5 | 2.7 | 1.4 | |
| Schools | 2011 | 3.7 | 2.0 | 0.5 | 0.2 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.3 | 0.0 | 0.1 | 0.5 | |
| | 2016 | 8.0 | 3.9 | 1.4 | 0.5 | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.8 | 0.0 | 0.3 | 0.9 | |
| | 2021 | 13.2 | 5.5 | 2.6 | 0.7 | 0.6 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 2.0 | 0.0 | 0.6 | 1.2 | |
| | 2026 | 19.1 | 7.1 | 3.6 | 0.9 | 1.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 3.9 | 0.0 | 1.1 | 1.3 | |
| Accomodations | 2011 | 9.0 | 3.0 | 3.7 | 0.1 | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | -0.6 | 0.2 | 0.1 | 2.5 | |
| | 2016 | 18.4 | 5.8 | 6.8 | 0.2 | 0.1 | 0.0 | 0.0 | 0.2 | 0.0 | 0.0 | 0.3 | 0.4 | 0.3 | 4.4 | |
| | 2021 | 20.7 | 5.8 | 7.0 | 0.2 | 0.2 | 0.0 | 0.0 | 0.3 | 0.0 | 0.0 | 0.5 | 0.5 | 0.5 | 5.7 | |
| | 2026 | 22.7 | 5.7 | 7.2 | 0.3 | 0.3 | 0.0 | 0.0 | 0.4 | 0.0 | 0.0 | 0.7 | 0.6 | 0.9 | 6.5 | |
| University/College | 2011 | 4.8 | 2.8 | 1.1 | 0.1 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.3 | 0.3 | |
| | 2016 | 9.8 | 5.1 | 2.2 | 0.3 | 0.3 | 0.0 | 0.0 | 0.2 | 0.0 | 0.0 | 0.1 | 0.1 | 1.1 | 0.5 | |
| | 2021 | 13.9 | 6.8 | 2.3 | 0.4 | 0.6 | 0.0 | 0.0 | 0.3 | 0.0 | 0.0 | 0.1 | 0.2 | 2.5 | 0.7 | |
| | 2026 | 18.2 | 8.1 | 2.4 | 0.5 | 1.2 | 0.0 | 0.0 | 0.4 | 0.0 | 0.0 | 0.2 | 0.3 | 4.4 | 0.8 | |
| Warehouse/Wholesale | 2011 | 2.7 | 2.3 | 0.3 | 0.1 | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | -0.3 | 0.0 | 0.0 | 0.2 | |
| | 2016 | 5.5 | 3.9 | 0.5 | 0.2 | 0.1 | 0.0 | 0.0 | 0.3 | 0.0 | 0.0 | 0.1 | 0.0 | 0.1 | 0.3 | |
| | 2021 | 7.4 | 5.0 | 0.6 | 0.2 | 0.1 | 0.0 | 0.0 | 0.5 | 0.0 | 0.0 | 0.3 | 0.0 | 0.3 | 0.4 | |
| | 2026 | 8.7 | 5.5 | 0.7 | 0.3 | 0.2 | 0.0 | 0.0 | 0.7 | 0.0 | 0.0 | 0.4 | 0.1 | 0.5 | 0.4 | |
| Small Commercial | 2011 | 19.5 | | | | | | | | | | | | | | |
| | 2016 | 35.7 | | | | | | | | | | | | | | |
| | 2021 | 44.0 | | | | | | | | | | | | | | |
| | 2026 | 52.4 | | | | | | | | | | | | | | |
| Other Buildings | 2011 | 3.5 | | | | | | | | | | | | | | |
| | 2016 | 6.2 | | | | | | | | | | | | | | |
| | 2021 | 7.6 | | | | | | | | | | | | | | |
| | 2026 | 9.0 | | | | | | | | | | | | | | |
| Non Buildings | 2011 | 0.0 | | | | | | | | | | | | | | |
| | 2016 | 0.0 | | | | | | | | | | | | | | |
| | 2021 | 0.0 | | | | | | | | | | | | | | |
| | 2026 | 0.0 | | | | | | | | | | | | | | |
| Isolated Buildings | 2011 | 0.3 | | | | | | | | | | | | | | |
| | 2016 | 0.7 | | | | | | | | | | | | | | |
| | 2021 | 1.0 | | | | | | | | | | | | | | |
| | 2026 | 1.3 | | | | | | | | | | | | | | |
| Streetlighting | 2011 | 0.3 | | | | | | | | | | | | | | 0.3 |
| | 2016 | 0.6 | | | | | | | | | | | | | | 0.6 |
| | 2021 | 0.9 | | | | | | | | | | | | | | 0.9 |
| | 2026 | 1.2 | | | | | | | | | | | | | | 1.2 |
| Total | 2011 | 80.1 | 29.6 | 14.9 | 1.1 | 0.5 | 0.0 | 0.0 | 1.4 | 0.0 | 0.0 | 0.1 | 1.7 | 1.8 | 5.3 | 0.3 |
| | 2016 | 160.4 | 55.9 | 28.6 | 2.7 | 2.1 | 0.0 | 0.1 | 5.1 | 0.0 | 0.1 | 3.2 | 3.8 | 6.1 | 9.4 | 0.6 |
| | 2021 | 208.7 | 69.6 | 31.3 | 3.7 | 5.1 | 0.0 | 0.1 | 7.9 | 0.0 | 0.1 | 6.8 | 5.3 | 13.3 | 12.2 | 0.9 |
| | 2026 | 261.2 | 82.3 | 33.5 | 4.8 | 9.4 | 0.0 | 0.2 | 10.9 | 0.0 | 0.2 | 11.9 | 7.2 | 23.1 | 13.8 | 1.2 |

*Notes: 1) Results are measured at the customer's point-of-use and do not include line losses. 2) Any differences in totals are due to rounding. 3) In the above Exhibit, a value displays as 0 if it is between 0 and 0.5. Totals are calculated using the actual numerical value. 4) Negative values in the space heating end use are a result of the reduction in internal heat gains due to lighting and appliance measures being greater than any savings from space heating measures.*

## Exhibit 6.14: Summary of Annual Electricity Savings for the Labrador Interconnected Service Region by End Use and Sub Sector, Upper Achievable Potential (GWh/yr.)

| Building Type | Milestone Year | Total | General Lighting | Secondary Lighting | Outdoor Lighting | Computer Equipment | Other Plug Loads | Food Service Equipment | Refrigeration | Elevators | Miscellaneous | Space Heating | Space Cooling | HVAC Fans and Pumps | Domestic Hot Water | Street Lighting |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Office | 2011 | 0.2 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | |
| | 2016 | 0.6 | 0.2 | 0.0 | 0.0 | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 | 0.1 | 0.1 | |
| | 2021 | 1.1 | 0.3 | 0.0 | 0.0 | 0.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | 0.0 | 0.1 | 0.1 | |
| | 2026 | 1.6 | 0.4 | 0.0 | 0.0 | 0.6 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | 0.0 | 0.2 | 0.1 | |
| Non-food Retail | 2011 | 2.0 | 1.8 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | -0.1 | 0.1 | 0.1 | 0.1 | |
| | 2016 | 4.3 | 3.5 | 0.0 | 0.1 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | 0.1 | 0.2 | 0.1 | |
| | 2021 | 5.0 | 3.8 | 0.0 | 0.1 | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | 0.2 | 0.3 | 0.1 | |
| | 2026 | 5.8 | 4.0 | 0.1 | 0.1 | 0.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.3 | 0.3 | 0.5 | 0.1 | |
| Food Retail | 2011 | 0.3 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | |
| | 2016 | 0.6 | 0.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | |
| | 2021 | 0.9 | 0.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 0.1 | 0.1 | |
| | 2026 | 1.2 | 0.5 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.2 | 0.0 | 0.0 | 0.2 | 0.0 | 0.1 | 0.1 | |
| Healthcare | 2011 | 1.6 | 0.1 | 0.5 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.3 | 0.0 | 0.1 | 0.4 | |
| | 2016 | 2.6 | 0.2 | 0.8 | 0.1 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.4 | 0.0 | 0.2 | 0.7 | |
| | 2021 | 3.5 | 0.2 | 1.0 | 0.1 | 0.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.7 | 0.0 | 0.4 | 0.8 | |
| | 2026 | 4.2 | 0.2 | 1.1 | 0.1 | 0.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.8 | 0.1 | 0.5 | 0.9 | |
| Schools | 2011 | 0.4 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | |
| | 2016 | 0.8 | 0.2 | 0.1 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | 0.0 | 0.1 | 0.1 | |
| | 2021 | 1.2 | 0.4 | 0.1 | 0.0 | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.3 | 0.0 | 0.1 | 0.1 | |
| | 2026 | 1.6 | 0.5 | 0.1 | 0.0 | 0.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.3 | 0.0 | 0.2 | 0.1 | |
| Accomodations | 2011 | 0.3 | 0.1 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | -0.1 | 0.0 | 0.0 | 0.1 | |
| | 2016 | 0.7 | 0.2 | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | |
| | 2021 | 0.8 | 0.2 | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.3 | |
| | 2026 | 0.9 | 0.2 | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 | 0.1 | 0.3 | |
| University/College | 2011 | 0.2 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | |
| | 2016 | 0.5 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 | 0.1 | 0.0 | |
| | 2021 | 0.7 | 0.2 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 | 0.2 | 0.1 | |
| | 2026 | 1.0 | 0.3 | 0.0 | 0.0 | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 | 0.3 | 0.1 | |
| Warehouse/Wholesale | 2011 | 0.2 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | |
| | 2016 | 0.4 | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | -0.1 | 0.0 | 0.0 | 0.0 | |
| | 2021 | 0.7 | 0.5 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | -0.1 | 0.0 | 0.1 | 0.1 | |
| | 2026 | 1.1 | 0.7 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.1 | |
| Small Commercial | 2011 | 1.7 | | | | | | | | | | | | | | |
| | 2016 | 2.9 | | | | | | | | | | | | | | |
| | 2021 | 3.5 | | | | | | | | | | | | | | |
| | 2026 | 4.0 | | | | | | | | | | | | | | |
| Other Buildings | 2011 | 0.7 | | | | | | | | | | | | | | |
| | 2016 | 1.1 | | | | | | | | | | | | | | |
| | 2021 | 1.3 | | | | | | | | | | | | | | |
| | 2026 | 1.5 | | | | | | | | | | | | | | |
| Non Buildings | 2011 | 0.0 | | | | | | | | | | | | | | |
| | 2016 | 0.0 | | | | | | | | | | | | | | |
| | 2021 | 0.0 | | | | | | | | | | | | | | |
| | 2026 | 0.0 | | | | | | | | | | | | | | |
| Other Institutional | 2011 | 1.8 | | | | | | | | | | | | | | |
| | 2016 | 3.0 | | | | | | | | | | | | | | |
| | 2021 | 3.7 | | | | | | | | | | | | | | |
| | 2026 | 4.2 | | | | | | | | | | | | | | |
| Streetlighting | 2011 | 0.0 | | | | | | | | | | | | | | 0.0 |
| | 2016 | 0.0 | | | | | | | | | | | | | | 0.0 |
| | 2021 | 0.0 | | | | | | | | | | | | | | 0.0 |
| | 2026 | 0.0 | | | | | | | | | | | | | | 0.0 |
| Total | 2011 | 9.3 | 2.5 | 0.6 | 0.1 | 0.2 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.4 | 0.1 | 0.3 | 0.8 | 0.0 |
| | 2016 | 17.5 | 4.9 | 1.2 | 0.2 | 0.6 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.9 | 0.2 | 0.8 | 1.3 | 0.0 |
| | 2021 | 22.4 | 5.9 | 1.5 | 0.3 | 1.2 | 0.0 | 0.0 | 0.2 | 0.0 | 0.0 | 1.5 | 0.3 | 1.3 | 1.6 | 0.0 |
| | 2026 | 27.2 | 6.7 | 1.7 | 0.3 | 2.2 | 0.0 | 0.1 | 0.2 | 0.0 | 0.0 | 2.1 | 0.4 | 2.0 | 1.7 | 0.0 |

*Notes: 1) Results are measured at the customer's point-of-use and do not include line losses. 2) Any differences in totals are due to rounding. 3) In the above Exhibit, a value displays as 0 if it is between 0 and 0.5. Totals are calculated using the actual numerical value. 4) Negative values in the space heating end use are a result of the reduction in internal heat gains due to lighting and appliance measures being greater than any savings from space heating measures.*

**Exhibit 6.15: Summary of Annual Electricity Savings for the Labrador Interconnected Service Region by End Use and Sub Sector, Lower Achievable Potential (GWh/yr.)**

| Building Type | Milestone Year | Total | General Lighting | Secondary Lighting | Outdoor Lighting | Computer Equipment | Other Plug Loads | Food Service Equipment | Refrigeration | Elevators | Miscellaneous | Space Heating | Space Cooling | HVAC Fans and Pumps | Domestic Hot Water | Street Lighting |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Office | 2011 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | |
| | 2016 | 0.3 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | |
| | 2021 | 0.6 | 0.2 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 | 0.1 | 0.1 | |
| | 2026 | 0.8 | 0.3 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | 0.0 | 0.1 | 0.1 | |
| Non-food Retail | 2011 | 1.7 | 1.6 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | -0.1 | 0.0 | 0.0 | 0.0 | |
| | 2016 | 3.6 | 3.1 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.1 | 0.1 | 0.1 | |
| | 2021 | 4.0 | 3.3 | 0.0 | 0.1 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | 0.1 | 0.2 | 0.1 | |
| | 2026 | 4.5 | 3.5 | 0.0 | 0.1 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | 0.2 | 0.3 | 0.1 | |
| Food Retail | 2011 | 0.2 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | |
| | 2016 | 0.4 | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | |
| | 2021 | 0.6 | 0.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | |
| | 2026 | 0.8 | 0.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | |
| Healthcare | 2011 | 1.2 | 0.1 | 0.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | 0.0 | 0.1 | 0.3 | |
| | 2016 | 2.0 | 0.2 | 0.7 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.3 | 0.0 | 0.1 | 0.5 | |
| | 2021 | 2.5 | 0.2 | 0.8 | 0.1 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.4 | 0.0 | 0.2 | 0.7 | |
| | 2026 | 3.0 | 0.2 | 1.0 | 0.1 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.5 | 0.0 | 0.3 | 0.7 | |
| Schools | 2011 | 0.3 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | |
| | 2016 | 0.5 | 0.1 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | 0.0 | 0.0 | 0.1 | |
| | 2021 | 0.8 | 0.2 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | 0.0 | 0.1 | 0.1 | |
| | 2026 | 1.0 | 0.3 | 0.1 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | 0.0 | 0.1 | 0.1 | |
| Accomodations | 2011 | 0.3 | 0.1 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | -0.1 | 0.0 | 0.0 | 0.1 | |
| | 2016 | 0.6 | 0.2 | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | |
| | 2021 | 0.7 | 0.2 | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | |
| | 2026 | 0.7 | 0.2 | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | |
| University/College | 2011 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | |
| | 2016 | 0.3 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 | 0.1 | 0.0 | |
| | 2021 | 0.4 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 | 0.1 | 0.0 | |
| | 2026 | 0.5 | 0.2 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 | 0.1 | 0.0 | |
| Warehouse/Wholesale | 2011 | 0.1 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | |
| | 2016 | 0.3 | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | |
| | 2021 | 0.5 | 0.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | -0.1 | 0.0 | 0.0 | 0.1 | |
| | 2026 | 0.7 | 0.6 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.1 | |
| Small Commercial | 2011 | 1.3 | | | | | | | | | | | | | | |
| | 2016 | 2.3 | | | | | | | | | | | | | | |
| | 2021 | 2.5 | | | | | | | | | | | | | | |
| | 2026 | 2.7 | | | | | | | | | | | | | | |
| Other Buildings | 2011 | 0.5 | | | | | | | | | | | | | | |
| | 2016 | 0.9 | | | | | | | | | | | | | | |
| | 2021 | 1.0 | | | | | | | | | | | | | | |
| | 2026 | 1.0 | | | | | | | | | | | | | | |
| Non Buildings | 2011 | 0.0 | | | | | | | | | | | | | | |
| | 2016 | 0.0 | | | | | | | | | | | | | | |
| | 2021 | 0.0 | | | | | | | | | | | | | | |
| | 2026 | 0.0 | | | | | | | | | | | | | | |
| Other Institutional | 2011 | 1.4 | | | | | | | | | | | | | | |
| | 2016 | 2.4 | | | | | | | | | | | | | | |
| | 2021 | 2.7 | | | | | | | | | | | | | | |
| | 2026 | 2.9 | | | | | | | | | | | | | | |
| Streetlighting | 2011 | 0.0 | | | | | | | | | | | | | | 0.0 |
| | 2016 | 0.0 | | | | | | | | | | | | | | 0.0 |
| | 2021 | 0.0 | | | | | | | | | | | | | | 0.0 |
| | 2026 | 0.0 | | | | | | | | | | | | | | 0.0 |
| Total | 2011 | 7.2 | 2.1 | 0.5 | 0.1 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.2 | 0.1 | 0.2 | 0.6 | 0.0 |
| | 2016 | 13.4 | 4.2 | 1.0 | 0.2 | 0.2 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.6 | 0.2 | 0.4 | 1.0 | 0.0 |
| | 2021 | 16.2 | 5.0 | 1.2 | 0.2 | 0.3 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.9 | 0.2 | 0.7 | 1.3 | 0.0 |
| | 2026 | 18.8 | 5.6 | 1.4 | 0.2 | 0.5 | 0.0 | 0.0 | 0.2 | 0.0 | 0.0 | 1.3 | 0.3 | 1.0 | 1.4 | 0.0 |

*Notes: 1) Results are measured at the customer's point-of-use and do not include line losses. 2) Any differences in totals are due to rounding. 3) In the above Exhibit, a value displays as 0 if it is between 0 and 0.5. Totals are calculated using the actual numerical value. 4) Negative values in the space heating end use are a result of the reduction in internal heat gains due to lighting and appliance measures being greater than any savings from space heating measures.*

**Exhibit 6.16: Savings by Major End Use, Upper Achievable – Island and Isolated Service Region 2026 (%)**

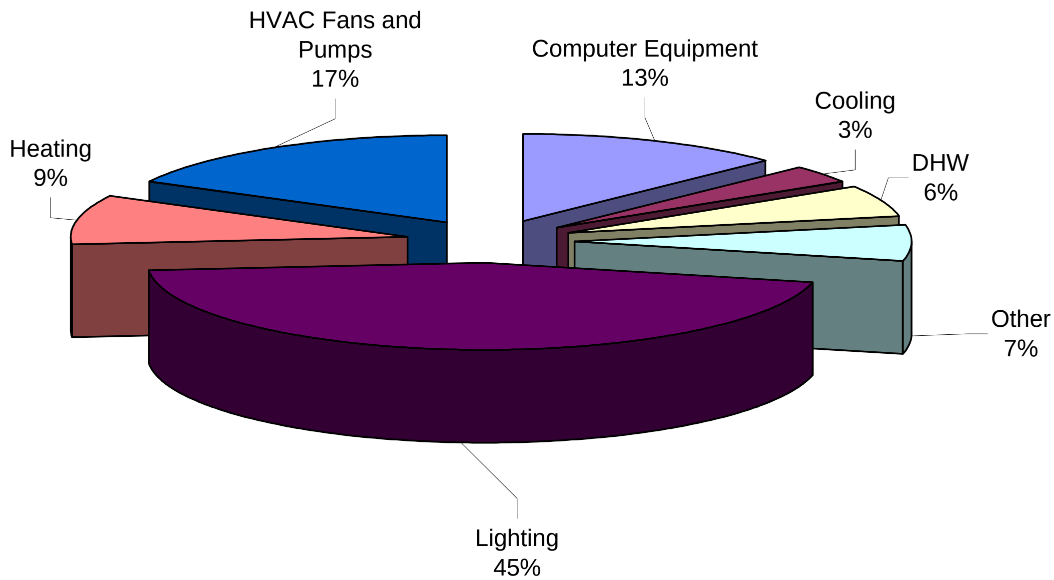



**Exhibit 6.17: Savings by Major End Use, Lower Achievable – Island and Isolated Service Region 2026 (%)**

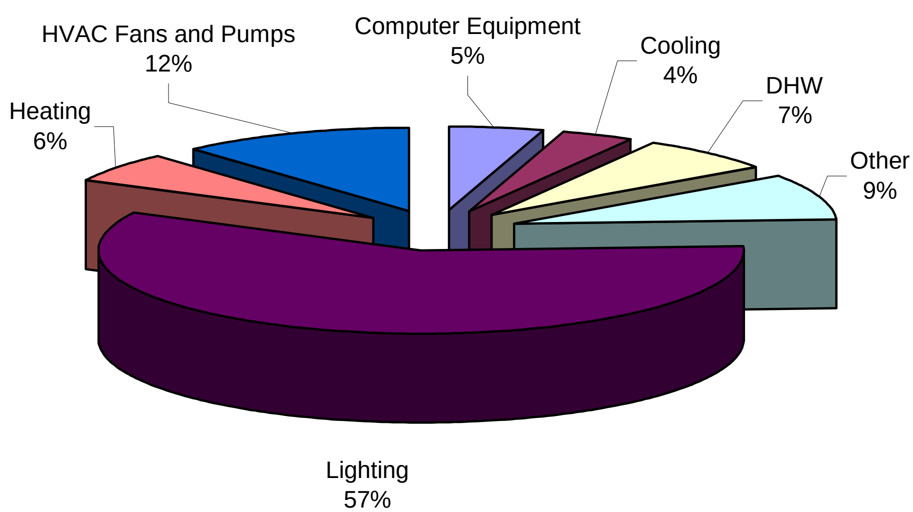


**Exhibit 6.18: Savings by Major End Use, Upper Achievable – Labrador Interconnected Service Region 2026 (%)**

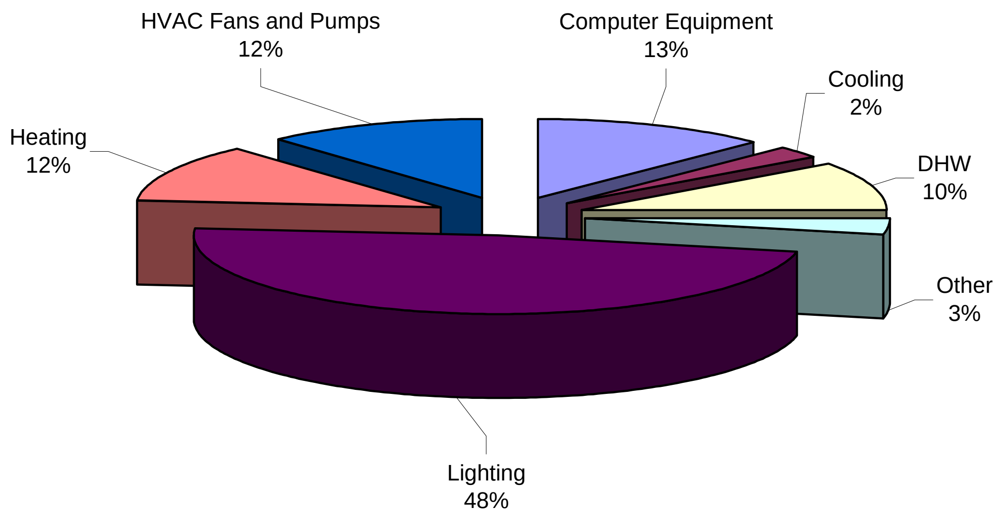



**Exhibit 6.19: Savings by Major End Use, Lower Achievable – Labrador Interconnected Service Region 2026 (%)**

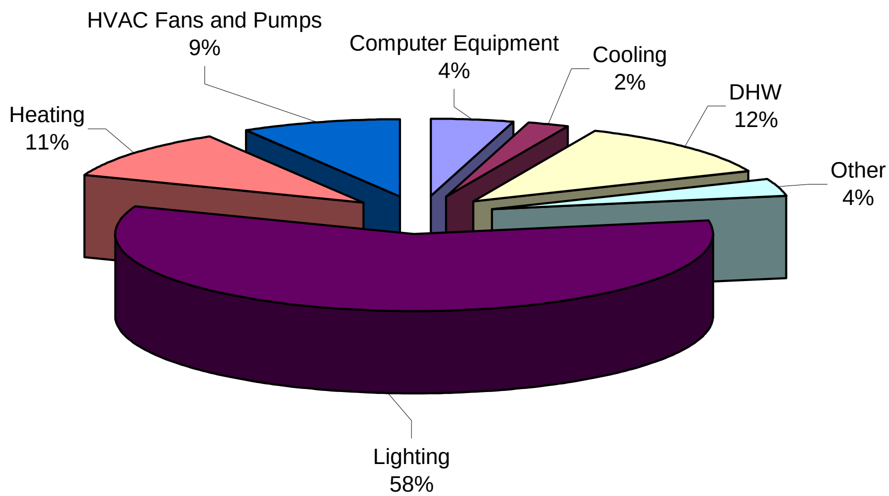
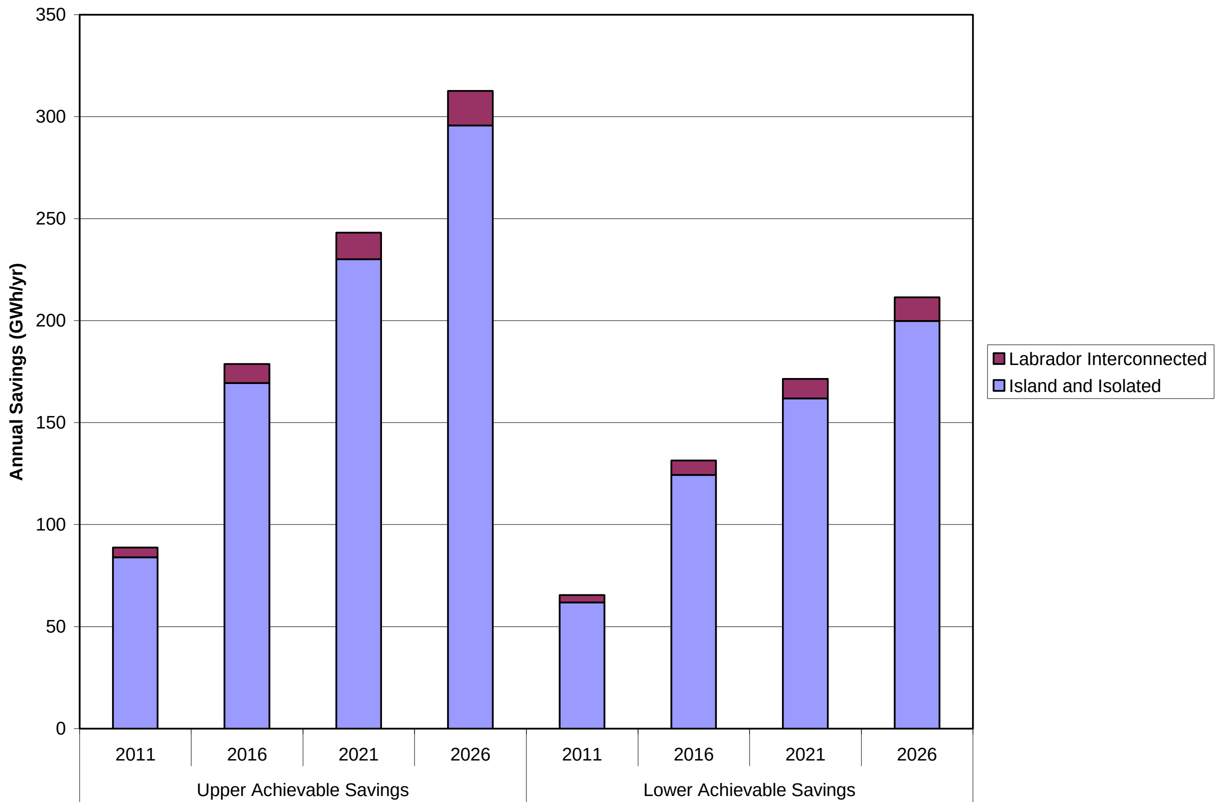


**Exhibit 6.20: Savings by Scenario, Milestone Year and Service Region**




## 6.6 PEAK LOAD IMPACTS

The electricity (electric energy) savings (GWh) contained in the preceding scenarios also result in a reduction in electric demand (MW).[55]

The conversion of electricity savings to hourly demand requires the following steps:

- Annual electricity savings for each combination of sub sector and end use are disaggregated *by month*
- Monthly electricity savings are then further disaggregated *by day type* (weekday, weekend day and peak day)
- Finally, each day type is disaggregated *by hour*.

The above steps that convert electricity to electric demand require the development and application of the following four factors (sets of ratios).

[55] Peak load savings were modelled using Applied Energy Group's Cross-Sector Load Shape Library Model (LOADLIB).

- **Monthly Usage Factor**

This factor represents the percentage of annual electricity use that occurs in each month of the year. This set of monthly fractions (percentages) reflects the seasonality of the load shape, whether a facility, process or end use, and is dictated by weather or other seasonal factors. This allocation factor can be obtained from either (in decreasing order of priority): (a) monthly consumption statistics from end-use load studies; (b) monthly seasonal sales (preferably weather normalized) obtained by subtracting a “base” month from winter and summer heating and cooling months; or (c) heating or cooling degree days on an appropriate base.

- **Weekend to Weekday Factor**

This factor is a ratio that describes the distribution of electricity use between weekends and weekdays

- **Peak Day Factor**

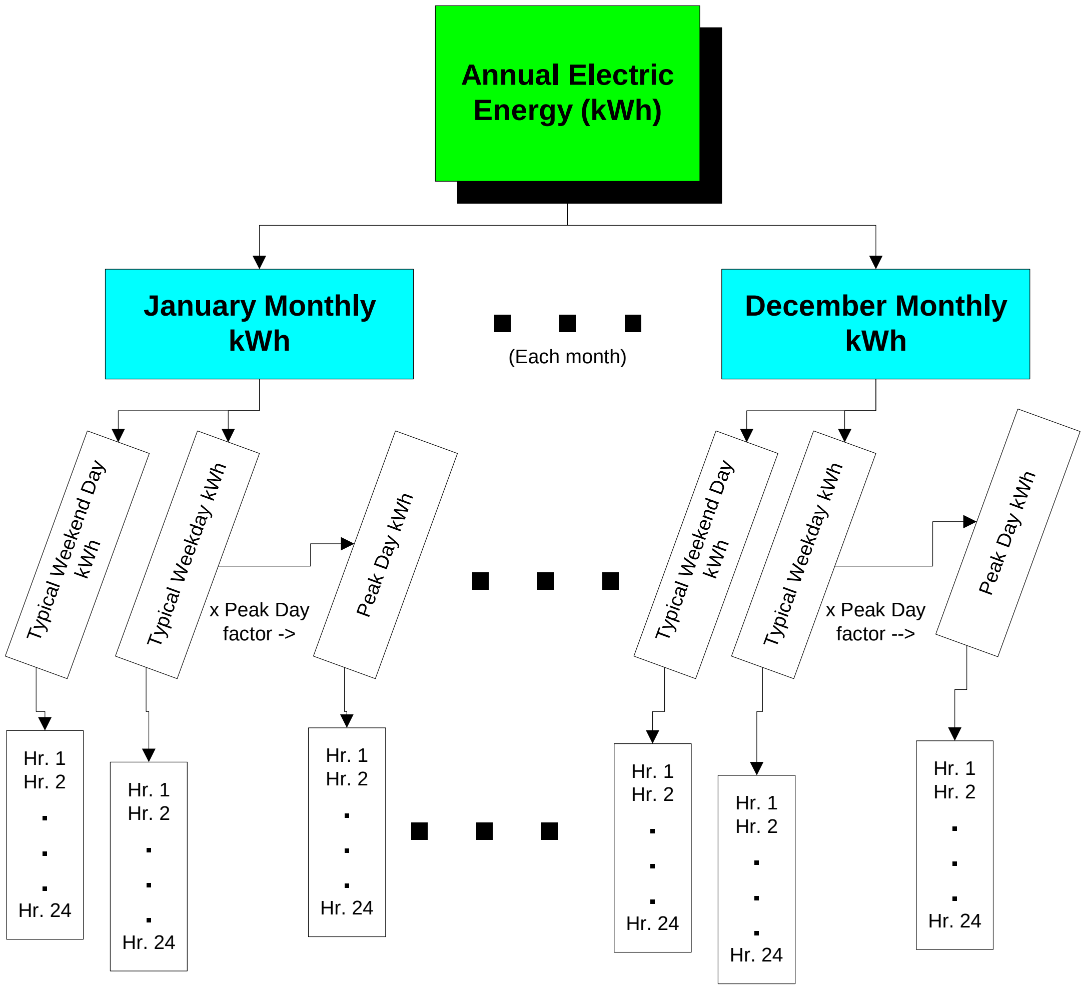
This factor defines the degree of daily weather sensitivity associated with the load shape, particularly heating or cooling; it compares a peak (e.g., hottest or coldest) day to a typical weekday in that month.

- **Hourly Factor**

This factor describes the typical distribution of daily electricity use for each day type (weekday, weekend day, peak day) and for each month. It reflects the operating hours of the electric equipment or end use by sub sector. For example, for lighting, this would be affected by time of day and season (affected by daylight).

Exhibit 6.21 provides an illustration of the sequential application of the above factors to convert annual electricity to hourly demand. Further description is provided in Appendix E.

**Exhibit 6.21: Illustration of Electricity to Peak load Calculation**




For the purposes of this study, the peak load period was defined as

> *The morning period from 7 am to noon and the evening period from 4 pm to 8 pm on the four coldest days in the December to March period; this is a total of 36 hours per year.*

Exhibit 6.22 presents a summary of the peak load reductions that would occur during the peak period noted above as a result of the electricity savings contained in Upper and Lower Achievable scenarios. In each case, the reductions are an average value over the peak period and are defined relative to the Reference Case.

**Exhibit 6.22: Peak load Reductions (MW) Relative to Reference Case by Milestone Year, Service Region and Achievable Scenario**

| Service Region | Milestone Year | Peak Load Reduction (MW) | |
|---|---|---|---|
| | | Upper Achievable | Lower Achievable |
| Island and Isolated | 2011 | 16 | 11 |
| | 2016 | 31 | 23 |
| | 2021 | 41 | 29 |
| | 2026 | 53 | 34 |
| Labrador Interconnected | 2011 | 0.8 | 0.7 |
| | 2016 | 2.0 | 1.6 |
| | 2021 | 2.6 | 1.9 |
| | 2026 | 3.2 | 2.2 |

# 7. CONCLUSIONS AND NEXT STEPS

This study has confirmed the existence of significant cost-effective CDM potential within Newfoundland and Labrador's commercial sector. The study results provide:

- Specific estimates of the potential CDM savings opportunities, defined by sector, sub sector, end use and, in several cases, specific technology(s)
- A baseline set of energy technology penetrations and energy use practices that can assist in the design of specific programs.

The next step[56] in this process involves the selection of a cost-effective portfolio of CDM programs and the setting of specific CDM targets and spending levels. To provide a preliminary reference point for this next step in the program development process, the study team conducted a brief literature search in an attempt to identify typical CDM spending levels in other jurisdictions. The literature search identified two (relatively) recent studies that had addressed similar issues on behalf of other Canadian utilities. The two studies are:

- *Demand-Side Management: Determining Appropriate Spending Levels and Cost-Effectiveness Testing,* which was prepared by Summit Blue Consulting and the Regulatory Assistance Project for the Canadian Association of Members of Public Utility Tribunals (CAMPUT). The study was completed January 30, 2006.
- *Planning and Budgeting for Energy Efficiency/Demand-Side Management Programs,* which was prepared by Navigant Consulting for Union Gas (Ontario) Limited. The study was completed in July 2005.

The CAMPUT study, which included a review of U.S. and Canadian jurisdictions, concluded that an annual CDM expenditure equal to about 1.5% of annual electricity revenues might be appropriate for a utility (or jurisdiction) that is in the early stages of CDM[57] programming. This level of funding recognizes that it takes time to properly introduce programs into the market place.

The same study found that once program delivery experience is gained, a ramping up to a level of about 3% of annual electricity revenues is appropriate. The study also notes that higher percentages may be warranted if rapid growth in electricity demand is expected or if there is an increasing gap between demand and supply due to such things as plant retirements or siting limitations. The current emphasis on climate change mitigation measures would presumably also fall into a similar category of potential CDM drivers.

The CAMPUT study also notes that even those states with 3% of annual revenues as their CDM target have found that there are more cost-effective CDM opportunities than could be met by the 3% funding. The finding is consistent with the situation in British Columbia. In the case of BC Hydro, CDM expenditures over the past few years have been about 3.3% of electricity

[56] Full treatment of these next steps is beyond the scope of the current project.
[57] The term DSM (demand-side management) and CDM are used interchangeably in this section.

revenues.[58] However, the results of BC Hydro's recently completed study (Conservation Potential Review (CPR) 2007) identified over 20,000 GWh of remaining cost-effective CDM opportunities by 2026. The magnitude of remaining cost-effective CDM opportunities combined with the aggressive targets set out in British Columbia's provincial Energy Plan suggest that BC Hydro's future CDM expenditures are likely to increase significantly if the new targets are to be met.

- **Additional notes:**

- Neither of the studies noted above found any one single, simple model for setting CDM spending levels and targets. Rather, the more general conclusion is that utilities use a number of different approaches that are reasonable for their context. In fact, the CAMPUT report identified seven approaches to setting CDM spending levels.

  - Based on cost-effective CDM potential estimates
  - Based on percentages of utility revenues
  - Based on Mills/kWh of utility electric sales
  - Levels set through resource planning process
  - Levels set through the restructuring process
  - Tied to projected load growth
  - Case-by-case approach.

- The CAMPUT study also notes that, although not always explicit, a key issue in most jurisdictions is resolving the trade off between wanting to procure all cost-effective energy-efficiency measures and concerns about the resulting short-term effect on rates. The study concludes that CDM budgets based on findings from an Integrated Resource Plan or a benefit-cost assessment tend to accept whatever rate effects are necessary to secure the overall resource plan, inclusive of the cost-effective energy-efficiency measures.

[58] CAMPUT, 2006. p. 14.

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# 9. TERMS USED IN BUILDING PROFILES

| Profile Term | Explanation |
|---|---|
| **Building Envelope** | Defines the thermal characteristics of a building's exterior components |
| U-value | The rate of heat loss, in Btu per hour per square foot per degree Fahrenheit (BTU/hr. $f^2.^oF$) through walls, roofs and windows. The U-value is the reciprocal of the R-value |
| Shading coefficient (SC) | Is a measure of the total amount of heat passing through the glazing compared with that through a single clear glass |
| Window-to-wall ratio | Defines the ratio of window to insulated exterior wall area |
| **General Lighting** | Defines the lighting types that are used within the main areas of a building, e.g., for a school, the area is classrooms and the lighting type is fluorescent; for a Food Retail store, the main area is the retail floor and the lighting types are fluorescent and metal halide. |
| LPD | Lighting power density expressed in terms of $W/ft^2$ |
| Lux | The amount of visible light per square meter incident on a surface ($lumen/m^2$) |
| Inc | Incandescent lamps |
| CFL | Compact fluorescent lamps |
| T12 | T12 fluorescent lamps with magnetic ballasts |
| T8 | T8 fluorescent lamps with electronic ballasts |
| MH | Metal halide lamps |
| HPS | High-pressure sodium lamps |
| HID | High-intensity discharge lighting includes both MH and HPS |
| **Secondary Lighting** | Defines the lighting types that are used within the secondary areas of a building, e.g., for a school, the secondary areas are corridors, lobbies, foyers, etc., and the lighting type is fluorescent. |
| **Tertiary Lighting** | Defines the lighting types that are used within special purpose areas of a building, e.g., for a school, the tertiary area is a gymnasium and the lighting type is metal halide. |
| **Outdoor Lighting** | Defines the outdoor lighting including parking lot and façade |
| **Overall LPD** | The total floor weighted LPD that includes general, secondary, tertiary, and outdoor. |
| **Fans** | Defines mix of air handling systems |
| CAV | Constant air volume |
| VAV | Variable air volume |
| **Space Heating** | Defines the mix of heating equipment types found within the stock of buildings |
| ASHP | Air source heat pump |
| WSHP | Water source heat pump |
| Resistance | Electric resistance heating equipment including boilers and baseboard heaters |
| Natural Gas | Natural gas heating equipment including packaged rooftop units and boilers |
| **Space Cooling** | Defines the mix of cooling equipment types found within the stock of buildings |
| Centrifugal | Standard centrifugal chillers with a full load performance of 0.75 kW/ton |
| Centri HE | High-efficiency centrifugal chillers assumed to have a performance of <0.65 kW/ton |
| Recip Open | Semi-hermetic reciprocating chillers |
| DX | Direct expansion cooling equipment that use small tonnage hermetic R-22 compressors |

# CONSERVATION AND DEMAND MANAGEMENT (CDM) POTENTIAL

# NEWFOUNDLAND and LABRADOR

# Industrial Sector

***–Final Report–***

*Prepared for:*

**Newfoundland & Labrador Hydro and**
**Newfoundland Power**

*Prepared by:*

**Marbek Resource Consultants Ltd.**

*In association with:*
**CBCL Ltd.**

*January 18, 2008*

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# EXECUTIVE SUMMARY

## ❑ Background and Objectives

Newfoundland and Labrador Hydro and Newfoundland Power (collectively the Utilities) have partnered to produce this study, recognizing the role that each has in energy conservation and least cost electric utility planning within the province. Increasing electricity costs and the expectations of a growing number of their customers and stakeholders have contributed to the increased focus on conservation and demand management (CDM) and resulted in a number of recent initiatives and projects targeting energy savings in the province. This study is the next step in the Utilities efforts to develop a comprehensive plan for CDM in Newfoundland and Labrador. The Utilities envision electricity conservation and demand management (CDM) to be a valuable component in meeting the province's future electricity requirements.

This study will also be a significant component in the further implementation of the Province's recently released Energy Plan. The Energy Plan establishes a long-term vision for how the province's energy resources will be developed and utilized to benefit the people of the province today as well as for future generations. Electricity conservation and demand management (CDM) are an important component of the provincial Energy Plan as are the conservation and demand management components for the other energy resources of the province.

This report meets, in part, the requirements of the Public Utilities Board Order PU 8 2007 requiring NLH to file this study and a five-year plan for implementation of CDM programs in 2008.

The objective of this study is to identify the potential contribution of specific CDM technologies and measures in the Residential, Commercial and Industrial sectors and to assess their economic costs and benefits. The Newfoundland and Labrador economy is expected to grow over the next 20 years, with an associated increase in energy consumption. The benefits of increased penetration of energy efficiency technologies include reduced energy costs for individuals and businesses, as well as environmental benefits through reduced pollution and greenhouse gas emissions.

The outputs from this study will assist the Utilities CDM planners and others to develop specific CDM programs for implementation and to optimize the contribution of CDM technologies and measures to the province's overall energy future.

## ❑ Scope and Organization

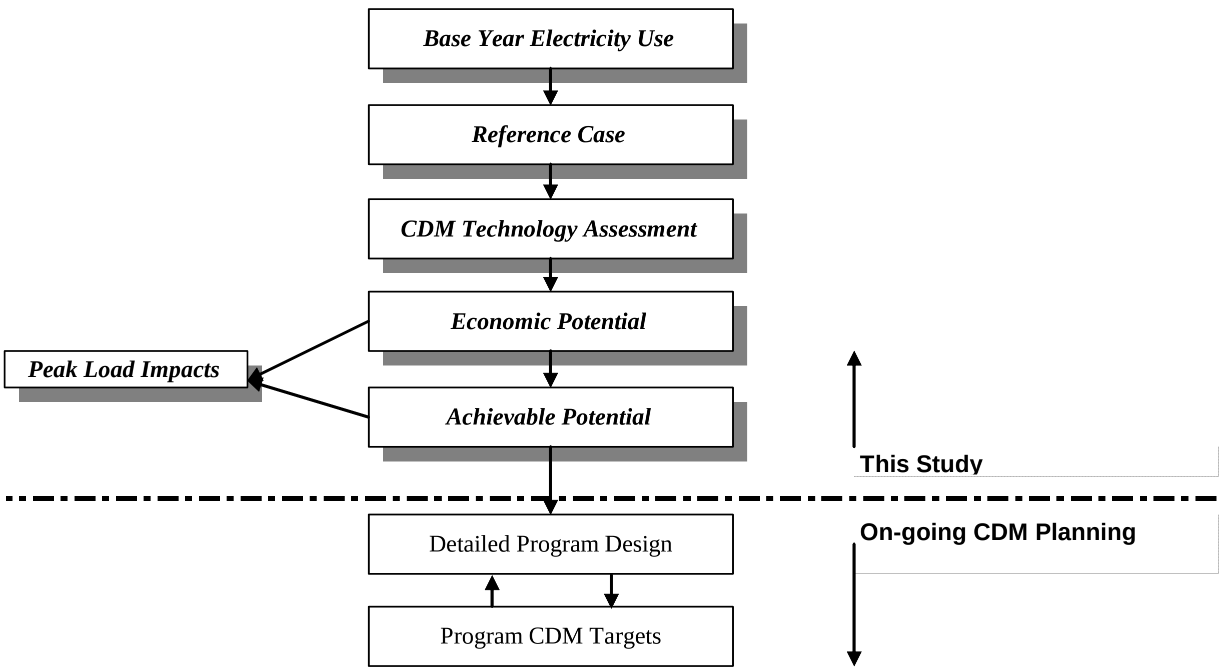
This study covers a 20-year study period from 2006 to 2026 and addresses the Residential, Commercial and Industrial sectors as well as street lighting. The study addresses the customers from both utilities. Due to differences in cost and rate structures, the Utilities' customers are organized into two service regions, which in this report are referred to as the Island and Isolated, and the Labrador Interconnected. For the purposes of this study, the isolated diesel system customers have been combined with those in the Island service region due to their relatively small size and electricity usage. The study reviews all commercially viable electrical efficiency technologies or measures.

## ❑ Approach

It was agreed that the Industrial sector, including the large transmission level customers, would be treated at a much higher level than the Residential and Commercial sectors, The detailed end-use analysis of electrical efficiency opportunities in the Industrial sector employed Marbek's customized spreadsheet model. The model is organized by major industrial sub sector and major end use. The sub sectors and end uses are described in detail in Section 2.

The major steps involved in the analysis are shown in Exhibit ES1 and are discussed in greater detail in Section 1. As illustrated in Exhibit ES1, the results of this study, and in particular the estimation of Achievable Potential,[1] support the on-going work of the Utilities; however, it should be emphasized that the estimation of Achievable Potential is not synonymous with either the setting of specific targets or with program design.

**Exhibit ES1: Study Approach - Major Analytical Steps**




## ❑ Overall Study Findings

As in any study of this type, the results presented in this report are based on a large number of important assumptions. Assumptions such as those related to the current penetration of energy-efficient technologies and the rate of future growth in the stock of industrial buildings are particularly influential. Wherever possible, the assumptions used in this study are consistent with those used by the Utilities and are based on best available information, which in many cases includes the professional judgement of the consultant team, Utilities' personnel and local experts.

[1] The proportion of savings identified that could realistically be achieved within the study period without consideration of budgetary constraints.

The reader should, therefore, use the results presented in this report as best available estimates; major assumptions, information sources and caveats are noted throughout the report.

The study findings confirm the existence of significant potential cost-effective opportunities for CDM in Newfoundland and Labrador's Industrial sector. Electricity savings from efficiency improvements within the Island and Isolated service region would provide between 125 and 59 GWh/yr. of electricity savings by 2026 in, respectively, the Upper and Lower Achievable scenarios. The most significant Achievable Savings opportunities were in the actions that addressed motors and compressed air, and refrigeration/freezing and cooling for the Small and Medium Sector, and process specific equipment in the Large Industrial Sector.

- **Summary of Electricity Savings**

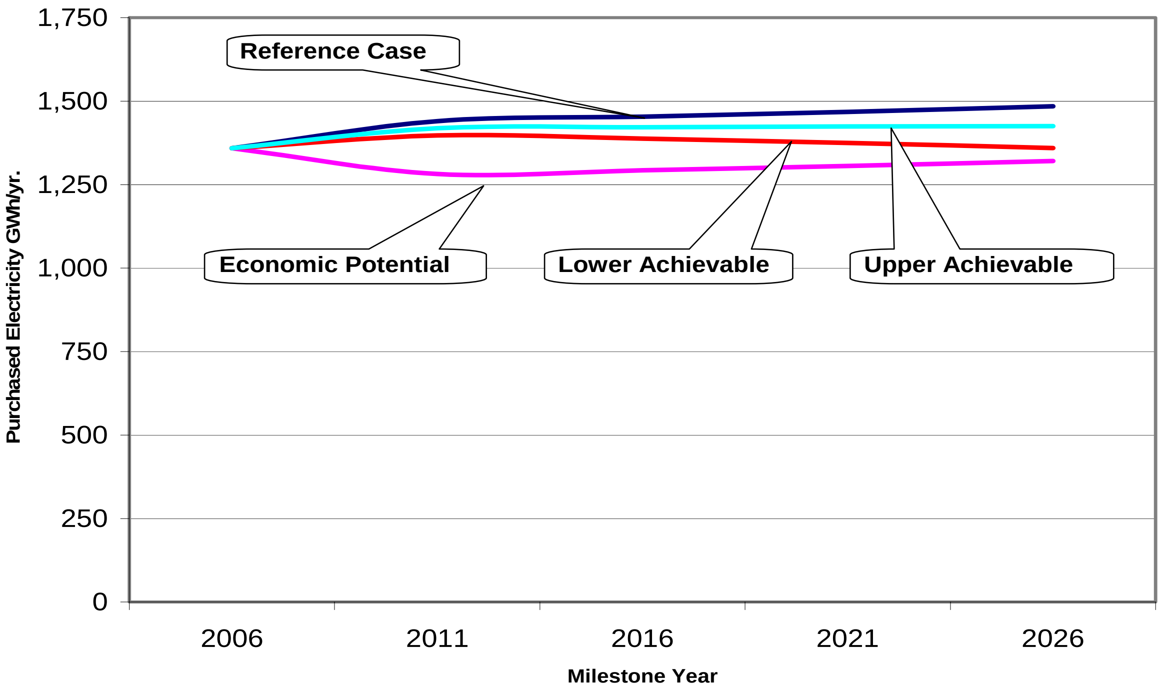
A summary of the levels of annual electricity consumption contained in each of the forecasts addressed by the study is presented in Exhibits ES2 and ES3, by milestone year, and discussed briefly in the paragraphs below.

**Exhibit ES2: Summary of Forecast Results for the Island and Isolated Service Region – Annual Purchased Electricity Consumption,* Industrial Sector (GWh/yr.)**

| Annual Consumption (GWh/yr.) | | | | | | Potential Annual Savings | | |
|---|---|---|---|---|---|---|---|---|
| Milestone Year | Base Year | Reference Case | Economic | Achievable | | Economic | Achievable | |
| | | | | Upper | Lower | | Upper | Lower |
| 2006 | 1,359 | 1,359 | | | | | | |
| 2011 | | 1,440 | 1,282 | 1,397 | 1,419 | 158 | 43 | 21 |
| 2016 | | 1,454 | 1,293 | 1,388 | 1,422 | 161 | 66 | 32 |
| 2021 | | 1,468 | 1,306 | 1,375 | 1,424 | 162 | 93 | 44 |
| 2026 | | 1,484 | 1,321 | 1,360 | 1,425 | 164 | 125 | 59 |

**Results are measured at the customer's point-of-use and do not include line losses and exclude self-generation of about 3,200 GWh/yr.*

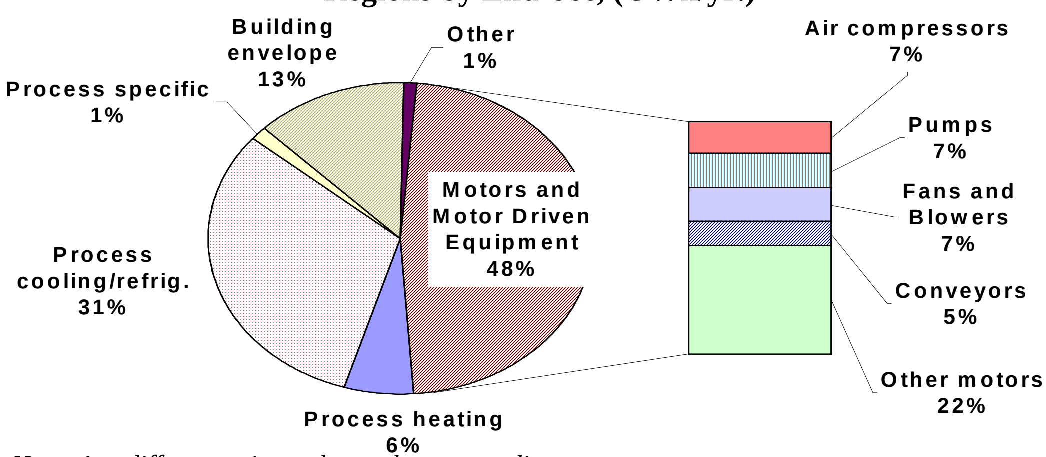
**Exhibit ES3: Reference Case versus Upper and Lower Achievable Potential Electricity Consumption in the Industrial Sector (GWh/yr.)**




## Base Year Electricity Use

In the Base Year of 2006, the Island and Isolated and Labrador Interconnected service regions consumed about 4,558 GWh, of which 1,359 GWh was purchased electricity. The Large Industrial sub sector consumed 79% of the total purchased electricity. Exhibit ES4 shows the purchase electricity use by end use for the Small and Medium Industrial sector. Most of the electricity is used by motor and motor drive equipment (48%) and process cooling and refrigeration/freezing (31%).

**Exhibit ES4: Small and Medium Industry Base Year Modelled Annual Purchased Electricity Consumption for the Island and Isolated and Labrador Interconnected Service Regions by End Use, (GWh/yr.)**




*Note: Any differences in totals are due to rounding.*

*Reference Case*

In the absence of new Utilities CDM initiatives, the study estimates that purchased electricity consumption in the Industrial sector will grow from 1,359 GWh/yr. in 2006 to about 1,484 GWh/yr. by 2026 in the Island and Isolated and Labrador Interconnected service regions. This represents an overall growth of about 9% in the period and compares very closely with NLH's load forecast, which also included consideration of the impacts of "natural conservation" for the Small and Medium Industrial sectors.

*Economic Potential Forecast*

Under the conditions of the Economic Potential Forecast,[2] the study estimated that electricity consumption in the Industrial sector would decline to about 1,321 GWh/yr. by 2026 in the Island and Isolated and Labrador Interconnected service regions. Annual savings relative to the Reference Case are 164 GWh/yr. or about 11%.

*Achievable Potential*

The Achievable Potential is the proportion of the economic electricity savings (as noted above) that could realistically be achieved within the study period. In the Industrial sector within the Island and Isolated and Labrador Interconnected service regions, the Achievable Potential for electricity savings was estimated to be 125 GWh/yr. and 59 GWh/yr. by 2026 in, respectively, the Upper and Lower scenarios.

The most significant Achievable savings opportunities were in the actions that addressed motors and compressed air, refrigeration/freezing and cooling for the Small and Medium Industrial Sectors, and process specific equipment in the Large Industrial sector.

[2] The level of electricity consumption that would occur if all equipment were upgraded to the level that is cost effective against future avoided electricity costs.

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**APPENDICES**

Appendix A: Industry Electricity Survey
Appendix B: Opportunity Profiles
Appendix C: Opportunity Profile Worksheets

## List of Exhibits

# 1. INTRODUCTION

## 1.1 BACKGROUND AND OBJECTIVES

Newfoundland and Labrador Hydro and Newfoundland Power (collectively the Utilities) have partnered to produce this study, recognizing the role that each has in energy conservation and least cost electric utility planning within the province. Increasing electricity costs and the expectations of a growing number of their customers and stakeholders have contributed to the increased focus on conservation and demand management (CDM) and resulted in a number of recent initiatives and projects targeting energy savings in the province. This study is the next step in the Utilities efforts to develop a comprehensive plan for CDM in Newfoundland and Labrador. The Utilities envision electricity conservation and demand management (CDM) to be a valuable component in meeting the province’s s future electricity requirements.

This study will also be a significant component in the further implementation of the Province's recently released Energy Plan. The Energy Plan establishes a long-term vision for how the province's energy resources will be developed and utilized to benefit the people of the province today as well as for future generations. Electricity conservation and demand management (CDM) are an important component of the provincial Energy Plan as are the conservation and demand management components for the other energy resources of the province.

This report is prepared to meet, in part, the requirements of the Public Utilities Board Order PU 8 2007 requiring NLH to file this study and a five year plan for implementation of CDM programs in 2008.

The objective of this study is to identify the potential contribution of specific CDM technologies and measures in the Residential, Commercial and Industrial sectors and to assess their economic costs and benefits. The Newfoundland and Labrador economy is expected to grow over the next 20 years, with an associated increase in energy consumption. The benefits of increased penetration of energy efficiency technologies include reduced energy costs for individuals and businesses, as well as environmental benefits through reduced pollution and greenhouse gas emissions.

The outputs from this study will assist the Utilities CDM planners and others to develop specific CDM programs for implementation and to optimize the contribution of CDM technologies and measures to the province's overall energy future.

## 1.2 STUDY SCOPE

The scope of this study is summarized below.

- **Sector Coverage:** This study addresses the Residential, Commercial and Industrial sectors as well as street lighting. It was agreed that the Industrial sector, including the large transmission level customers, would be treated at a much higher level than the Residential and Commercial sectors.

- **Geographical Coverage**: The study addresses the customers from both utilities. Due to differences in cost and rate structures, the Utilities' customers are organized into two service regions, which in this report are referred to as the Island and Isolated and the Labrador Interconnected. For the purposes of this study, the isolated diesel system customers have been combined with those in the Island service region due to their relatively small size and electricity usage..

- **Study Period**: This study covers a 20-year period. The Base Year is the calendar year 2006, with milestone periods at five-year increments: 2011, 2016, 2021 and 2026. The Base Year of 2006 was selected as this was the most recent calendar year for which complete customer data were available.

- **Technologies:** The study addresses conservation and demand management (CDM) measures. CDM refers to a broad range of potential measures (see Section 1.3, Definitions); however, for the purposes of this study, it was agreed that the primary focus is on energy-efficiency measures. This includes measures that reduce electricity use, and for the Residential and Commercial sectors the associated capacity impact on a winter peak period was included.

### 1.2.1 Data Caveat

As in any study of this type, the results presented in this report are based on a large number of important assumptions. Assumptions such as those related to the current penetration of energy-efficient technologies, the rate of future growth in the province's industrial electricity load and customer willingness to implement new CDM measures are particularly influential.

Wherever possible, the assumptions used in this study are consistent with those used by the Utilities and are based on best available information, which in many cases includes the professional judgement of the consultant team, client personnel and/or local experts. The reader should use the results presented in this report as best available estimates; major assumptions, information sources and caveats are noted throughout the report.

## 1.3 DEFINITIONS

This study uses numerous terms that are unique to analyses and consequently it is important to ensure that readers have a clear understanding of what each term means when applied to this study. A brief description of some of the most important terms and their application within this study is included below.

| | |
|---|---|
| ***Base Year Electricity Use*** | The Base Year is the starting point for the analysis. It provides a description of "where" and "how" electrical energy is currently used in the existing Industrial sector facilities. The results are calibrated to actual utility customer billing data for the Base Year. As noted previously, the Base Year for this study is the calendar year 2006. |

| | |
|---|---|
| ***Reference Case Electricity Use*** | The Reference Case Electricity Use estimates the expected level of electrical energy consumption that would occur over the study period in the absence of new (post-2006) utility-based CDM initiatives. It provides the point of comparison for the subsequent calculation of "economic" and "achievable" electricity savings potentials. The Reference Case aligns well with the NLH Long Term Planning (PLF) Review Forecast, Summer/Fall 2006. |
| ***Conservation and Demand Management (CDM) Measures*** | CDM refers to a broad range of potential measures that can include: energy efficiency (use more efficiently), energy conservation (use less), demand management (use less during peak periods), fuel switching (use a different fuel to provide the energy service) and self-generation/co-generation (displace load off of grid).<br><br>As noted in Section 1.2, it was agreed that the primary focus is on energy-efficiency measures and this includes measures that reduce electricity use. |
| ***The Cost of Conserved Energy (CCE)*** | The CCE is calculated for each energy-efficiency measure. The CCE is the annualized incremental capital and operating and maintenance (O&M) cost of the upgrade measure divided by the annual energy savings achieved, excluding any administrative or program costs. The CCE represents the cost of conserving one kWh of electricity; it can be compared directly to the cost of supplying one new kWh of electricity. |
| ***Economic Potential Electricity Forecast*** | The Economic Potential Electricity Forecast is the level of electricity consumption that would occur if all equipment and facilities were upgraded to the level that is cost effective against the future avoided cost of electricity in the Newfoundland and Labrador Hydro service area (for this study, the value was set at $0.0980/kWh for the Island and Isolated service area and $0.0432/kWh for the Labrador Interconnected service area).[3]). All the energy-efficiency upgrades included in the technology assessment that had a CCE equal to, or less than, the preceding avoided cost of new electricity supply were incorporated into the Economic Potential Forecast. |
| ***Achievable Potential*** | The Achievable Potential is the proportion of the savings identified in the Economic Potential Forecast that could realistically be achieved within the study period. Achievable Potential recognizes that it is difficult to induce customers to |

[3] Sensitivity analysis was also conducted using avoided cost values expected to prevail if the Lower Churchill/DC Link project is completed.

purchase and install all the electrical efficiency technologies that meet the criteria defined by the Economic Potential Forecast. The results are presented as a range, defined as "upper" and "lower."

## 1.4 APPROACH

To meet the objectives outlined above, the study was conducted within an iterative process that involved a number of well-defined steps. At the completion of each step, the client reviewed the results and, as applicable, revisions were identified and incorporated into the interim results. The study then progressed to the next step. A summary of the steps is presented below.

***Step 1:*** **Develop Base Year Electricity Use Profile**

- Compile available data on the Utilities' industrial customers.
- Conduct "high-level" facility energy use survey of transmission level customers.
- Develop "high-level" technical profile of electricity use within the major industrial facilities, based on survey results, existing facility data, experience in other jurisdictions and study team experience.
- Create sector model inputs and generate results.
- Calibrate sector model results using actual utility billing data.

***Step 2:*** **Develop Reference Case Electricity Use Profile**

- Develop computer spreadsheet simulations of electricity use in each industrial sub sector and electricity end use.
- Compile data on forecast levels of growth in Industrial sub sectors, "natural" changes in equipment efficiency levels and/or practices.
- Define sector model inputs and create forecasts of electricity use for each of the milestone years.

***Step 3:*** **Identify and Assess Energy-efficiency Measures**

- Develop list of energy-efficiency measures.
- Compile cost and performance data for each measure.
- Identify the baseline technologies employed in the Reference Case, develop energy-efficiency upgrade options and associated electricity savings for each option and determine the CCE for each upgrade option.

***Step 4:*** **Estimate Economic Electricity Savings Potential**

- Compile utility economic data on the forecast cost of new electricity generation; costs of $0.0980/kWh and $0.0432/kWh were selected as the economic screens for, respectively, the Island and Isolated and Labrador Interconnected service regions.
- Screen the identified energy-efficiency upgrade options from Step 3 against the utility economic data.
- Identify the energy-efficiency upgrade measures and industry sub sectors where the cost of saving one kilowatt of electricity is equal to, or less than, the cost of new electricity generation.

- Apply the economically attractive electrical efficiency measures from Step 3 within the energy use simulation model developed previously for the Reference Case.
- Determine annual electricity consumption in each industrial sub sector and end use when the economic efficiency measures are employed.
- Compare the electricity consumption levels when all economic efficiency measures are used with the Reference Case consumption levels and calculate the electricity savings.

***Step 5:*** **Estimate Achievable Potential Electricity Savings**

- "Bundle" the electricity reduction opportunities identified in the Economic Potential Forecasts into a set of opportunities.
- For each of the identified opportunities, create an Opportunity Profile that provides a "high-level" implementation framework, including measure description, cost and savings profile, target sub sectors, potential delivery allies, barriers and possible synergies.
- Review historical achievable program results and prepare preliminary Assessment Worksheets.
- Conduct workshop with industry, suppliers and engineering consulting representatives to define achievable potential.
- Determine achievable potential for each end use and sub sector.

## 1.5 ANALYTICAL MODEL

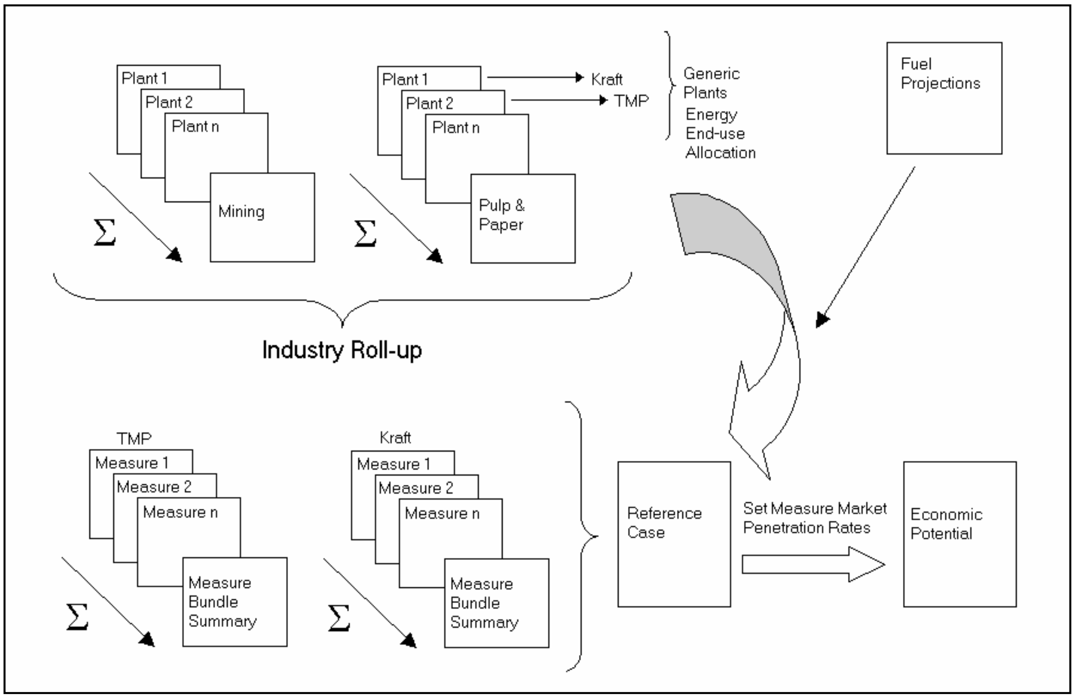
The analysis of the Industrial sector employed Marbek's customized spreadsheet model. The model is organized by major industrial sub sector and major end use. The sub sectors and end uses are described in detail in Section 2.

The model addresses each sub sector by defining a "generic" plant for the sub sector as a whole. Exhibit 1.1 illustrates how the model combines sub sector, end use, efficiency measures and fuel share data to generate the energy use forecasts used in the study.

The generic plant construct within the model is used to define an energy consumption profile representative of a "typical" or archetype plant within a given industry sub sector (or a specific type of plant within a given sub sector if there are substantial process differences). In Exhibit 1.1, the Pulp and Paper sub sector is used as an example with two archetype plants: TMP (thermomechanical pulping mill) and Kraft (kraft pulping mill). The generic plant is a composite of energy use patterns, energy intensities and consumption levels within the particular target sub sector. The candidate energy management measures are applied to the generic plant to model energy savings potential.

Marbek's existing stock of generic industrial plants was used as a starting point for the analysis. The model was customized to the specific Newfoundland and Labrador facilities based on a survey of Large industry and input from Newfoundland and Labrador study team experts familiar with the provincial industrial facilities.

**Exhibit 1.1: Industry Model Diagram**




Note:

- TMP :Thermomechanical pulping mill (Archetype plant in pulp and paper sector)
- Kraft: Kraft pulping mill (Archetype plant in pulp and paper sector)

## 1.6 STUDY ORGANIZATION AND REPORTS

The study was organized and conducted by sector using a common methodology, as outlined above. The results for each sector are presented in individual reports as well as in a summary report. They are entitled:

- *Conservation and Demand Management Potential (2006 to 2026), Newfoundland and Labrador, Residential Sector*
- *Conservation and Demand Management Potential (2006 to 2026), Newfoundland and Labrador, Commercial Sector*
- *Conservation and Demand Management Potential (2006 to 2026), Newfoundland and Labrador, Industrial Sector*
- *Conservation and Demand Management Potential (2006 to 2026), Newfoundland and Labrador, Residential, Commercial and Industrial Sectors, Summary Report*

The study also prepared a brief CDM program evaluation report, which is entitled:

- *Conservation and Demand Management Potential (2006 to 2026), Newfoundland and Labrador, Program Evaluation Guidelines*.

This report presents the Industrial sector results; it is organized as follows:

- Section 2 presents a profile of Industrial sector Base Year electricity use in Newfoundland and Labrador, including a discussion of the major steps involved and the data sources employed.
- Section 3 presents a profile of Industrial sector Reference Case electricity use in Newfoundland and Labrador for the study period 2006 to 2026, including a discussion of the major steps involved.
- Section 4 identifies and assesses the economic attractiveness of the selected energy-efficiency technology measures for the Industrial sector.
- Section 5 presents the Industrial sector Economic Potential Electricity Forecast for the study period 2006 to 2026.
- Section 6 presents the estimated Upper and Lower Achievable Potential for electricity savings for the study period 2006 to 2026.
- Section 7 presents conclusions and next steps.
- Section 8 presents a listing of major references.

# 2. BASE YEAR (F2006) ELECTRICITY USE

## 2.1 INTRODUCTION

This section provides a profile of Base Year (2006) electricity use in Newfoundland and Labrador's Industrial sector. The discussion is organized into the following subsections:

- Segmentation of Industrial Sector
- Definition of End Uses
- Development of Electricity Use Profiles
- Summary of Results.

## 2.2 SEGMENTATION OF INDUSTRIAL SECTOR

The first major task in developing the Base Year calibration involved the segmentation of the industrial customers into specific sub sectors. The choice of sub sectors was determined by the combination of four factors:

- Data availability
- The need to maintain customer confidentiality
- The need to facilitate subsequent analysis of potential electrical efficiency improvements, which means that there must be similarity in terms of major design and operating considerations, such as manufacturing process, hours of operation and product type
- The resources required to assess industrial facilities, especially with large industrial facilities being significantly different from each other. As noted in Section 1, it was agreed that the Industrial sector would be treated at a "high level."

A summary of the Industrial sub sectors that are used in this study is provided in Exhibit 2.1

**Exhibit 2.1: Industrial Sub Sectors**

- **Large Industrial** (includes: Pulp and Paper, Large Mining and Oil Refining)
- **Small and Medium Industrial**:
  - Fishing and Fish Processing
  - Manufacturing
  - Other

A brief description of the industrial customers included in each of the sub sectors shown in Exhibit 2.1 is provided below.

- **Large Industrial**. This classification is based on the amount of electricity used and not on production volumes or number of employees. Facilities included in this category use more than 50 GWh electricity annually. This sub sector consists of six transmission level customers from the following sub sectors: Mining, Pulp and Paper and Oil Refining.

- **Small and Medium Industrial.** Similar to the Large Industrial category, this category is based on the amount of electricity and includes facilities that use less than 50 GWh/yr. The following sub sectors are included:

  - **Fishing and Fish Processing**. This sub sector consists of approximately 175 facilities. This sub sector's monthly electricity consumption is seasonal (monthly consumption peaking in July and August; minimum usage from January to March). The monthly peak consumption is almost 3.5 times more than the minimum monthly consumption.

  - **Manufacturing.** This sub sector consists of approximately 135 facilities; monthly electricity consumption is relatively stable throughout the year.

  - **Other.** This sub sector includes all the industrial facilities using less than 50 GWh/yr. and which are not included under the Fishing or Manufacturing sub sectors. The sub sectors included are: Small and Medium Mining, Municipal Water and Sewer Facilities and Commercial and Utility Water Systems. Approximately 95 facilities are included in this sub sector and the monthly electricity consumption is relatively consistent throughout the year.

The modeling of energy use was executed at the sub sector level, with archetypes for each of the three Large, and Small and Medium Industrial sub sectors. For the Large Industrial sector, the data and results are presented at the aggregated Large Industrial sub sector level to ensure that confidentiality of facility information is maintained.

## 2.3 DEFINITION OF END USES

Electricity use within each of the sub sectors noted above is further defined on the basis of specific end uses. In this study, an end use is defined as, "the final application or final use to which energy is applied. End uses are the services of economic value to the users of energy."

A summary of the major Industrial sector end uses used in this study is provided in Exhibit 2.2 together with a brief description of each.

**Exhibit 2.2: Industrial Sector End Uses**

| Electricity End Use | | Description |
|---|---|---|
| Process heating | | Process heating, including hot water and steam production and distribution |
| Process cooling / refrigeration / freezing | | Process related cooling, refrigeration and freezing |
| Motors and motor driven equipment | Compressed air | Compressed air utilities, including compressors and compressed air distribution system |
| | Pumps | Process pumps |
| | Fans and blowers | Fans and blowers |
| | Conveyors | Conveyors and material handling |
| | Other motors | Motors not included in other categories, for example, motors in grinding, stamping, pressing equipment |
| Process specific | | Processes and equipment not included in the other process categories and are specific to a sub sector |
| Building envelope and comfort | Lighting | Lighting systems |
| | Comfort heating, cooling, ventilation and air conditioning (HVAC) | HVAC for comfort and work space climate control |
| Other | | End uses not included in the other categories. These end-uses include system-wide end uses, such as plant-wide control systems and other supporting end uses, such as electric doors, electric charging for electric forklifts. |

## 2.4 DEVELOPMENT OF INDUSTRIAL ELECTRICITY USE PROFILES

Electricity end-use profiles were developed for the six sub sectors described above. The profiles map proportionally how much electricity is used by each of the end uses for each sub sector. These profiles represent the sub sector archetypes and are used in the model to calculate the electricity used by each end use for each sub sector.

Three archetype profiles were developed for Large industry based on the results of a survey of the facilities included in these sub sectors.[4] In each case, site personnel provided data, which addressed both the allocation of electricity use by end use and general best practices implemented at the sites. A copy of the survey instrument is contained in Appendix A.

Experience from previous industry studies in other Canadian jurisdictions provided the necessary archetype end-use profiles for the three Small and Medium Industrial sub sectors. These profiles were reviewed by industry experts familiar with industry in Newfoundland and Labrador (NL) and were revised to be representative of the NL industrial sub sectors.

[4] The results were also compared with those from detailed studies of similar industries undertaken by Marbek and were found to compare well.

## 2.5 SUMMARY OF MODEL RESULTS

The summary of Base Year model results are measured at the customer's point-of-use.[5]

Exhibit 2.3 presents the model results for the Island and Isolated and Labrador Interconnected service regions with the results broken out by Industrial sub sector and end use. It is assumed that self-generated electricity is mixed with purchased electricity and does not apply selectively to end uses. Purchased electricity is the main focus to determine savings potential and self-generated electricity is presented separately.[6]

Highlights of the results are as follows:

### 2.5.1 Base Year Electricity Use by Sub Sector

Exhibits 2.3 and 2.4 indicate that:

- Almost 70% of all electricity use by industry is self-generated, while the remaining 30% (1,359 GWh/yr.) is supplied by NLH and NP. All the self-generated electricity is produced by the Large Industrial sub sector.
- Large industrial facilities use approximately 94% of all the electricity used by industry in Newfoundland and Labrador but consume about 1,067 GWh/yr. (79%) if only purchased electricity is considered.
- Of the Small and Medium Industrial sub sector, the Fishing and Fish Processing sub sector accounts for about 53% of electricity use.

**Exhibit 2.3: Base Year Modelled Annual Electricity Consumption for the Island and Isolated and Labrador Interconnected Service Regions by Sub Sector, (GWh/yr.)**

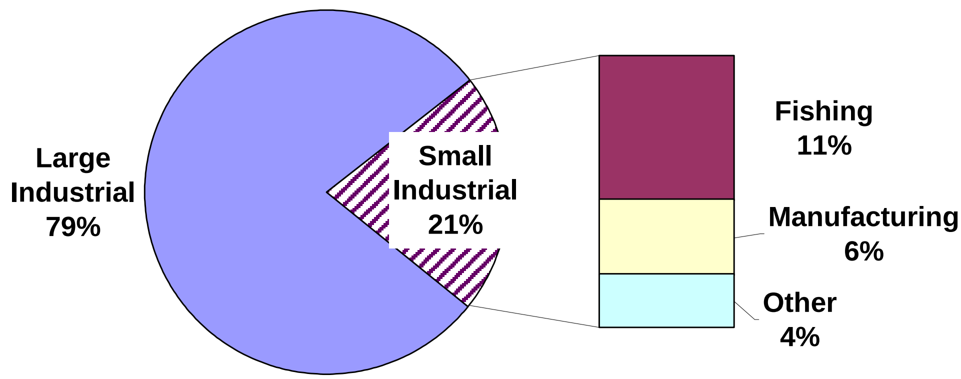
| Sectors | | Purchased Electricity (GWh/yr.) | Self-generated Electricity (GWh/ yr.) | Total Electricity Use (GWh/yr.) | Percentage of Total (%) |
|---|---|---|---|---|---|
| Large Industrial | | 1,067 | 3,229 | 4,296 | 94% |
| Small and Medium Industrial | *Fishing* | *156* | | *156* | *3%* |
| | *Manufacturing* | *81* | | *81* | *2%* |
| | *Other* | *56* | | *56* | *1%* |
| | Sub-total | 292 | 0 | 292 | 6% |
| ***Total*** | | ***1,359*** | ***3,229*** | ***4,588*** | ***100%*** |
| ***Percentage of Total*** | | ***29.6%*** | ***70.4%*** | ***100.0%*** | |

*Note: Any differences in totals are due to rounding.*

[5] Self-generated electricity includes line losses of transmission facilities not owned by NLH.

[6] Self-generation sites are owned and operated by individual customers, not the Utilities. As detailed, site-specific analysis of individual industrial facilities was outside the scope of this study, these facilities and related CDM opportunities were not included in the results presented.

**Exhibit 2.4: Base Year Modelled Annual Purchased Electricity Consumption for the Island and Isolated and Labrador Interconnected Service Region by Sub Sector, (GWh/yr.)**




*Note: Any differences in totals are due to rounding.*

### 2.5.2 Base Year Electricity Use by End Use

The electricity use by industrial end uses is summarized and illustrated in Exhibits 2.5 to 2.7. The results indicate that:

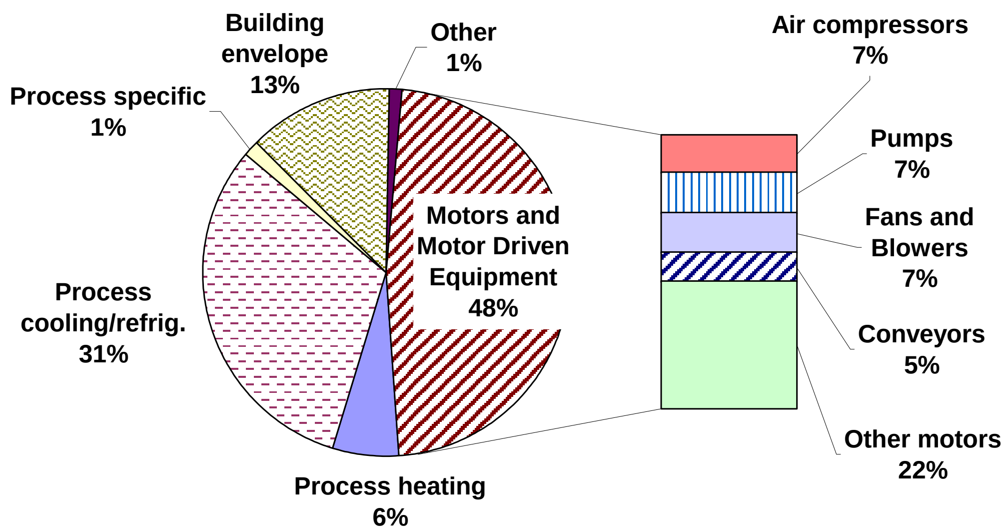
- Motors and motor driven equipment, including compressed air systems, use close to 63% of all the electricity in industry. Within this end use "other motors" account for almost 55% of end-use electricity; pumps account for 17%.
- The second largest electricity end-use consumption is associated with the process-specific end use, namely 18% of total industrial electricity use.
- When only purchased electricity is assessed and self-generation is excluded, the motor and motor driven equipment portion of electricity use decreases slightly to 60% (as illustrated in Exhibit 2.6). Within this end use, the portion of electricity used by "other motors" decreases to 45%, while the portion allocated to pumps increases to 22% and compressed air increases from 10% to 16%. This change is mainly due to the difference in end-use profiles of Large industry, which is responsible for all self-generated electricity.

## Exhibit 2.5: Base Year Modelled Annual Total Electricity Consumption for the Island and Isolated and Labrador Interconnected Service Region by Sub Sector and End Use, (GWh/yr.)

| Electricity End Use | | Large Industry – Electricity Use | | Small and Medium Industry – Electricity Use | | | | | Total | Percentage of Total (%) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Sub Total (GWH/yr.) | Percentage of Total (%) | Fishing (GWH/yr.) | Manufact. (GWH/yr.) | Other (GWH/yr.) | Sub Total (GWH/yr.) | Percentage of Total (%) | | |
| Process heating (incl. water heaters, steam production) | | 260 | 6% | *12* | *2* | *2* | 17 | 5.7% | **277** | 6.0% |
| Process cooling / refrigeration / freezing | | 26 | < 1% | *90* | *< 1* | *1* | 92 | 31.4% | **118** | 2.6% |
| Motors and motor driven equipment | Air compressors | 189 | 4% | *5* | *14* | *1* | 20 | 6.7% | **209** | 4.5% |
| | Pumps | 474 | 11% | *9* | *4* | *7* | 20 | 7.0% | **494** | 10.8% |
| | Fans and blowers | 273 | 6% | *2* | *11* | *8* | 20 | 6.9% | **293** | 6.4% |
| | Conveyors | 292 | 7% | *6* | *3* | *5* | 12 | 4.0% | **304** | 6.6% |
| | Other motors | 1,542 | 36% | *6* | *33* | *25* | 64 | 22.1% | **1,606** | 35.0% |
| Process specific | | 817 | 19% | *3* | *< 1* | *1* | 4 | 1.5% | **822** | 17.9% |
| Building envelope and comfort | Lighting | 220 | 5% | *12* | *11* | *3* | 29 | 10.1% | **250** | 5.5% |
| | Comfort heating, cooling, ventilation and air conditioning (HVAC) | 140 | 3% | *8* | *2* | *2* | 11 | 3.8% | **151** | 3.3% |
| Other | | 62 | 2% | *2* | *< 1* | *1* | 2 | 0.8% | **65** | 1.4% |
| ***TOTAL*** | | ***4,296*** | 100% | *156* | *81* | *56* | ***292*** | 100.0% | ***4,588*** | ***100.0%*** |
| Percentage of Total | | 94% | | *3.4%* | *1.8%* | *1.2%* | 6.4% | | 100.0% | |

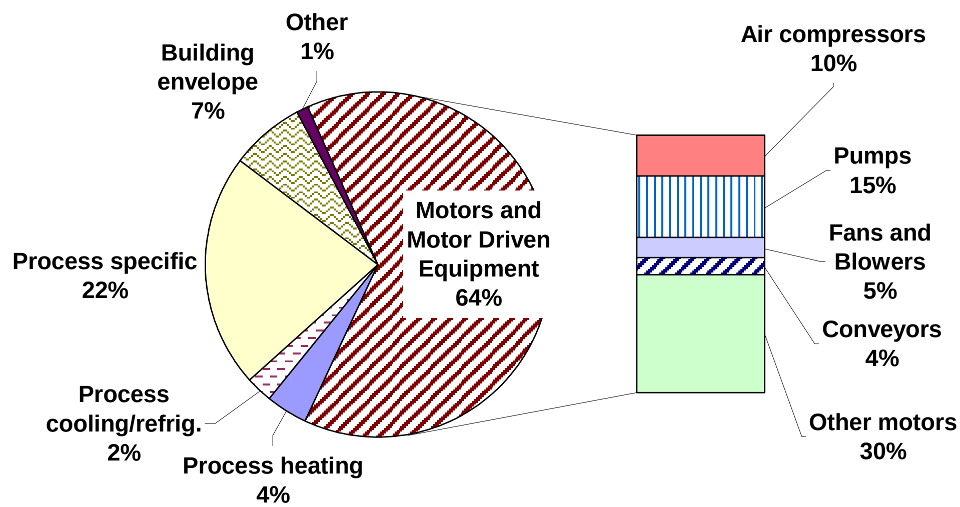
*Note: Any differences in totals are due to rounding.*

**Exhibit 2.6: Small and Medium Industry Base Year Modelled Annual Purchased Electricity Consumption for the Island and Isolated and Labrador Interconnected Service Regions by End Use, (GWh/yr.)**




*Note: Any differences in totals are due to rounding.*

**Exhibit 2.7: Large Industry Base Year Modelled Annual Purchased Electricity Consumption for the Island and Isolated and Labrador Interconnected Service Regions by End Use, (GWh/yr.)**




*Note: Any differences in totals are due to rounding.*

# 3. REFERENCE CASE ELECTRICITY USE

## 3.1 INTRODUCTION

This section presents the Industrial sector Reference Case for the study period (2006 to 2026). The Reference Case estimates the expected level of electricity consumption that would occur over the study period in the absence of new Utilities-based CDM initiatives.

The Reference Case, therefore, provides the point of comparison for the calculation of electricity savings opportunities associated with each of the subsequent scenarios that are assessed within this study.

The discussion is presented within the following subsections:

- Forecast Electricity Consumption
- "Natural" Changes Affecting Electricity Use
- Summary of Model Results.

## 3.2 FORECAST ELECTRICITY CONSUMPTION

Exhibit 3.1 provides the electricity consumption forecast for the milestone years 2011, 2016, 2021 and 2026. The forecast is based on projected growth forecasts for Small and Medium industry provided by NLH, which includes anticipated closing of existing facilities and opening of new facilities. Potential new large industrial loads on the system are not included due to the uncertain and unknown make-up of process end use energy requirements. The self-generated electricity consumption is frozen for the 20-year forecast.

**Exhibit 3.1: Forecast Annual Electricity Consumption for the Island and Isolated and Labrador Interconnected Service Regions by Sub Sector and Milestone Year, (GWh/yr.)**

| Sub Sector | | Electricity Use by Milestone Year (GWH/y) | | | | |
|---|---|---|---|---|---|---|
| | | **2006** | **2011** | **2016** | **2021** | **2026** |
| Large Industrial | Purchased electricity | 1,067 | 1,132 | 1,132 | 1,132 | 1,132 |
| | Self-generation | 3,229 | 3,229 | 3,229 | 3,229 | 3,229 |
| | *Sub-total* | *4,296* | *4,361* | *4,361* | *4,361* | *4,361* |
| Small and Medium Industrial (Purchased) | Fishing | 156 | 161 | 168 | 174 | 181 |
| | Manufacturing | 81 | 85 | 89 | 94 | 99 |
| | Other | 56 | 62 | 65 | 68 | 71 |
| | *Sub-total* | *292* | *308* | *322* | *336* | *352* |
| Total purchased electricity | | 1,359 | 1,440 | 1,454 | 1,468 | 1,484 |
| Total self-generated electricity | | 3,229 | 3,229 | 3,229 | 3,229 | 3,229 |
| ***TOTAL*** | | ***4,588*** | ***4,669*** | ***4,683*** | ***4,697*** | ***4,713*** |

### 3.3 "NATURAL" CHANGES AFFECTING ELECTRICITY USE

The Reference Case is calibrated to the Utilities' forecasts, which assumes "natural" conservation through efficiency improvements in Small and Medium industry over the 20-year forecast period.

### 3.4 SUMMARY OF MODEL RESULTS

Exhibits 3.2 to 3.5 summarize the model results for each of the milestone years in the study period. Consistent with the scope of analysis for this sector, the results shown assume that the generic plant end-use profiles are frozen for the study period. As a result, the distribution of electricity use in each of the forecast milestone years is very similar to the Base Year results. For example:

- The Large Industrial sub sector continues to dominate electricity use, accounting for approximately 76% of total purchased industrial electricity use in 2026.
- Motors and motor driven equipment (61%) continue to account for the largest share of total (large, and Small and Medium combined) industrial electricity use in 2026.
- In the Small and Medium Industrial sub sector, process refrigeration accounts for about 30% of the electricity use.
- The building envelope and comfort end use continues to account for less than 5% of total electricity use in both the Large, and Small and Medium Industrial sub sectors over the study period.

## Exhibit 3.2: Forecast Year 2011 Modelled Annual Purchased Electricity Consumption for the Island and Isolated and Labrador Interconnected Service Regions by Sub Sector and End Use, (GWh/yr.)

| Electricity End Use | | Large Industry - Electricity Use | | Small Industry - Electricity Use | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Sub-Total (GWH/y) | Percentage of Total (%) | Fishing (GWH/y) | Manufact. (GWH/y) | Other (GWH/y) | Sub-Total (GWH/y) | Percentage of Total (%) | Total | Percentage of Total (%) |
| Process heating (incl. water heaters, steam production) | | 48 | 4% | *13* | *2* | *3* | 18 | 6% | 66 | 5% |
| Process cooling / refrigeration / freezing | | 26 | 2% | *94* | *0.1* | *2* | 95 | 31% | 122 | 8% |
| Motors and motor driven equipment | Air compressors | 111 | 10% | *5* | *14* | *1* | 21 | 7% | 132 | 9% |
| | Pumps | 169 | 15% | *10* | *4* | *7* | 22 | 7% | 191 | 13% |
| | Fans and Blowers | 59 | 5% | *2* | *12* | *8* | 21 | 7% | 80 | 6% |
| | Conveyors | 54 | 5% | *6* | *3* | *6* | 16 | 5% | 70 | 5% |
| | Other motors | 335 | 30% | *6* | *35* | *27* | 69 | 22% | 404 | 28% |
| Process specific | | 238 | 21% | *3* | *0.3* | *1* | 4 | 1% | 242 | 17% |
| Building envelope and comfort | Lighting | 52 | 5% | *13* | *12* | *3* | 28 | 9% | 79 | 5% |
| | Comfort heating, cooling, ventilation and air conditioning (HVAC) | 28 | 2% | *8* | *2* | *2* | 12 | 4% | 40 | 3% |
| Other | | 12 | 1% | *2* | *0.4* | *1* | 3 | 1% | 15 | 1% |
| ***TOTAL*** | | ***1,132*** | 100% | *161* | *85* | *62* | ***308*** | 100% | ***1,440*** | ***100%*** |
| Percentage of Total | | 79% | | *11%* | *6%* | *4%* | 21% | | 100% | |

*Note: Any differences in totals are due to rounding.*

**Exhibit 3.3: Forecast Year 2016 Modelled Annual Purchased Electricity Consumption for the Island and Isolated and Labrador Interconnected Service Regions by Sub Sector and End Use, (GWh/yr.)**

| Electricity End Use | | Large Industry - Electricity Use | | Small Industry - Electricity Use | | | | | Total | Percentage of Total (%) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Sub-Total (GWH/y) | Percentage of Total (%) | Fishing (GWH/y) | Manufact. (GWH/y) | Other (GWH/y) | Sub-Total (GWH/y) | Percentage of Total (%) | | |
| Process heating (incl. water heaters, steam production) | | 48 | 4% | *13* | *2* | *3* | 19 | 6% | 67 | 5% |
| Process cooling / refrigeration / freezing | | 26 | 2% | *97* | *0.1* | *2* | 99 | 31% | 125 | 9% |
| Motors and motor driven equipment | Air compressors | 111 | 10% | *5* | *15* | *1* | 22 | 7% | 133 | 9% |
| | Pumps | 169 | 15% | *10* | *5* | *8* | 23 | 7% | 192 | 13% |
| | Fans and Blowers | 59 | 5% | *2* | *12* | *9* | 23 | 7% | 82 | 6% |
| | Conveyors | 54 | 5% | *7* | *4* | *6* | 17 | 5% | 70 | 5% |
| | Other motors | 335 | 30% | *7* | *36* | *29* | 72 | 22% | 407 | 28% |
| Process specific | | 238 | 21% | *3* | *0.3* | *1* | 5 | 1% | 243 | 17% |
| Building envelope and comfort | Lighting | 52 | 5% | *13* | *12* | *3* | 29 | 9% | 80 | 6% |
| | Comfort heating, cooling, ventilation and air conditioning (HVAC) | 28 | 2% | *8* | *2* | *2* | 12 | 4% | 40 | 3% |
| Other | | 12 | 1% | *2* | *0.4* | *1* | 3 | 1% | 15 | 1% |
| ***TOTAL*** | | ***1,132*** | 100% | *168* | *89* | *65* | ***322*** | 100% | ***1,454*** | ***100%*** |
| Percentage of Total | | 78% | | *12%* | *6%* | *4%* | 22% | | 100% | |

*Note: Any differences in totals are due to rounding.*

## Exhibit 3.4: Forecast Year 2021 Modelled Annual Purchased Electricity Consumption for the Island and Isolated and Labrador Interconnected Service Regions by Sub Sector and End Use, (GWh/yr.)

| Electricity End Use | | Large Industry - Electricity Use | | Small Industry - Electricity Use | | | | | Total | Percentage of Total (%) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Sub-Total (GWH/y) | Percentage of Total (%) | Fishing (GWH/y) | Manufact. (GWH/y) | Other (GWH/y) | Sub-Total (GWH/y) | Percentage of Total (%) | | |
| Process heating (incl. water heaters, steam | | 48 | 4% | *14* | *2* | *3* | 19 | 6% | 67 | 5% |
| Process cooling / refrigeration / freezing | | 26 | 2% | *101* | *0.1* | *2* | 103 | 31% | 129 | 9% |
| Motors and motor driven equipment | Air compressors | 111 | 10% | *5* | *16* | *2* | 23 | 7% | 134 | 9% |
| | Pumps | 169 | 15% | *10* | *5* | *8* | 24 | 7% | 193 | 13% |
| | Fans and Blowers | 59 | 5% | *2* | *13* | *9* | 24 | 7% | 83 | 6% |
| | Conveyors | 54 | 5% | *7* | *4* | *7* | 17 | 5% | 71 | 5% |
| | Other motors | 335 | 30% | *7* | *38* | *30* | 76 | 22% | 411 | 28% |
| Process specific | | 238 | 21% | *3* | *0.3* | *1* | 5 | 1% | 243 | 17% |
| Building envelope and comfort | Lighting | 52 | 5% | *14* | *13* | *3* | 30 | 9% | 82 | 6% |
| | Comfort heating, cooling, ventilation and air conditioning (HVAC) | 28 | 2% | *9* | *2* | *2* | 13 | 4% | 41 | 3% |
| Other | | 12 | 1% | *2* | *0.5* | *1* | 3 | 1% | 15 | 1% |
| ***TOTAL*** | | ***1,132*** | 100% | *174* | *94* | *68* | ***336*** | 100% | ***1,468*** | ***100%*** |
| Percentage of Total | | *77%* | | *12%* | *6%* | *5%* | 23% | | 100% | |

*Note: Any differences in totals are due to rounding.*

**Exhibit 3.5: Forecast Year 2026 Modelled Annual Total Electricity Consumption for the Island and Isolated and Labrador Interconnected Service Regions by Sub Sector and End Use, (GWh/yr.)**

| Electricity End Use | | Large Industry - Electricity Use | | Small Industry - Electricity Use | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Sub-Total (GWH/y) | Percentage of Total (%) | Fishing (GWH/y) | Manufact. (GWH/y) | Other (GWH/y) | Sub-Total (GWH/y) | Percentage of Total (%) | Total | Percentage of Total (%) |
| Process heating (incl. water heaters, steam production) | | 48 | 4% | *15* | *2* | *3* | 20 | 6% | 68 | 5% |
| Process cooling / refrigeration / freezing | | 26 | 2% | *105* | *0.1* | *2* | 107 | 30% | 133 | 9% |
| Motors and motor driven equipment | Air compressors | 111 | 10% | *5* | *17* | *2* | 24 | 7% | 135 | 9% |
| | Pumps | 169 | 15% | *11* | *5* | *9* | 25 | 7% | 194 | 13% |
| | Fans and Blowers | 59 | 5% | *2* | *14* | *10* | 25 | 7% | 84 | 6% |
| | Conveyors | 54 | 5% | *7* | *4* | *7* | 18 | 5% | 72 | 5% |
| | Other motors | 335 | 30% | *7* | *41* | *32* | 80 | 23% | 415 | 28% |
| Process specific | | 238 | 21% | *4* | *0.3* | *1* | 5 | 1% | 243 | 16% |
| Building envelope and comfort | Lighting | 52 | 5% | *15* | *14* | *4* | 32 | 9% | 83 | 6% |
| | Comfort heating, cooling, ventilation and air conditioning (HVAC) | 28 | 2% | *9* | *2* | *2* | 13 | 4% | 42 | 3% |
| Other | | 12 | 1% | *2* | *0.5* | *1* | 3 | 1% | 15 | 1% |
| ***TOTAL*** | | ***1,132*** | 100% | *181* | *99* | *71* | ***352*** | 100% | ***1,484*** | ***100%*** |
| Percentage of Total | | 76% | | *12%* | *7%* | *5%* | 24% | | 100% | |

*Note: Any differences in totals are due to rounding.*

# 4. CONSERVATION & DEMAND MANAGEMENT (CDM) MEASURES

## 4.1 INTRODUCTION

This section identifies and assesses the economic attractiveness of the selected energy-efficiency technology measures for the Industrial sector and is presented as follows:

- Methodology
- Description of Energy-efficiency Technologies
- CCE Summary.

## 4.2 METHODOLOGY FOR ASSESSMENT OF ENERGY-EFFICIENCY MEASURES

The following steps were employed:

- Select candidate energy-efficiency measures
- Establish technical performance for each option within a range of applications
- Establish the capital and installation costs for each option
- Calculate the CCE for each conservation measure.

Consistent with the agreed study scope, the analysis of energy-efficiency measures presented in this section is limited to "generic" opportunities that are broadly applicable across North American industrial facilities. As outlined below, the technology descriptions and typical technology cost data draw heavily from the study team's previous and current work in other Canadian jurisdictions.[7] Energy savings estimates are based on the best available data for Newfoundland and Labrador.

A brief discussion of each step is outlined below.

***Step 1 Select Candidate Measures***

The candidate measures were selected in collaboration with the Utilities and from a literature review and previous study team experience. The selected measures are considered to be technically proven and commercially available, even if only at an early stage of market entry. Technology costs were not a factor in the initial selection of candidate technologies.

***Step 2 Establish Technical Performance***

Information on the performance improvements provided by each measure was compiled from available secondary sources including the experience and on-going research work of study team members.

[7] Marbek Resource Consultants and Willis Energy. *BC Hydro Conservation Potential Review- 2007, Industrial Sector.* Prepared for BC Hydro, 2007.

***Step 3 Establish Capital, Installation and Operating Costs for Each Measure***

Information on the cost of implementing each measure was also compiled from secondary sources including the experience and on-going research work of study team members.

The incremental cost is applicable when a measure is installed in a new facility or at the end of its useful life in an existing facility; in this case, incremental cost is defined as the cost difference for the energy-efficiency measure relative to the “baseline” technology. The full cost is applicable when an operating piece of equipment is replaced with a more efficient model prior to the end of its useful life.

In both cases, the costs and savings are annualized, based on the number of years of equipment life and the discount rate, which in this study has been set at 6%. All costs are expressed in constant (2007) dollars.

***Step 4 Calculate CCE for Each Measure***

One of the important sets of information provided in this section is the CCE associated with each energy-efficiency measure. The CCE for an energy-efficient measure is defined as the annualized incremental cost of the upgrade measure divided by the annual energy savings achieved, excluding any administrative or program costs required to achieve full use of the technology or measure. All cost information presented in this section is expressed in constant (2007) dollars.

The CCE provides a basis for the subsequent selection of measures to be included in the Economic Potential Forecast. The CCE is calculated according to the following formula:

$$\frac{C_A + M}{S}$$

Where:

$C_A$ is the annualized installed cost
$M$ is the incremental annual cost of O&M
$S$ is the annual kWh energy savings.

And $A$ is the annualization factor.

Where: $$A = \frac{i(1+i)^n}{(1+i)^n - 1}$$

$i$ is the discount rate
$n$ is the life of the measure.

The detailed results (see Exhibit 4.2) show both “incremental” and “full” installed costs for the energy-efficiency measures, as applicable. If the measure or technology is installed in a new facility, or at the point of natural replacement in an existing facility, then the “incremental” cost of the efficient measure versus the cost of the baseline technology is used.

If, prior to the end of its life, an operating piece of equipment is replaced with a more efficient model, then the “full” cost of the efficient measure is used. In both cases, the costs of the measures are annualized, based on the number of years of equipment life and the discount rate, and the costs incorporate applicable changes in annual O&M costs.

The annual saving associated with the efficiency measure is the difference in annual electricity consumption with and without the measure.

The CCE calculation is sensitive to the chosen discount rate. In the CCE calculations that accompany this document, three discount rates are shown: 4%, 6% and 8%. The 6% real discount rate was used for the primary CCE calculation. The CCE was also calculated using the 4% and 8% real discount rates to provide sensitivity analysis.

Selection of the appropriate discount rate to be used in this analysis was guided by the intended use of the study results. This study seeks to identify the economic potential for CDM in Newfoundland and Labrador from a provincial perspective. Therefore, the appropriate discount rate is the social opportunity cost of capital, which is the estimated average pre-tax rate of return on public and private investments in the provincial economy.[8]

## 4.3 DESCRIPTION OF ENERGY-EFFICIENCY TECHNOLOGIES

Exhibit 4.1 shows a summary of the energy-efficient measures included in this study.

**Exhibit 4.1: Energy-efficiency Technologies and Measures – Industrial Sector**

| | |
|---|---|
| • Cooling, refrigeration/freezing measures | • Conveyors or material handling measures |
| • Compressed air measures | • Motors measures |
| • Pump measures | • Lighting measures |
| • Fan/blower measures | • Process specific measures |

Energy-efficiency improvement opportunities are presented along with a brief description of the technology, savings relative to the baseline, typical installed costs, applicability and co-benefits. A detailed list of the results of the economic assessment of all measures is provided in Exhibit 4.2. The discussion of measures is organized by end use and sub sector.[9]

The following sources were relied upon for technology descriptions, installed cost data, electricity savings data and useful life data.

[8] This discount rate allows for analytic consistency with the earlier NERA Marginal Cost Study, which used a nominal discount rate of 8.4% (approximately 6% real, i.e. net of inflation). NLH lowered its nominal discount rate in the summer of 2007 to 7.75%; however, this change has no material impact on the results of this study.

[9] Measure inputs not otherwise sourced are based on the consultants’ recent work with BC Hydro and other utility clients.

- Marbek Resource Consultants and Willis Energy. *BC Hydro Conservation Potential Review- 2007, Industrial Sector*. Prepared for BC Hydro, 2007.

- Electricity savings potential studies for Nova Scotia (in progress) and New Brunswick. Both studies were commissioned by the Canadian Manufacturers and Exporters with member of the electric utilities present on the steering committees.

- Electricity savings potential studies for Ontario commissioned by the Ontario Power Authority. The studies addressed Small and Medium industrial facilities and fuel substitution.

- Natural Resources Canada, Office of Energy Efficiency research publications.

### 4.3.1 Cooling and Refrigeration/Freezing

The following efficiency measures for cooling and refrigeration (or freezing) were considered:

- Premium efficiency refrigeration equipment including efficient compressors, optimized floating head pressure and equipment size optimization
- Improved control including adjustable speed drives (ASD)
- Premium efficiency control including computer control and floating head pressure control
- Improved distribution system including increased insulation and piping network optimization.

- **Premium Efficiency Refrigeration Equipment**

Improving the efficiency of refrigeration equipment is accomplished through system reconfiguration, such as optimizing the condenser size, and through technology applications such as efficient compressors and condenser fans. Additional energy savings opportunities include high-efficiency refrigeration compressors, which use more efficient electric motors and have lower compressor losses, additional insulation for the refrigeration units and thermo siphon oil coolers for screw compressors.

This measure has attractive energy savings but increased equipment costs. To capitalize on all potential benefits, the feasibility of efficient refrigeration system opportunities are best evaluated during system expansion or as part of a system reliability and safety review.

| **Measure Profile** | |
|---|---|
| Sub Sectors | Small and Medium Industry |
| Typical Measure Size/Specification | 50-HP |
| Typical Measure Costs | $41,000 (full cost)<br>$ 2,000 (incremental cost) |
| Typical Measure Savings | 11 MWh/yr. |
| Useful Measure Life | 25 years |

- **Improved Control**

Improved control is accomplished through the use of ASD on the evaporator fan and condenser fan, compressor speed control and improved defrost control. Currently, most refrigeration systems employ constant speed fan motors on the evaporator and condenser fans. ASD control reduces fan horsepower at part load and reduces the refrigeration load associated with waste heat generated by the fan motors. Improved defrost controls reduce the compressor load by activating the defrost cycle only when excessive ice has accumulated or the temperature has dropped below a preset point.

| **Measure Profile** | |
|---|---|
| Sub Sectors | Small and Medium Industry |
| Typical Measure Size/Specification | 50-HP |
| Typical Measure Costs | $60,000 (full cost)<br>$30,000 (incremental cost) |
| Typical Measure Savings | 13 MWh/yr. |
| Useful Measure Life | 15 years |

- **Premium Efficiency Control**

Premium efficiency refrigeration control is accomplished by using computer controls for the refrigeration equipment, floating head pressure controls to take advantage of low outdoor air temperatures and computerized defrost controls.

Currently, most refrigeration equipment is not designed with computer controls, efficient defrost cycles or floating head pressure controls. Premium refrigeration controls result in improved compressor, evaporator and condenser controls. With floating head pressure controls the system is also able to take advantage of lower outdoor air temperatures. Modern refrigeration controls also include improved defrost cycle algorithms that will reduce the defrost time by as much as 60% compared to conventional defrost controls. Barriers to the implementation of this measure include the high equipment costs and the capacity of the refrigeration plant to incorporate improved refrigeration controls.

| **Measure Profile** | |
|---|---|
| Sub Sectors | Small and Medium Industry |
| Typical Measure Size/Specification | 50-HP |
| Typical Measure Costs | $78,000 (full cost)<br>$48,000 (incremental cost) |
| Typical Measure Savings | 20 MWh/yr. |
| Useful Measure Life | 15 years |

- **Improved Distribution System**

Improving distribution piping requires a thorough analysis of the complex relationship between the flow of refrigerant, oil and pipe insulation. Improved distribution must compromise between maximum capacity at minimum cost and proper oil return to the compressor, while using well-insulated piping.

In industrial screw compressors, oil lubricates the system. Small amounts of oils are always present in the refrigerant. Oil is properly circulated only when the mass velocity of the refrigerant vapour is great enough. Currently, the refrigeration industry uses oil purgers and refrigerant decontamination systems to ensure that the oil does not create problems in the refrigerant system.

Insulation on the refrigerant piping and other parts of the system reduces the absorption of heat by the refrigerant from any environment other than the refrigerated area. An improved distribution system ensures proper refrigerant feed to evaporators without excessive pressure drop, prevents excessive lubricating oil in any part of the system, ensures the compressor is adequately lubricated and optimizes refrigerant distribution.

| **Measure Profile** | |
|---|---|
| Sub Sectors | Small and Medium Industry |
| Typical Measure Size/Specification | 50-HP |
| Typical Measure Costs | $10,000 (full cost)<br>$3,000 (incremental cost) |
| Typical Measure Savings | 7 MWh/yr. |
| Useful Measure Life | 25 years |

### 4.3.2 Compressed Air

Measures that were considered for the compressed air end use include:

- Efficient equipment including efficient compressors, air dryers and equipment size optimization
- Efficient control including ASD, sequencing and dryer dewpoint control
- Efficient distribution system including increased air storage and reduced piping friction losses.

Below is a brief description of the most promising measures as well as summaries of the results of their economic assessment.

- **Premium Efficiency Compressed Air Equipment**

Premium efficiency compressed air equipment includes both the compressor and the air dryer. Each is described briefly below.

Premium efficiency air compressors come with built-in ASD control that allows the compressor output to match the plant air demand. These compressors may save as much as 40% over standard compressors which typically use modulated control.

| Measure Profile | |
|---|---|
| Sub Sectors | All |
| Typical Measure Size/Specification | 200-HP compressor |
| Typical Measure Cost | $62,000 (full cost)<br>$25,000 (incremental cost) |
| Typical Measure Savings | 89 MWh/yr. |
| Useful Measure Life | 25 years |

Premium efficiency air dryers are of the refrigerated type with dewpoint control. These dryers are typically at least 15% more efficient than regenerative desiccant dryers, which are still commonly used in industry.

| Measure Profile | |
|---|---|
| Sub Sectors | All |
| Typical Measure Size/Specification | 2,000 CFM refrigerated air dryer |
| Typical Measure Cost | $37,000 (full cost)<br>$12,000 (incremental cost) |
| Typical Measure Savings | 60 MWh/yr. |
| Useful Measure Life | 20 years |

- **Premium Efficiency Sequencing Control**

As mentioned above, premium efficiency air compressors come with built-in ASD control. The additional measure considered here is sequencing control.

Industrial facilities typically have several air compressors. Sequencing control systems can operate the compressors so that the larger compressor is base loaded (always on), the mid-sized compressors are used as needed to increase supply and an ASD compressor acts as the trim compressor (provides for the variable component of the process air demand). This setup is intended to closely match the demand for compressed air, to maintain consistent pressure and flow and to reduce O&M costs.

This measure applies to a retrofit or to a new facility. In each case, the alternative is to do nothing, i.e., use the factory installed control system. Therefore, the full and the incremental costs are equivalent.

| Measure Profile | |
|---|---|
| Sub Sectors | All |
| Typical Measure Size/Specification | 800-HP compressed air system |
| Typical Measure Cost | $41,000 (full cost) |
| Typical Measure Savings | 119 MWh/yr. |
| Useful Measure Life | 15 years |

- **Improved Distribution System**

This measure involves the addition of air storage to reduce pressure fluctuations, and air piping redesign to reduce friction losses. Not included in this measure are leak fixing and nozzle improvement, which are considered separate O&M measures.

| **Measure Profile** | |
|---|---|
| Sub Sectors | All |
| Typical Measure Size/Specification | 800-HP compressed air system |
| Typical Measure Cost | $10,000 (full cost)<br>$7,000 (incremental cost |
| Typical Measure Savings | 167 MWh/yr. |
| Useful Measure Life | 25 years |

### 4.3.3 Pumps

Measures that were considered for this end use include:

- Efficient and premium efficiency equipment including equipment size optimization
- Efficient control including ASD.

Below is a brief description of these measures as well as summaries of the results of their economic assessment.

- **Premium Efficiency Pump**

In industrial applications pumps are often used for cooling tower sprays, spray cooler, water boosters, liquid transport, liquid recovery and liquid mixing. Energy savings can be gained by replacing older stock pumps with premium efficiency models that are application specific or with premium efficiency impellers and motors. Pumps should be sized and selected based on their performance curve for the required flow. Impeller sizing is also an important consideration; impellers should be sized for a specific application.

| **Measure Profile** | |
|---|---|
| Sub Sectors | All |
| Typical Measure Size/Specification | 50-HP pump |
| Typical Measure Costs | $2,000 (full cost)<br>$600 (incremental cost) |
| Typical Measure Savings | 10 MWh/yr. |
| Useful Measure Life | 20 years |

- **Premium Efficiency Control, Including Adjustable Speed Drives**

Pumps used for variable flow in industrial applications may be candidates for ASD. Currently, most pump installations are single speed and operate continuously independent of the actual load. Installing ASD on smaller pumps will result in significant energy savings in variable load applications where full operation may be required for less than 30% of the operating time. In these applications, 40% energy savings can be achieved. Modulating valves installed on by pass lines will provide sufficient flow at all times, allowing the pump to perform at maximum efficiency on the pump curve. Barriers to implementation include large capital investment equipment; however, energy savings and production improvements will make this an attractive investment.

| **Measure Profile** | |
|---|---|
| Sub Sectors | All |
| Typical Measure Size/Specification | 50-HP pump |
| Typical Measure Costs | $8,100 (full cost)<br>$4,300 (incremental cost) |
| Typical Measure Savings | 15 MWh/yr. |
| Useful Measure Life | 15 years |

### 4.3.4 Fans and Blowers

Measures that were considered for the fans and blowers end use include:

- Efficient and premium efficiency equipment, including equipment size optimization
- Efficient control, including timers and ASD.

❑ **Premium Efficiency Fans and Blowers**

Fans and blowers are often used for ventilation, exhaust, cooling, dust collection and aeration. Energy savings can be gained by replacing older stock fans and blowers with premium efficiency models that are application specific. Fans should be sized and selected for an application based on the performance curve of the fan at the required airflow.

| **Measure Profile** | |
|---|---|
| Sub Sectors | All |
| Typical Measure Size/Specification | 50-HP |
| Typical Measure Cost | $2,000 (full cost)<br>$600 (incremental cost) |
| Typical Measure Savings | 7 MWh/yr. |
| Useful Measure Life | 20 years |

❑ **Premium Efficiency Control, Including Adjustable Speed Drives**

Fans are widely used in industry for conveyance, drying and ventilation purposes. Operations requiring variable air delivery, such as drying, can benefit from premium control with ASD allowing air delivery to match process requirements. ASD save electricity and improve product quality by providing plant operators greater and finer control.

| Measure Profile | |
|---|---|
| Sub Sectors | All |
| Typical Measure Size/Specification | 220-HP fan |
| Typical Measure Cost | $51,500 (full cost)<br>$26,500 (incremental cost) |
| Typical Measure Savings | 66 MWh/yr. |
| Useful Measure Life | 15 years |

### 4.3.5 Conveyors and Material Handling

Measures that were considered for the conveyor (or material handling) end use include:

- Efficient and premium efficiency equipment, including equipment size optimization, low friction systems and drive optimization
- Efficient control, including ASD.

Where variation exists between the economic assessment results for large versus small systems, the measures are grouped by size.

- **Premium Efficiency Conveyors**

Conveyors often use gear boxes to isolate the motor and to provide better torque control. Currently, most gear boxes in most of the Large Industrial sub sectors consist of transmissions with 90%-92% efficiencies. Opportunities include using higher-efficiency drives, couplings and gear/speed reducer alternatives. In older conveyor systems, or where process requirements have changed, it may be possible to resize a conveyor, upgrade the controls or re-engineer the system to improve layout and configuration, all of which will result in energy savings.

| Measure Profile | |
|---|---|
| Sub Sectors | Large Industry |
| Typical Measure Size/Specification | 100-HP system |
| Typical Measure Costs | $40,000 (full cost)<br>$17,5000 (incremental cost) |
| Typical Measure Savings | 12 MWh/yr. |
| Useful Measure Life | 20 years |

- **Premium Efficiency Control for Conveyors**

Incorporating programmable logic controls (PLC) into the conveyor system will result in energy savings. PLC controls can shut down unloaded conveyors and control the conveyor based on load. Barriers to implementation include additional maintenance costs due to increased number of components in the system.

| **Measure Profile** | |
|---|---|
| Sub Sectors | Small and Medium Industry |
| Typical Measure Size/Specification | 50-HP system |
| Typical Measure Costs | $12,000 (full cost)<br>$6,0000 (incremental cost) |
| Typical Measure Savings | 9 MWh/yr. |
| Useful Measure Life | 15 years |

### 4.3.6. Premium Efficiency Motors

The three motor efficiency levels included in this study are standard (93.5% efficient), high efficiency (94.5% efficient) and premium efficiency (95.5% efficient). Premium efficiency motors apply to all sub sectors and end uses.

Electric motors convert approximately 85% of industrial plant electricity use to torque to drive industrial end uses such as fans, pumps, material handling and a large portion of process loads. These motors range in size from 75 Watts to more than 25,000 kW, with corresponding efficiencies of 40%-98%. While inherently efficient in converting electricity to shaft or motive power, on average 5%-8% of this power is lost in motor inefficiencies that occur before the driven equipment losses.

Both synchronous and induction motors are used in industrial facilities. It is estimated that induction motors in the 1-HP to 500-HP range use over 50% of the motor energy use, while induction motors in the 500-HP to 5,000-HP range account for 15% to 20% of the total plant load. Induction motor efficiency can be increased through adherence to proper specification or though the implementation of an efficient motor purchasing program. Synchronous motors are typical of refiner motors in the Pulp and Paper sub sector and of Large Mining grinding operations. These motors are often built up for efficiency in the design process.

Electric motor efficiency improvement has been a major thrust in the North American market for more than 25 years. Throughout the 1980s, standard efficiency induction motors dominated industrial plant installations. Prior to 1990, only 5% of new motor purchases were considered energy efficient. Since the late 1990s, energy-efficient motors comprised the majority of sales.

| **Measure Profile** | |
|---|---|
| Sub Sectors | All |
| Typical Measure Size/Specification | 150-HP motor |
| Typical Measure Costs | $13,000 (full cost)<br>$700 (incremental cost) |
| Typical Measure Savings | 9 MWh/yr. |
| Useful Measure Life | 25 years |

### 4.3.7 Synchronous Belts

Synchronous belts, also called timing, positive drive or high torque drive belts, apply to all sub sectors and end uses.

Often, industrial end uses are driven by pulleys that use V-Belts. By replacing the pulley sheaves with synchronous belt pulleys and installing synchronous belts onto the end use (e.g., fan) an efficiency gain of 3%-5% can be achieved because of reduced slippage and friction between the pulley and belt. Synchronous belts may require motor vibration sensors to prevent damage from continuous operation following a system failure.

Since the alternative to this measure is to do nothing, the full and incremental costs are the same.

| **Measure Profile** | |
|---|---|
| Sub Sectors | All |
| Typical Measure Size/Specification | 150-HP motor |
| Typical Measure Costs | $1,450 (full cost) |
| Typical Measure Savings | 13 MWh/yr. |
| Useful Measure Life | 10 years |

### 4.3.8 Building Envelope and Comfort

This end use includes lighting, comfort heating and cooling, plug loads and elevators. This end use consumed about 8% of electricity in the Industrial sector in the Base Year. Lighting systems account for more than 60% of the electricity consumed by this end use and, therefore, are the focus for this end use.

- **Lighting**

Numerous lighting retrofit measures exist. Summarized here are two of the largest potential lighting measures for industrial facilities: 1) major lighting fixtures and controls retrofit, and 2) replacement of high-intensity discharge lighting with fluorescent high-bay T5 high-output lighting.

Opportunities exist for major lighting retrofits at older facilities, especially larger facilities. The lighting systems in these facilities are often several decades old. In some cases, low-efficiency mercury vapor lighting is still in use and no lighting control measures are in place. Potential electricity savings at such facilities are significant but retrofits are often complicated by a lack of dedicated circuits, and consistency across the facility.

In all cases, these projects are necessarily full cost measures because the retrofit is considered for an existing facility before the end of the useful life of the existing lighting system.

| Measure Profile | |
|---|---|
| Sub Sectors | All |
| Typical Measure Size/Specification | Medium-sized facility |
| Typical Measure Costs | $38,000 (full cost) |
| Typical Measure Savings | 45 MWh/yr. |
| Useful Measure Life | 10 years |

A medium-sized facility is defined as a facility with about 120 lamps, including fluorescent, high-pressure sodium and mercury vapor types. The upgrade measures include retrofitting the lighting fixtures to high-efficiency fixtures and lamps and installing lighting control.

High-intensity discharge (HID) lighting, such as the metal halide lamp, is the most widely used lighting type in industrial facilities. Recent advances in the development of high-bay T5 high-output fluorescent lighting indicate that replacing HID lighting with T5 high-output lighting may be a promising efficiency measure.

HID lighting is used for illuminating high bay areas such as production facilities. HID lighting includes mercury vapor, metal halide and high-pressure sodium lamps. The most widely used type of lamp in industrial facilities is the metal halide. Replacing them with T5 high-output lamps is estimated to reduce electricity use by 20%-40%. Other benefits of T5 high-output lighting over HID lighting are better colour rendering and longer lamp life. Although T5 high-output lighting is commercially available, advances in the technology are fairly recent. To date, the technology has had negligible impact and is not expected to gain market share in the absence of utility or other CDM programs.

| Measure Profile | |
|---|---|
| Sub Sectors | All |
| Typical Measure Size/Specification | 19x4 lamp T5 high-output luminaire plus 24x6 lamp T5 high-output luminaires |
| Typical Measure Costs | $13,000 (full cost)<br>$3,000 (incremental cost) |
| Typical Measure Savings | 4 MWh/yr. |
| Useful Measure Life | 10 years |

### 4.3.9 Process Specific

Electricity consumed in the process-specific end use is about 1% for Small and Medium industry in Newfoundland and Labrador, but is close to 22% of the total electricity use for industry. Large industry in Newfoundland and Labrador consists of six large facilities. Process-specific energy-efficiency measures are very site specific and are best addressed through the use of on-site assessments, which are beyond the scope of this study.

Based on experience in other jurisdictions, potential electricity savings would be expected to be in the range of 10% to 15% for process-specific end uses such as those typically found in the Pulp and Paper, Mining and Oil Refining sub sectors.

### 4.3.10 Other

This end use includes non-specific miscellaneous loads and consumed only 1% of electricity in the Industrial sector in the Base Year; therefore, a detailed economic analysis was not considered.

## 4.4 CCE SUMMARY

Exhibit 4.2 shows the CCE for each measure.

## Exhibit 4.2: CCE Summary Table – Savings and Costs per Measure

| End Use | Sub Sector | Measure Description | Annual Savings (kWh/year) | Total Cost ($) | Basis: Full or Incremental | Useful Measure Life (y) | 4% Discount Rate: CCE (c/kWh) | 6% Discount Rate: CCE (c/kWh) | 8% Discount Rate: CCE (c/kWh) |
|---|---|---|---|---|---|---|---|---|---|
| Refrigeration / Freezing | Small / Medium | Premium efficiency refrigeration equipment | 11,186 | 41,000 | Full | 25 | 23.5 | 28.7 | 34.3 |
| | | Premium efficiency refrigeration equipment | 11,186 | 2,000 | Incremental | 25 | 1.1 | 1.4 | 1.7 |
| | | Improved control | 13,423 | 60,000 | Full | 15 | 47.7 | 53.5 | 59.7 |
| | | Improved control | 13,423 | 30,000 | Incremental | 15 | 27.6 | 30.5 | 33.6 |
| | | Premium efficiency control | 20,134 | 78,000 | Full | 15 | 40.8 | 45.8 | 51.2 |
| | | Premium efficiency control | 20,134 | 48,000 | Incremental | 15 | 27.4 | 30.5 | 33.8 |
| | | Improved distribution system | 6,711 | 10,000 | Full | 25 | 9.5 | 11.7 | 14.0 |
| | | Improved distribution system | 6,711 | 3,000 | Incremental | 25 | 2.9 | 3.5 | 4.2 |
| Compressed air | All | Premium efficiency ASD compressor | 89,484 | 62,000 | Full | 25 | 6.7 | 7.7 | 8.7 |
| | | Premium efficiency ASD compressor | 89,484 | 25,000 | Incremental | 25 | 4.0 | 4.4 | 4.9 |
| | | Premium efficiency refrigerated air dryer | 59,656 | 37,000 | Full | 20 | 5.4 | 6.2 | 7.2 |
| | | Premium efficiency refrigerated air dryer | 59,656 | 12,000 | Incremental | 20 | 2.3 | 2.6 | 2.9 |
| | | Premium efficiency sequencing control | 119,312 | 41,000 | Full | 15 | 3.8 | 4.2 | 4.7 |
| | | Improved distribution system | 167,037 | 10,000 | Full | 25 | 0.4 | 0.5 | 0.6 |
| | | Improved distribution system | 167,037 | 7,000 | Incremental | 25 | 0.3 | 0.3 | 0.4 |
| Pump | All | Premium efficiency pump | 10,440 | 1,900 | Full | 20 | 3.7 | 4.0 | 4.2 |
| | | Premium efficiency pump | 10,440 | 600 | Incremental | 20 | 2.8 | 2.9 | 3.0 |
| | | Premium efficiency control, incl ASD | 14,914 | 8,100 | Full | 15 | 6.2 | 6.9 | 7.7 |
| | | Premium efficiency control, incl ASD | 14,914 | 4,300 | Incremental | 15 | 3.9 | 4.3 | 4.7 |
| Fans/Blowers | All | Premium efficiency fan / blower | 7,457 | 2,000 | Full | 20 | 5.3 | 5.7 | 6.1 |
| | | Premium efficiency fan / blower | 7,457 | 600 | Incremental | 20 | 3.9 | 4.1 | 4.2 |
| | | Premium efficiency control, including ASD | 65,622 | 51,500 | Full | 15 | 7.7 | 8.8 | 9.9 |
| | | Premium efficiency control, including ASD | 65,622 | 26,500 | Incremental | 15 | 4.3 | 4.8 | 5.4 |
| Conveyors | All | Premium efficiency small conveyors | 5,966 | 4,000 | Full | 20 | 9.1 | 10.0 | 11.0 |
| | | Premium efficiency small conveyors | 5,966 | 2,000 | Incremental | 20 | 6.7 | 7.1 | 7.6 |
| | | Premium efficiency control for small conveyors | 8,948 | 12,000 | Full | 15 | 14.9 | 16.6 | 18.5 |
| | | Premium efficiency control for small conveyors | 8,948 | 6,000 | Incremental | 15 | 8.8 | 9.7 | 10.6 |
| | | Premium efficiency large conveyors | 11,931 | 40,000 | Full | 20 | 27.6 | 32.2 | 37.1 |
| | | Premium efficiency large conveyors | 11,931 | 17,500 | Incremental | 20 | 13.7 | 15.7 | 17.9 |
| | | Premium efficiency control for large conveyors | 17,897 | 43,000 | Full | 15 | 24.4 | 27.5 | 30.9 |
| | | Premium efficiency cotnrol for large conveyors | 17,897 | 20,500 | Incremental | 15 | 13.1 | 14.6 | 16.2 |

# Exhibit 4.2 (Continued)

| End Use | Sub Sector | Measure Description | Annual Savings (kWh/year) | Total Cost ($) | Basis: Full or Incremental | Useful Measure Life (y) | 4% Discount Rate: CCE (c/kWh) | 6% Discount Rate: CCE (c/kWh) | 8% Discount Rate: CCE (c/kWh) |
|---|---|---|---|---|---|---|---|---|---|
| Motors | All | Synchronous belts | 13,423 | 1,450 | Full | 10 | 2.2 | 2.4 | 2.5 |
| | | 30 HP Standard to premium efficiency motor | 1,790 | 6,000 | Full | 25 | 32.6 | 37.4 | 42.6 |
| | | 30 HP High to premium efficiency motor | 1,790 | 1,100 | Incremental | 25 | 12.3 | 13.2 | 14.1 |
| | | 150 HP Standard to premium efficiency motor | 8,948 | 13,000 | Full | 25 | 9.3 | 11.4 | 13.6 |
| | | 150 HP High to premium efficiency motor | 8,948 | 700 | Incremental | 25 | 0.5 | 0.6 | 0.7 |
| | | 1000 HP Standard to premium efficiency motor | 74,570 | 72,000 | Full | 25 | 6.9 | 8.2 | 9.7 |
| | | 1000 HP High to premium efficiency motor | 74,570 | 6,000 | Incremental | 25 | 0.9 | 1.0 | 1.2 |
| Lighting | All | Metal halide to high bay T5 HO | 4,474 | 13,000 | Full | 10 | 47.0 | 50.7 | 54.5 |
| | | Metal halide to high bay T5 HO | 4,474 | 3,000 | Incremental | 10 | 19.4 | 20.3 | 21.2 |
| | | Efficient lighting system, incl design, fixtures, control | 44,742 | 38,000 | Full | 10 | 12.7 | 13.8 | 14.9 |

# 5. ECONOMIC POTENTIAL ELECTRICITY FORECAST

## 5.1 INTRODUCTION

This section presents the Industrial sector Economic Potential Forecast for the study period 2006 to 2026. The Economic Potential Forecast estimates the level of electricity consumption that would occur if all equipment were upgraded to the level that is cost effective against the long-run avoided cost of electricity in the Newfoundland Labrador service area. In this study, "cost effective" means that the technology upgrade cost, referred to as the cost of conserved energy (CCE) in the preceding section, is equal to, or less than, the economic screen.[10]

The discussion in this section is organized and presented in the following subsections:

- Avoided Cost Used for Screening
- Major Modelling Tasks
- Technologies Included in Economic Potential Forecast
- Summary of Results.

## 5.2 AVOIDED COST USED FOR SCREENING

NLH has determined that the primary avoided costs of new electricity supply to be used for this analysis are $0.0980/kWh for the Island and Isolated service region and $0.0432/kWh for the Labrador Interconnected service region. These avoided costs represent a future in which the Lower Churchill project is not built and there is no DC link from Labrador to the Island.[11]

Therefore, the Economic Potential Forecast incorporates all the CDM measures reviewed in Section 4 that have a CCE equal to or less than the avoided costs.

NLH is currently studying the Lower Churchill/DC Link project. However, a decision on whether to proceed is not expected until 2009 and, even if the project proceeds, the earliest completion date would be in late 2014. This means that regardless of the decision, the avoided cost values shown above will be in effect until the approximate mid point of the study period. If the project does proceed, the avoided costs presented above are expected to change. To provide insight into the potential impacts of the Lower Churchill/DC Link project on this study, it was agreed that the consultants would provide a high-level sensitivity analysis.

[10] Costs related to program design and implementation are not yet included.
[11] The avoided costs draw on the results of the earlier study conducted by NERA Economic Consulting, which is entitled: Newfoundland and Labrador Hydro. *Marginal Costs of Generation and Transmission*. May 2006. The avoided costs used in this study include generation, transmission and distribution.

## 5.3 MAJOR MODELLING TASKS

By comparing the results of the Industrial sector Economic Potential Electricity Forecast with the Reference Case, it is possible to determine the aggregate level of potential electricity savings within the Industrial sector, as well as identify which specific end uses provide the most significant opportunities for savings.

To develop the Industrial sector Economic Potential Forecast, the following tasks were completed:

- The CCE for each of the energy-efficient upgrades presented in Exhibit 4.2 were reviewed, using the 6% (real) discount rate. Due to the limited interactive effects between measures in industry, an analysis of interactive effects was excluded from the study.

- Technology upgrades that had a CCE equal to, or less than, the avoided cost threshold were selected for inclusion in the economic potential scenario, either on a "full cost" or "incremental" basis. It is assumed that technical upgrades having a "full cost" CCE that met the cost threshold were implemented in the first forecast year. It is assumed that those upgrades that only met the cost threshold on an "incremental" basis are being introduced more slowly as the existing stock reaches the end of its useful life.

- Electricity use within the Large, and Small and Medium Industrial sectors was modelled with the same energy models used to generate the Reference Case. However, for this forecast, the remaining "baseline" technologies included in the Reference Case forecast were replaced with the most efficient "technology upgrade option" and associated performance efficiency that met the cost threshold of $0.0980/kWh for the Island and Isolated service region and $0.0432/kWh for the Labrador Interconnected service region.

- When more than one upgrade option was applied, the measures were bundled and overall efficiency and market penetration rates were determined.

- A sensitivity analysis was conducted using preliminary avoided cost values that assume development of the Lower Churchill/DC Link.

## 5.4 TECHNOLOGIES INCLUDED IN ECONOMIC POTENTIAL FORECAST

Exhibits 5.1 and 5.2 provide a listing of the technologies selected for inclusion in this forecast for, respectively, the Small and Medium, and Large Industrial sectors. In each case, the exhibits show the following:

- End use affected
- Upgrade measures selected
- Rate at which the upgrade measures were introduced into the stock.

**Exhibit 5.1: Technologies Included in Economic Potential Forecast for Small and Medium Industry and Total Economic Potential Market Penetration Rates**

| End Use | Measures | 2006 | 2011 | 2016 | 2021 | 2026 |
|---|---|---|---|---|---|---|
| Refrigeration / Freezing | Premium efficiency refrigeration equipment | 10% | 36% | 62% | 88% | 100% |
| | Improved distribution system | | | | | |
| Compressed air | Premium efficiency ASD compressor | 15% | 100% | 100% | 100% | 100% |
| | Premium efficiency refrigerated air dryer | | | | | |
| | Premium efficiency sequencing control | | | | | |
| | Improved distribution system | | | | | |
| Pump | Premium efficiency pump | 18% | 100% | 100% | 100% | 100% |
| | Premium efficiency control, incl ASD | | | | | |
| Fans/Blowers | Premium efficiency fan / blower | 18% | 100% | 100% | 100% | 100% |
| | Premium efficiency control, including ASD | | | | | |
| Motors | Synchronous belts | 18% | 100% | 100% | 100% | 100% |
| | 150 HP High to premium efficiency motor | | | | | |
| | 1000 HP High to premium efficiency motor | | | | | |

**Exhibit 5.2: Technologies Included in Economic Potential Forecast for Large Industry and Total Economic Potential Market Penetration Rates**

| End Use | Measures | 2006 | 2011 | 2016 | 2021 | 2026 |
|---|---|---|---|---|---|---|
| Compressed air | Premium efficiency refrigerated air dryer | 18% | 100% | 100% | 100% | 100% |
| | Premium efficiency ASD compressor | | | | | |
| | Premium efficiency sequencing control | | | | | |
| | Improved distribution system | | | | | |
| Pump | Premium efficiency pump | 25% | 100% | 100% | 100% | 100% |
| | Premium efficiency control, incl ASD | | | | | |
| Fans/Blowers | Premium efficiency fan / blower | 25% | 100% | 100% | 100% | 100% |
| | Premium efficiency control, including ASD | | | | | |
| Motors | Synchronous belts | 25% | 100% | 100% | 100% | 100% |
| | 150 HP High to premium efficiency motor | | | | | |
| | 1000 HP High to premium efficiency motor | | | | | |

## 5.5 SUMMARY OF RESULTS

This section compares the Reference Case and Economic Potential Electricity Forecast levels of industry electricity consumption. The results are presented as electricity savings that would occur at the customer’s point-of-use. Due to the small sample size of industry in the Labrador Interconnected service region, the results are presented at an aggregated industry level for both Labrador Interconnected and the Island and Isolated service regions. The results are presented in the following exhibits:

- Exhibit 5.3 shows the electricity savings for the Industrial sector over the study period. As illustrated, under the Reference Case industrial electricity use would grow from the Base Year level of 1,359 GWh/yr. to approximately 1,484 GWh/yr. by 2026. This contrasts with the Economic Potential Forecast in which electricity use would decrease to approximately 1,321 GWh/yr. for the same period, a difference of approximately 164 GWh/yr.

- Exhibit 5.4 presents the results by end use, Industrial sector and milestone year.

- Exhibit 5.5 illustrates the 2026 savings by major end use and industrial sector.

**Exhibit 5.3: Reference Case versus Economic Potential Electricity Consumption in Industrial Sector (GWh/yr.)**

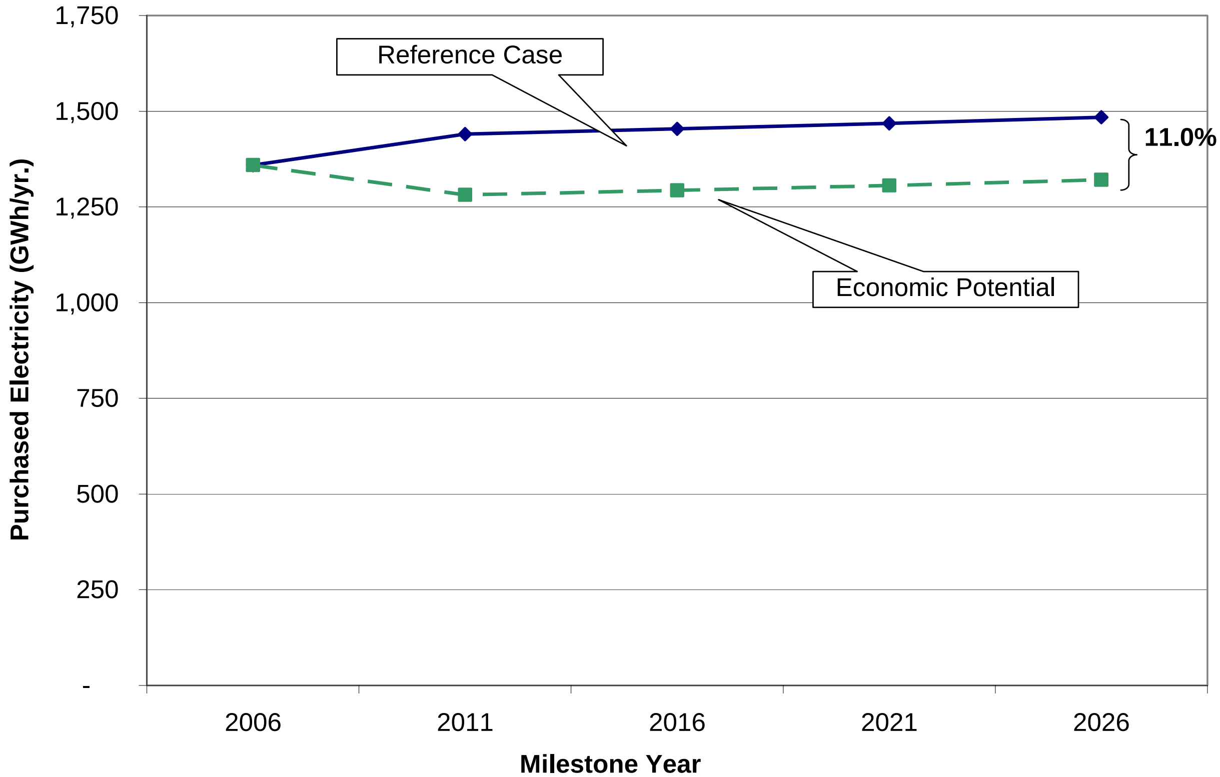
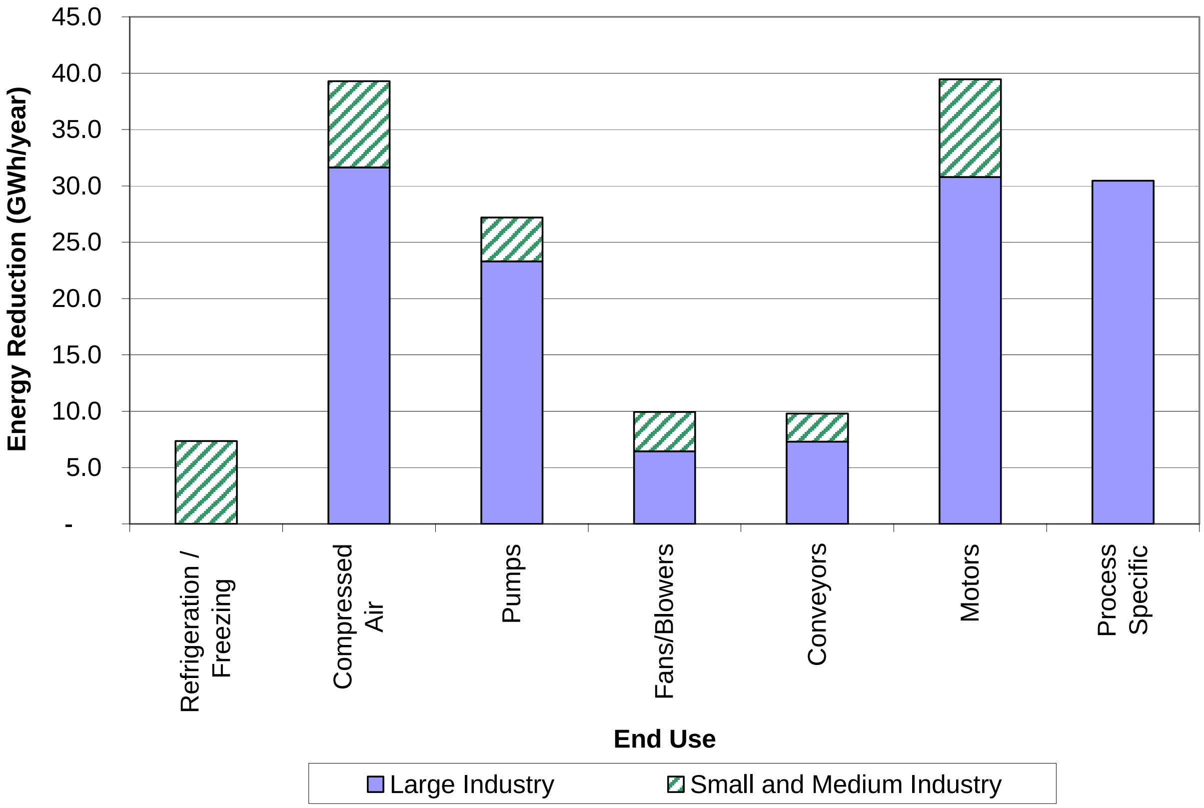


**Exhibit 5.4: Total Potential Electricity Savings by End Use, Industry Sector and Milestone Year (GWh/yr.)**

| End Use | 2006 | 2011 | 2016 | 2021 | 2026 | 2026 Percentage of Total (%) |
|---|---|---|---|---|---|---|
| **Small and Medium Industry** | | | | | | |
| Refrigeration / Freezing | 0.0 | 1.9 | 4.0 | 6.2 | 7.4 | 22% |
| Compressed air | 0.0 | 6.9 | 7.1 | 7.4 | 7.7 | 23% |
| Pumps | 0.0 | 3.5 | 3.6 | 3.7 | 3.9 | 12% |
| Fans/Blowers | 0.0 | 3.1 | 3.2 | 3.3 | 3.5 | 10% |
| Conveyors | 0.0 | 2.2 | 2.3 | 2.4 | 2.5 | 7% |
| Motors | 0.0 | 7.7 | 7.9 | 8.2 | 8.7 | 26% |
| ***Sub-Total*** | ***0.0*** | ***25.2*** | ***28.1*** | ***31.2*** | ***33.6*** | ***100%*** |
| **Large Industry** | | | | | | |
| Compressed air | 0.0 | 32.9 | 32.4 | 32.0 | 31.6 | 24% |
| Pumps | 0.0 | 24.3 | 24.0 | 23.6 | 23.3 | 18% |
| Fans/Blowers | 0.0 | 6.4 | 6.5 | 6.5 | 6.5 | 5% |
| Conveyors | 0.0 | 7.6 | 7.5 | 7.4 | 7.3 | 6% |
| Motors | 0.0 | 32.1 | 31.6 | 31.2 | 30.8 | 24% |
| Process specific | 0.0 | 30.2 | 30.5 | 30.5 | 30.5 | 23% |
| ***Sub-Total*** | ***0.0*** | ***133.5*** | ***132.5*** | ***131.3*** | ***129.9*** | ***100%*** |
| **Total** | | | | | | |
| Refrigeration / Freezing | 0.0 | 1.9 | 4.0 | 6.2 | 7.4 | 5% |
| Compressed air | 0.0 | 39.7 | 39.6 | 39.4 | 39.3 | 24% |
| Pumps | 0.0 | 27.8 | 27.6 | 27.4 | 27.2 | 17% |
| Fans/Blowers | 0.0 | 9.5 | 9.7 | 9.9 | 9.9 | 6% |
| Conveyors | 0.0 | 9.6 | 9.5 | 9.5 | 9.5 | 6% |
| Motors | 0.0 | 40.0 | 39.9 | 39.7 | 39.8 | 24% |
| Process specific | 0.0 | 30.2 | 30.5 | 30.5 | 30.5 | 19% |
| ***TOTAL*** | ***0.0*** | ***158.7*** | ***160.6*** | ***162.5*** | ***163.5*** | ***100%*** |

*Note: The potential electricity savings for the process-specific end use in the Large Industrial sector is based on an assumed savings of 13% (see Section 4.3.9). Any differences in totals are due to rounding.*

**Exhibit 5.5: Savings by Major End Use and Industrial Sector, 2026**




### 5.5.1 Interpretation of Results – Primary Avoided Costs

A systems approach was used to model the energy impacts of the CDM measures presented in the preceding section. In the absence of a systems approach, there would be double counting of savings and an accurate assessment of the total contribution of the energy-efficient upgrades would not be possible.

Highlights of the results presented in the preceding exhibits are summarized below:

- **Electricity Savings by Milestone Year**

The estimated annual economic potential electricity savings in 2011 is about 159 GWh/yr. (11%) compared to the Reference Case. As shown, the savings are relatively flat from 2011 to the end of the study period with estimated savings of about 164 GWh/yr. in 2026. This is because a significant portion of the energy-efficiency measures are applied at full cost and, consequently, were modelled to achieve full market penetration by 2011. The variability to the savings impact between 2011 and 2026 is due to the effect of the measures applied at stock turn-over rates.

- **Electricity Savings by Sector and End Use**

About 80% of the total economic potential savings of 164 GWh/yr. in 2026 is attributed to the Large Industrial sector. The largest potential savings in this sector are associated with motors (29% of total savings) and compressed air and process specific (each contributing between 23% and 24% of total savings).

The end uses with the largest potential savings in the Small and Medium Industrial sector are motors (33%), compressed air (23%) and refrigeration/freezing (22%). Considering small, medium and Large industry, the economic electricity savings potential is the largest for the motors end use (30%) followed by compressed air (24%).

### 5.5.3 Sensitivity Analysis – Alternative Avoided Costs

A sensitivity analysis was conducted using preliminary avoided cost values that assume development of the Lower Churchill/DC Link. The sensitivity analysis reviewed the scope of measures that would pass or fail the economic screen under the changed avoided costs. Based on the preliminary avoided cost values assessed, the analysis concluded that any impacts would be modest.

# 6. ACHIEVABLE POTENTIAL

## 6.1 INTRODUCTION

This section presents the Industrial sector Achievable Potential electricity savings for the study period (2006 to 2026). The Achievable Potential is defined as the proportion of the savings identified in the Economic Potential Forecast that could realistically be achieved within the study period.

Consistent with the study's scope, the Industrial sector are presented at a less detailed level than for the Residential and Commercial sectors.

The remainder of this discussion is organized into the following subsections:

- Description of Achievable Potential
- Approach to Estimation of Achievable Potential
- Workshop Results
- Summary of Achievable Electricity Savings.

## 6.2 DESCRIPTION OF ACHIEVABLE POTENTIAL

Achievable Potential recognizes that it is difficult to induce all customers to purchase and install all the electrical efficiency technologies that meet the criteria defined by the Economic Potential Forecast. For example, customer decisions to implement energy-efficient measures can be constrained by important factors such as:

- Higher first cost of efficient product(s)
- Need to recover investment costs in a short period (payback)
- Lack of product performance information
- Lack of product availability
- Consumer awareness.

The rate at which customers accept and purchase energy-efficient products can be influenced by a variety of factors including, the level of financial incentives, information and other measures put in place by the Utilities, governments and the private sector to remove barriers such as those noted above.

Exhibit 6.1 presents the level of electricity consumption that is estimated in the Achievable Potential scenarios. As illustrated, the Achievable Potential scenarios are "banded" by the two forecasts presented in previous sections, namely, the Economic Potential Forecast and the Reference Case.

Electricity savings under Achievable Potential are typically less than in the Economic Potential Forecast. In the Economic Potential Forecast, efficient new technologies are assumed to fully penetrate the market as soon as it is financially attractive to do so. However, the Achievable Potential recognizes that under "real world" conditions, the rate at which customers are likely to implement new technologies will be influenced by additional practical considerations and will, therefore, occur more slowly than under the assumptions employed in the Economic Potential Forecast. Exhibit 6.1 also shows that future electricity consumption under the Reference Case is greater than in either of the two Achievable Potential forecasts. This is because the Reference Case represents a "worst case" situation in which there are no additional utility market interventions and hence no additional electricity savings beyond those that occur "naturally."

Exhibit 6.1 presents the achievable results as a band of possibilities, rather than a single line. This recognizes that any estimate of Achievable Potential over a 20-year period is necessarily subject to uncertainty and that there are different levels of potential CDM program intervention.

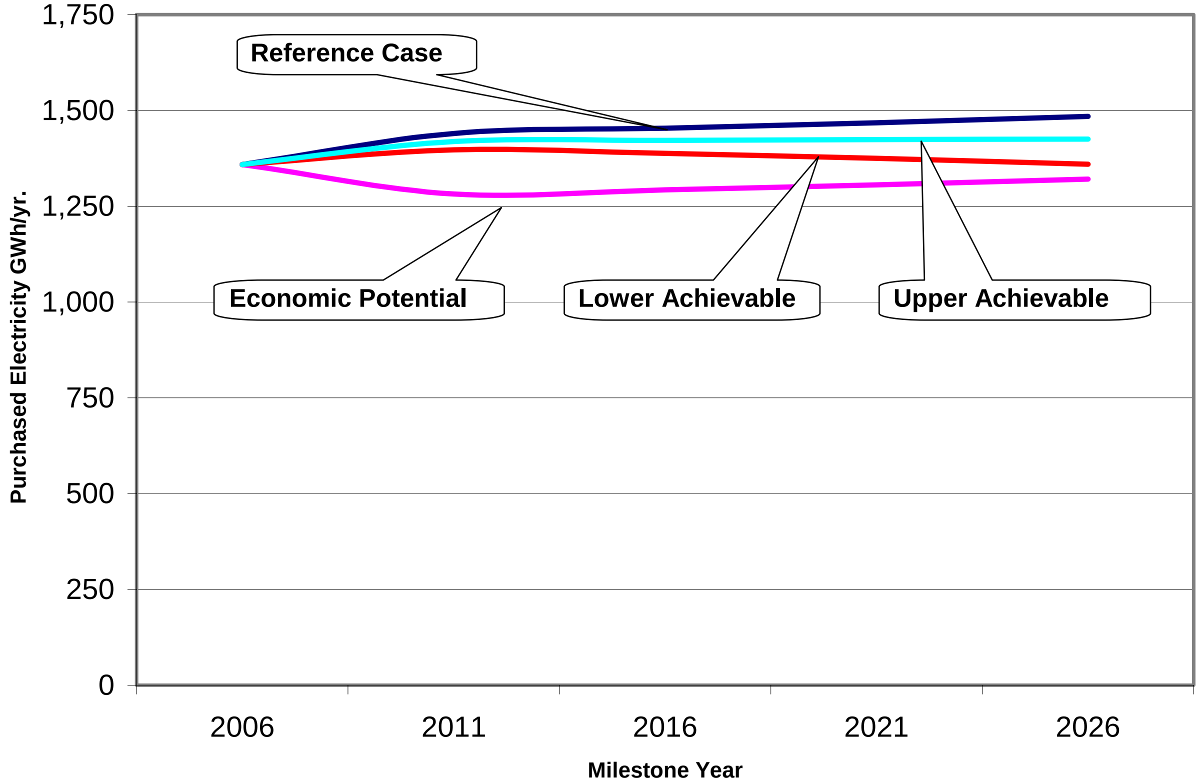
- **The Upper Achievable Potential** assumes both an aggressive program approach and a very supportive context, e.g., healthy economy, very strong public commitment to climate change mitigation, etc.

  However, the Upper Achievable Potential scenario also recognizes that there are limits to the scope of influence of any electric utility. It recognizes that some markets or submarkets may be so price sensitive or constrained by market barriers beyond the influence of CDM programs that they will only fully act if forced to by legal or other legislative means. It also recognizes that there are practical constraints related to the pace that existing inefficient equipment can be replaced by new, more efficient models or that existing building stock can be retrofitted to new energy performance levels

  For the purposes of this study, the Upper Achievable Potential can, informally, be described as: *"Economic Potential less those customers that "can't" or "won't" participate."*

- **The Lower Achievable Potential** assumes that existing CDM programs and the scope of technologies addressed are expanded, but at a more modest level than in the Upper Achievable Potential. Market interest and customer commitment to energy efficiency and sustainable environmental practices remain approximately as current. Similarly, federal, provincial and municipal government energy-efficiency and GHG mitigation efforts remain similar to the present.

**Exhibit 6.1: Annual Electricity Consumption – Example of Achievable Potential Relative to Reference Case and Economic Potential Forecast for the Industrial Sector**



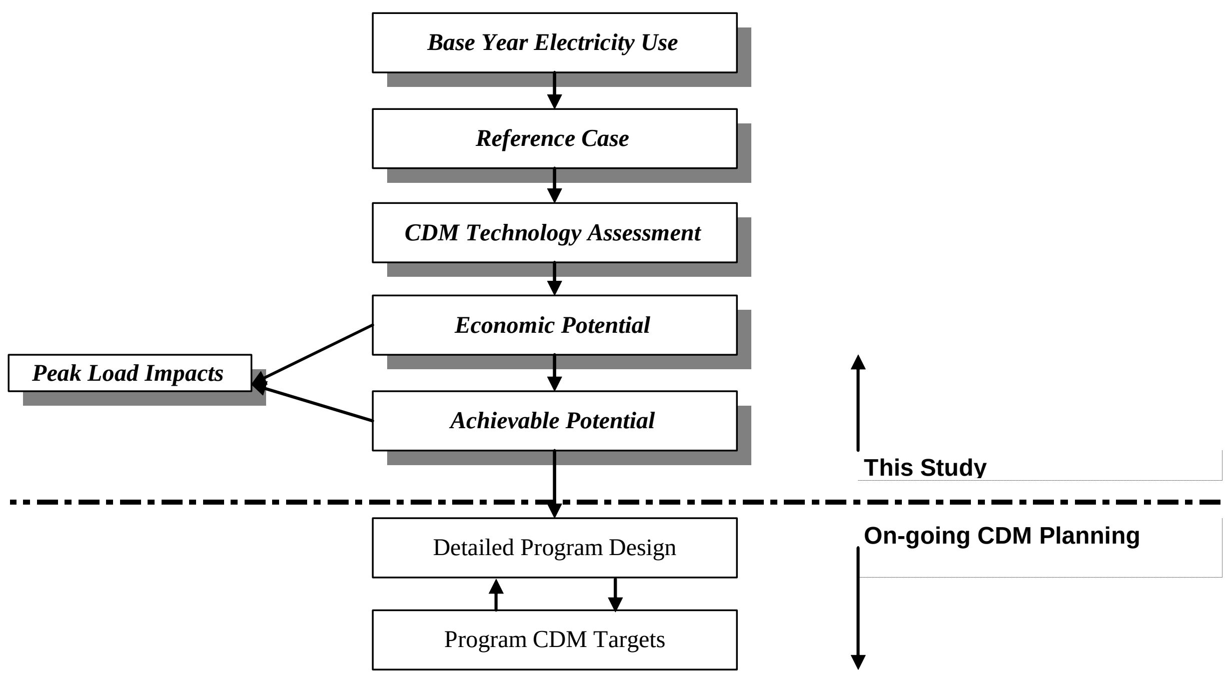

- **Achievable Potential versus Detailed Program Design**

It should also be emphasized that the estimation of Achievable Potential is not synonymous with either the setting of specific program targets or with program design. While both are closely linked to the discussion of Achievable Potential, they involve more detailed analysis that is beyond the scope of this study.[12]

Exhibit 6.2 illustrates the relationship between Achievable Potential and the more detailed program design.

[12] The Achievable Potential savings assume program start-up in 2007. Consequently, electricity savings in the first milestone year of 2011 will need to be adjusted to reflect actual program initiation dates. This step will occur during the detailed program design phase, which will follows this study.

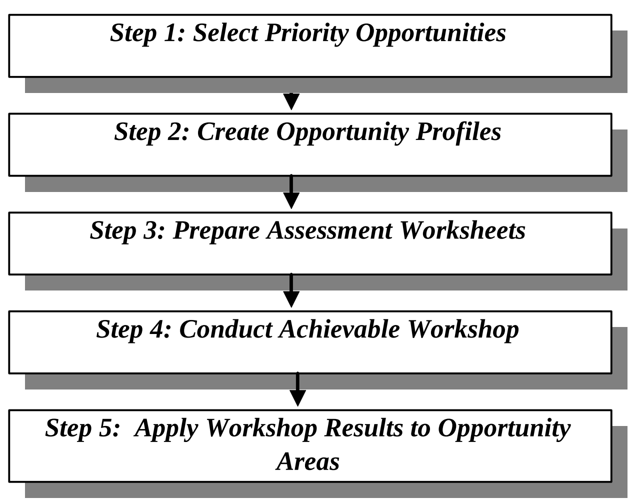
**Exhibit 6.2: Achievable Potential versus Detailed Program Design**




## 6.3 APPROACH TO THE ESTIMATION OF ACHIEVABLE POTENTIAL

Achievable Potential was estimated in a five-step approach. A schematic showing the major steps is shown in Exhibit 6.3 and each step is discussed below.

**Exhibit 6.3: Approach to Estimating Achievable Potential**



- **Step 1: Select Priority Opportunities**

The first step in developing the Achievable Potential estimates required that the energy saving opportunities identified in the Economic Potential Forecasts be "bundled" into a set of opportunity areas that would facilitate the subsequent assessment of their potential market penetration. The energy-efficiency opportunity areas were grouped by end use (Exhibit 6.4) for discussion in the Industrial sector workshop held November 1, 2007.

The workshop focused on the Small and Medium Industrial sectors. Exhibit 6.4 summarizes the opportunity areas and shows the approximate percentage that each represents of the total Small and Medium Industrial sectors potential contained in the Economic Potential Forecast. Large industry includes six facilities and the Achievable Potential is deemed to be very site specific. Within the scope of the high-level industry assessment, the Achievable Potential assessment focused on analyzing the Small and Medium Industrial sectors. The results from this assessment were extrapolated to Large industry and, as a "reality check," was compared to the project team's experience in other jurisdictions

**Exhibit 6.4: Industrial Sector Opportunity Areas for Small and Medium Industry – Percentage of Economic Potential for Sector**

| End Use | 2026 Percentage of Total (%) |
|---|---|
| **Small and Medium Industry** | |
| Refrigeration / Freezing | 22% |
| Compressed air | 23% |
| Pumps | 12% |
| Fans/Blowers | 10% |
| Conveyors | 7% |
| Motors | 26% |
| ***Sub-Total*** | ***100%*** |

*Note: Any differences in totals are due to rounding.*

- **Step 2: Create Opportunity Profiles**

The next step involved the development of brief profiles for the priority opportunity areas noted above in Exhibit 6.4. A sample profile for Opportunity I1 (cooling and refrigeration/freezing) is presented in Exhibit 6.5; the remaining Opportunity Profiles are provided in Appendix B.

The purpose of the Opportunity Profiles was to provide a "high-level" logic framework that would serve as a guide for participant discussions in the workshop. The intent was to define a broad rationale and direction without getting into the much greater detail required of program design, which, as noted previously, is beyond the scope of this project.

### Exhibit 6.5: Sample Opportunity Profile

| **I1 – Cooling and Refrigeration/Freezing** |
| --- |
| ***Overview:***<br>Cooling and refrigeration/freezing apply mainly to the Fishing and Fish Processing sub sector. The opportunity includes improving the efficiency of refrigeration equipment through system reconfiguration, such as optimizing the condenser size, and through technology applications, such as efficient compressors and condenser fans. Improving distribution piping requires a thorough analysis of the complex relationship between the flow of refrigerant, oil and pipe insulation. |
| ***Target Technologies and Measures:***<br>• Premium efficiency refrigeration equipment including efficient compressors, optimized floating head pressure and equipment size optimization<br>• Improved distribution system |
| ***Opportunity Costs and Savings Profile***:<br>• A typical cooling/refrigeration/freezing project has an implementation cost of $2,000 to $50,000<br>• The total economic potential for these measures is estimated to be 7.4 GWh/yr. by 2026<br>• Customer payback is in the range of 12 years<br>• The CCE for these opportunities is estimated to be $0.01 to $0.04/kWh |
| ***Target Audience(s)& Potential Delivery Allies:***<br>• Fishing and Fish Processing sub sector<br>• Cooling and refrigeration/freezing equipment manufacturers and suppliers<br>• Provincial and federal government |
| ***Constraints & Challenges:***<br>The most significant barriers are:<br>• Premium efficiency equipment has attractive energy savings but increased equipment costs<br>• Long payback periods<br>• Retrofitting main equipment and distribution system require systems to be out of operation and may interfere with production schedules |
| ***Opportunities & Synergies:***<br>• To capitalize on all potential benefits, the feasibility of efficient refrigeration system opportunities are best evaluated during system expansion or as part of a system reliability and safety review.<br>• Improved cooling and freezing may improve product quality and ensure compliance with food safety requirements. |
| ***Experience Related to Possible Participation Rates:*** |

As illustrated in Exhibit 6.5, each Opportunity Profile addresses the following areas:

- ***Overview*** – provides a summary statement of the broad goal and rationale for the opportunity.
- ***Target Technologies and Measures*** **–** highlights the major technologies where the most significant Opportunities have been identified in the Economic Potential Forecast.
- ***Opportunity Costs and Savings Profile*** – provides information on the financial attractiveness of the opportunity from the perspective of both the customer and NLH or NP.

- ***Target Audiences and Potential Delivery Allies*** – identifies key market players that would be expected to be involved in the actual delivery of services. The list of stakeholders shown is intended to be "indicative" and is by no means comprehensive.

- ***Constraints and Challenges –*** identifies key market barriers that are currently constraining the increased penetration of energy-efficient technologies or measures. Interventions for addressing the identified barriers are noted. Again, it is recognized that the interventions are not necessarily comprehensive; rather, their primary purpose was to help guide the workshop discussions.

- ***Opportunities and Synergies –*** identifies information or possible synergies with other Opportunities that may affect workshop participant views on possible customer participation rates.

- ***Experience Related to Possible Participation Rates*** – provides benchmark data on the past performance of Utilities programs, where available.

❑ **Step 3: Prepare Draft Opportunity Assessment Worksheets**

A draft Assessment Worksheet was prepared for each Opportunity Profile in advance of the workshop. The Assessment Worksheets complemented the information contained in the Opportunity Profiles by providing quantitative data on the potential energy savings for each opportunity as well as providing information on the size and composition of the eligible population of potential participants. Energy impacts and population data were taken from the detailed modelling results contained in the Economic Potential Forecast.

A sample Assessment Worksheet for Opportunity I1 (cooling and refrigeration/freezing) is presented in Exhibit 6.6 (worksheets for the remaining opportunity areas are provided in Appendix C). As illustrated in Exhibit 6.6, each Assessment Worksheet addresses the following areas:

- ***Typical Project Costs*** – provides the typical project costs (includes capital and installation costs) for participants to implement the opportunities.

- ***Customer Payback*** – shows the simple payback from the customer's perspective for the package of energy-efficiency measures included in the opportunity area. This information provided an indication of the level of attractiveness that the opportunity measures would present to customers.

- ***Cost of Conserved Energy (CCE)*** – shows the approximate CCE for the measure(s) included within each opportunity area. Where multiple measures are included, a weighted average value is presented. The CCE provides an indication of the relative economic attractiveness of the energy-efficiency measures from the Utilities' perspective. For the purposes of the workshop, this information provided participants with an indication of the scope for using financial incentives to influence customer participation rates. The CCE value combined with the preceding customer payback information provided an important reference point for the workshop participants when considering potential participation rates. The combined information enabled participants to "roughly" estimate the level of financial incentives that could be employed to increase the opportunity's attractiveness to customers without making the measures economically unattractive to NLH or NP.

- ***Total Capacity and Estimated Number of Units*** **–** shows the total population of potential units that could, theoretically, be addressed in the opportunity area. Numbers shown are from the eligible populations used in the Economic Potential Forecasts. The definition of "unit" varies by opportunity area. In the example shown, a unit is defined as a refrigeration unit with a capacity of 50 HP.

- ***Market Penetration Rates*** **–** show the percentage market penetration rates for the Base Year and the economic potential at the milestone years. As noted in the introduction to this section, the approach to the Industrial sector was less detailed than for the Residential and Commercial sectors. In the Industrial sector, market penetration rates were determined by the consultant's interpretation of the workshop discussions. Two scenarios were determined: Lower and Upper.

**Exhibit 6.6: Sample Industrial Sector Opportunity Assessment Worksheet**

### I1: Cooling / Refrigeration / Freezing

**Opportunities**
Premium efficiency equipment
Improved distribution system

| | |
|---|---|
| Typical project cost | $ 2,000 - $ 50,000 |
| Payback period | 12 years |
| CCE | $ 0.01 - 0.04 / kWh |
| Typical capacity | 50 HP |
| Estimated number of units | 400 - 550 |

| ***Milestone Year*** | ***Market Penetration Rate (%)*** | | | |
|---|---|---|---|---|
| | ***Reference Case*** | ***Achievable Lower*** | ***Achievable Upper*** | ***Economic Potential*** |
| ***2006*** | 10 | 10 | 10 | 10 |
| ***2016*** | 12 | | | 60 |
| ***2026*** | 15 | | | 100 |

- **Step 4: Achievable Potential Workshop**

The most critical step in developing the estimates of Achievable Potential was the half-day workshop held November 1, 2007. Workshop participants consisted of core members of the consultant team, program personnel from the Utilities, industrial facility operators and local trade allies.

The purpose of the workshop was to promote discussion regarding the technical and market conditions confronting the identified energy-efficiency opportunities. Estimates of the Achievable Potential were then developed based on the results of the workshop discussions.

The discussion of each opportunity area was structured around the following questions:

- What is the current age and general condition of the existing stock of equipment? What level of energy-efficiency activity has taken place to date?
- What are the major challenges to implementing energy-efficiency projects involving this type of equipment within the applicable industrial sub sectors?
- What are the minimum conditions that would be required to increase energy-efficiency investments affecting this type of equipment within the applicable industrial sub sectors? How can the Utilities best support additional energy-efficiency investments?

- **Step 5: Apply Workshop Results to Opportunity Areas**

The workshop discussions provided a qualitative understanding of the current Achievable Potential in industry, specifically the Small and Medium Industrial sector. The qualitative potential was converted to quantitative values by considering the profile of the equipment, in terms of age and type of technology, challenges limiting implementation of energy-efficiency opportunities, and experience in other jurisdictions, specifically recent Achievable Potential studies completed by the project team in Nova Scotia, New Brunswick, Ontario and British Columbia. The results for the Small and Medium assessment were extrapolated to the Large Industrial sector and compared with the aforementioned studies. Exhibits 6.7 and 6.8 provide the market penetration rates for the bundled opportunities by end use and milestone year.

**Exhibit 6.7: Market Penetration Rates of Energy-efficiency Opportunities by End Use and Milestone Year – Upper Achievable Potential**

| **Small and Medium Industry** | | | | | |
|---|---|---|---|---|---|
| **End Use** | **2006** | **2011** | **2016** | **2021** | **2026** |
| Refrigeration / Freezing | 10% | 41% | 64% | 78% | 83% |
| Compressed air | 15% | 43% | 63% | 75% | 80% |
| Pump | 18% | 23% | 35% | 54% | 80% |
| Fans/Blowers | 18% | 23% | 35% | 54% | 80% |
| Conveyors | 18% | 23% | 35% | 54% | 80% |
| Motors | 18% | 23% | 35% | 54% | 80% |
| **Large industry** | | | | | |
| **End Use** | **2006** | **2011** | **2016** | **2021** | **2026** |
| Compressed air | 18% | 45% | 64% | 76% | 81% |
| Pump | 25% | 29% | 40% | 58% | 82% |
| Fans/Blowers | 25% | 29% | 40% | 58% | 82% |
| Conveyors | 25% | 29% | 40% | 58% | 82% |
| Motors | 25% | 29% | 40% | 58% | 82% |

**Exhibit 6.8: Market Penetration Rates of Energy-efficiency Opportunities by End Use and Milestone Year – Lower Achievable Potential**

| **Small and Medium Industry** | | | | | |
|---|---|---|---|---|---|
| **End Use** | **2006** | **2011** | **2016** | **2021** | **2026** |
| Refrigeration / Freezing | 10% | 26% | 38% | 45% | 48% |
| Compressed air | 15% | 28% | 38% | 45% | 47% |
| Pump | 18% | 21% | 27% | 37% | 49% |
| Fans/Blowers | 18% | 21% | 27% | 37% | 49% |
| Conveyors | 18% | 21% | 27% | 37% | 49% |
| Motors | 18% | 21% | 27% | 37% | 49% |
| **Large industry** | | | | | |
| **End Use** | **2006** | **2011** | **2016** | **2021** | **2026** |
| Compressed air | 18% | 31% | 40% | 47% | 49% |
| Pump | 25% | 28% | 33% | 42% | 54% |
| Fans/Blowers | 25% | 28% | 33% | 42% | 54% |
| Conveyors | 25% | 28% | 33% | 42% | 54% |
| Motors | 25% | 28% | 33% | 42% | 54% |

## 6.4 WORKSHOP RESULTS

The following subsection provides a summary of the key issues identified by participants during the workshop and identifies the major assumptions employed by the consultants for applying the workshop results to achievable estimates.

The results are presented for each of the opportunity areas that were discussed during the workshop, which were:

- Cooling and refrigeration/freezing
- Compressed air
- Motors and driven equipment.[13]

### 6.4.1 I1 – Cooling and Refrigeration/Freezing

Highlights:

- Estimated 95% of the equipment is older than 15 years
- Hurdle rate to implement projects usually less than three years simple payback period
- Awareness of energy efficiency has grown in the past few years
- Short power disruption can have significant negative impact on production, especially in the Fishing and Fish Processing and Manufacturing sub sectors
- Facilities generally do not have expertise in energy efficiency and have a need for engineering resources to assist in developing projects.

Based on the above discussion the market penetration rates were developed as presented in Exhibit 6.7.

### 6.4.2 I2 – Compressed Air

- Estimated 70% of the equipment is older than 10 years
- Hurdle rate to implement projects usually less than two to three years simple payback period
- Compressed air energy-efficiency awareness and knowledge are lacking in industry
- Some suppliers provide free service to detect air leaks in system and to identify energy-efficiency opportunities.

Market penetration rates are presented in Exhibits 6.7 and 6.8.

[13] The discussion of motors (Opportunity Profile I6) was combined with the discussion of driven equipment, such as pumps, fans and blowers, etc.

### 6.4.3 I3-I6 – Motors and Driven Equipment

- Estimated 60% - 70% of the equipment is older than 15 years
- No general standardized frames for existing motors, which limits the direct replacement of motors with new, more efficient motors. More common practice is to repair motors rather than replace them
- Motor driven equipment energy-efficiency awareness and knowledge are lacking in industry. This includes limited use and understanding of energy metering and use profiling
- Limited supply of stock locally available due to wide variety of motors
- Limited take up of variable frequency drives (VFD) due to non-standardized motors, pumps and fans.

Market penetration rates are presented in Exhibits 6.7 and 6.8.

## 6.5 SUMMARY OF ACHIEVABLE ELECTRICITY SAVINGS

Exhibit 6.9 provides an illustration of the achievable electricity savings under both the Lower and Upper scenarios for the combined Island and Isolated and Labrador Interconnected service regions.[14]

As discussed, under the Reference Case industrial purchased electricity use would grow from the Base Year level 1,359 GWh/yr. to approximately 1,484 GWh/yr. by 2026. This contrasts with the Upper Achievable scenario in which electricity use would increase to approximately 1,360 GWh/yr. for the same period, a difference of approximately 125 GWh/yr., or about 8 %. Under the Lower Achievable scenario, electricity use would increase to approximately 59 GWh/yr. for the same period, a difference of approximately 59 GWh/yr., or about 4 %.

Further detail on the total potential electricity savings provided by the Achievable Potential forecasts is provided in Exhibits 6.10 and 6.11. The Exhibits present, respectively, the Upper and Lower Achievable results by end use, sub sector type and milestone year.

[14] The CDM Potential reports for the Residential and Commercial sectors also include an assessment of the peak load reduction impacts associated with the achievable electricity savings. A similar assessment was not included in the Industrial sector study due to the more limited scope applied to this sector and the absence of the required data.

**Exhibit 6.9: Reference Case versus Upper and Lower Achievable Potential Electricity Consumption in the Industrial Sector (GWh/yr.)**

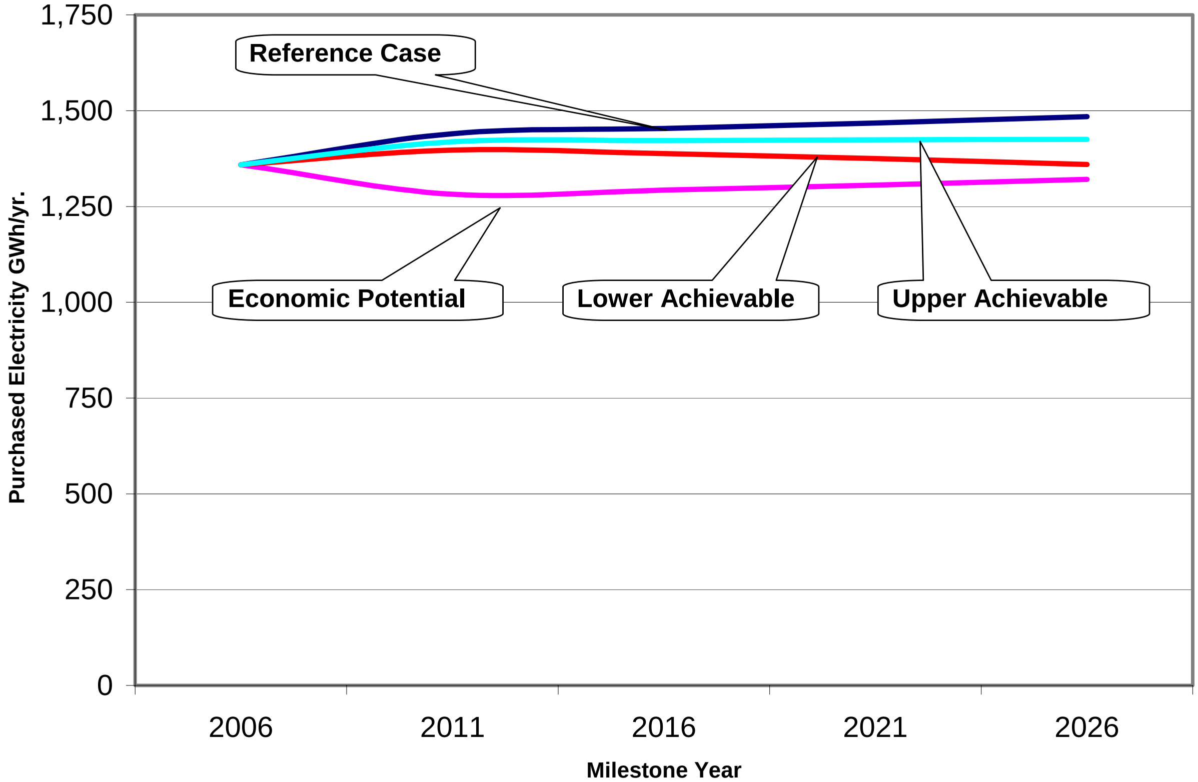


**Exhibit 6.10: Summary of Annual Electricity Savings by End Use and Sub Sector, Upper Achievable Potential (GWh/yr.)**

| End Use | 2006 | 2011 | 2016 | 2021 | 2026 | 2026 Percentage of Total (%) |
|---|---|---|---|---|---|---|
| **Small and Mediun Industry** | | | | | | |
| Refrigeration / Freezing | 0.0 | 2.3 | 4.1 | 5.3 | 5.9 | 23% |
| Compressed air | 0.0 | 2.2 | 3.9 | 5.1 | 5.7 | 22% |
| Pumps | 0.0 | 0.2 | 0.7 | 1.6 | 2.9 | 11% |
| Fans/Blowers | 0.0 | 0.1 | 0.6 | 1.4 | 2.6 | 10% |
| Conveyors | 0.0 | 0.1 | 0.4 | 1.0 | 1.9 | 7% |
| Motors | 0.0 | 0.4 | 1.5 | 3.5 | 6.5 | 25% |
| ***Sub-Total*** | ***0.0*** | ***5.2*** | ***11.1*** | ***17.9*** | ***25.6*** | ***100%*** |
| **Large Industry** | | | | | | |
| Compressed air | 0.0 | 10.4 | 17.8 | 22.2 | 23.7 | 24% |
| Pumps | 0.0 | 1.1 | 4.4 | 9.8 | 17.5 | 18% |
| Fans/Blowers | 0.0 | 0.3 | 1.2 | 2.7 | 4.8 | 5% |
| Conveyors | 0.0 | 0.3 | 1.4 | 3.1 | 5.5 | 6% |
| Motors | 0.0 | 1.4 | 5.8 | 13.0 | 23.1 | 23% |
| Process specific | 0.0 | 24.2 | 24.4 | 24.4 | 24.4 | 25% |
| ***Sub-Total*** | ***0.0*** | ***37.8*** | ***54.9*** | ***75.2*** | ***99.0*** | ***100%*** |
| **Total** | | | | | | |
| Refrigeration / Freezing | 0.0 | 2.3 | 4.1 | 5.3 | 5.9 | 5% |
| Compressed air | 0.0 | 12.6 | 21.7 | 27.4 | 29.5 | 24% |
| Pumps | 0.0 | 1.3 | 5.0 | 11.4 | 20.4 | 16% |
| Fans/Blowers | 0.0 | 0.4 | 1.8 | 4.1 | 7.5 | 6% |
| Conveyors | 0.0 | 0.4 | 1.7 | 4.0 | 7.1 | 6% |
| Motors | 0.0 | 1.8 | 7.3 | 16.6 | 29.8 | 24% |
| Process specific | 0.0 | 24.2 | 24.4 | 24.4 | 24.4 | 20% |
| ***TOTAL*** | ***0.0*** | ***43.0*** | ***66.0*** | ***93.1*** | ***124.5*** | ***100%*** |

*Note: Any differences in totals are due to rounding.*

**Exhibit 6.11: Summary of Annual Electricity Savings by End Use and Sub Sector, Lower Achievable Potential (GWh/yr.)**

| End Use | 2006 | 2011 | 2016 | 2021 | 2026 | 2026 Percentage of Total (%) |
|---|---|---|---|---|---|---|
| **Small and Medium Industry** | | | | | | |
| Refrigeration / Freezing | 0.0 | 1.1 | 2.0 | 2.7 | 2.9 | 24% |
| Compressed air | 0.0 | 1.0 | 1.8 | 2.4 | 2.7 | 22% |
| Pumps | 0.0 | 0.1 | 0.3 | 0.7 | 1.4 | 11% |
| Fans/Blowers | 0.0 | 0.1 | 0.3 | 0.7 | 1.2 | 10% |
| Conveyors | 0.0 | 0.0 | 0.2 | 0.5 | 0.9 | 7% |
| Motors | 0.0 | 0.2 | 0.7 | 1.6 | 3.0 | 25% |
| ***Sub-Total*** | ***0.0*** | ***2.5*** | ***5.3*** | ***8.5*** | ***12.1*** | ***100%*** |
| **Large Industry** | | | | | | |
| Compressed air | 0.0 | 4.8 | 8.3 | 10.4 | 11.1 | 24% |
| Pumps | 0.0 | 0.5 | 2.0 | 4.6 | 8.2 | 17% |
| Fans/Blowers | 0.0 | 0.1 | 0.6 | 1.3 | 2.3 | 5% |
| Conveyors | 0.0 | 0.2 | 0.6 | 1.4 | 2.6 | 5% |
| Motors | 0.0 | 0.7 | 2.7 | 6.1 | 10.8 | 23% |
| Process specific | 0.0 | 12.1 | 12.2 | 12.2 | 12.2 | 26% |
| ***Sub-Total*** | ***0.0*** | ***18.4*** | ***26.4*** | ***35.9*** | ***47.0*** | ***100%*** |
| **Total** | | | | | | |
| Refrigeration / Freezing | 0.0 | 1.1 | 2.0 | 2.7 | 2.9 | 5% |
| Compressed air | 0.0 | 5.9 | 10.1 | 12.8 | 13.8 | 23% |
| Pumps | 0.0 | 0.6 | 2.4 | 5.3 | 9.5 | 16% |
| Fans/Blowers | 0.0 | 0.2 | 0.8 | 1.9 | 3.5 | 6% |
| Conveyors | 0.0 | 0.2 | 0.8 | 1.8 | 3.3 | 6% |
| Motors | 0.0 | 0.8 | 3.4 | 7.7 | 13.9 | 24% |
| Process specific | 0.0 | 12.1 | 12.2 | 12.2 | 12.2 | 21% |
| ***TOTAL*** | ***0.0*** | ***20.9*** | ***31.8*** | ***44.4*** | ***59.1*** | ***100%*** |

*Note: Any differences in totals are due to rounding.*

# 7. CONCLUSIONS AND NEXT STEPS

This study has confirmed the existence of significant cost-effective CDM potential within Newfoundland and Labrador's Industrial sector. The study results provide:

- Specific estimates of the potential CDM savings opportunities, defined by sector, sub sector, end use and, in several cases, specific technology(s)
- A baseline set of energy technology penetrations and energy use practices that can assist in the design of specific programs.

The next step[15] in this process involves the selection of a cost-effective portfolio of CDM programs and the setting of specific CDM targets and spending levels. To provide a preliminary reference point for this next step in the program development process, the study team conducted a brief literature search in an attempt to identify typical CDM spending levels in other jurisdictions. The literature search identified two (relatively) recent studies that had addressed similar issues on behalf of other Canadian utilities. The two studies are:

- *Demand-Side Management: Determining Appropriate Spending Levels and Cost-Effectiveness Testing,* which was prepared by Summit Blue Consulting and the Regulatory Assistance Project for the Canadian Association of Members of Public Utility Tribunals (CAMPUT). The study was completed in January 2006.
- *Planning and Budgeting for Energy Efficiency/Demand-Side Management Programs,* which was prepared by Navigant Consulting for Union Gas (Ontario) Limited. The study was completed in July 2005.

The CAMPUT study, which included a review of U.S. and Canadian jurisdictions, concluded that an annual CDM expenditure equal to about 1.5% of annual electricity revenues might be appropriate for a utility (or jurisdiction) that is in the early stages of CDM[16] programming. This level of funding recognizes that it takes time to properly introduce programs into the market place.

The same study found that once program delivery experience is gained, a ramping up to a level of about 3% of annual electricity revenues is appropriate. The study also notes that higher percentages may be warranted if rapid growth in electricity demand is expected or if there is an increasing gap between demand and supply due to such things as plant retirements or siting limitations. The current emphasis on climate change mitigation measures would presumably also fall into a similar category of potential CDM drivers.

The CAMPUT study also notes that even those states with 3% of annual revenues as their CDM target have found that there are more cost-effective CDM opportunities than could be met by the 3% funding. The finding is consistent with the situation in British Columbia. In the case of BC Hydro, CDM expenditures over the past few years have been about 3.3% of electricity

[15] Full treatment of these next steps is beyond the scope of the current project.
[16] The term DSM (demand-side management) and CDM are used interchangeably in this section.

revenues.[17] However, the results of BC Hydro's recently completed study (Conservation Potential Review (CPR) 2007) identified over 20,000 GWh of remaining cost-effective CDM opportunities by 2026. The magnitude of remaining cost-effective CDM opportunities combined with the aggressive targets set out in British Columbia's provincial Energy Plan suggest that BC Hydro's future CDM expenditures are likely to increase significantly if the new targets are to be met.

- **Additional notes:**

- Neither of the studies noted above found any one single, simple model for setting CDM spending levels and targets. Rather, the more general conclusion is that utilities use a number of different approaches that are reasonable for their context. In fact, the CAMPUT report identified seven approaches to setting CDM spending levels.

    - Based on cost-effective CDM potential estimates
    - Based on percentages of utility revenues
    - Based on Mills/kWh of utility electric sales
    - Levels set through resource planning process
    - Levels set through the restructuring process
    - Tied to projected load growth
    - Case-by-case approach.

- The CAMPUT study also notes that, although not always explicit, a key issue in most jurisdictions is resolving the trade off between wanting to procure all cost-effective energy-efficiency measures and concerns about the resulting short-term effect on rates. The study concludes that CDM budgets based on findings from an Integrated Resource Plan or a benefit-cost assessment tend to accept whatever rate effects are necessary to secure the overall resource plan, inclusive of the cost-effective energy-efficiency measures.

[17] CAMPUT, 2006. p. 14.

# 8. REFERENCES

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# APPENDIX A

# Industry Electricity Survey

MARBEK
Resource Consultants Ltd.

# Newfoundland CDM Potential

# Industry Electricity Survey

## INTRODUCTION

This electricity survey focuses on the electricity use and operating practices that will inform the assessment of electricity Conservation and Demand Management (CDM) potential in the province.

Please complete the following questionnaire, and return it within 2 weeks. Should you need immediate assistance call Henri van Rensburg at (416) 364-3772.

## CLIENT INFORMATION

Facility Name: ………………………………………………………………………………..

Facility Address: ……………………………………………………………………………..

Your Name: ……………………………………………………………………………...

Title: ……………………………………………………………………………………….

Date: ……………………………………………………………………………………......

Telephone: …………………………………………………………………………………

Fax: ………………………………………………………………………………………..

Email Address: ……………………………………………………………………………….

## A ELECTRICITY USE

Please provide an estimate (in percentages) of how much of the total plant **electricity** is used by each of the end uses:

| Electricity End Use | | Percentage of Total Plant Electricity (%) |
|---|---|---|
| Process heating (incl. water heaters, steam production) | | |
| Process cooling / refrigeration | | |
| Motors and motor driven equipment | Air compressors | |
| | Pumps | |
| | Fans and Blowers | |
| | Conveyors | |
| | Other motors | |
| Process specific | | |
| Building envelope and comfort | Lighting | |
| | Comfort heating, cooling, ventilation and air conditioning (HVAC) | |
| Other | | |
| ***TOTAL*** | | ***100 %*** |

## B GENERAL PRACTICES

Please answer the following questions:

B.1 Does your facility contain any of the following?

| | Yes | No |
|---|---|---|
| Interval metering system | ☐ | ☐ |
| Sub-metering on various plant areas or processes | ☐ | ☐ |
| Electricity demand management control | ☐ | ☐ |
| Power Factor correction equipment | ☐ | ☐ |
| Overall plant control system | ☐ | ☐ |
| Program to replace old motors with high/premium efficiency motors | ☐ | ☐ |
| Program to ensure variable speed/frequency drives (VSD/VFD) are installed on motors/pumps/fans where possible | ☐ | ☐ |

B.2 Does your cooling / refrigeration system contain any of the following systems?

| | Yes | No |
|---|---|---|
| Standalone compressor control system | ☐ | ☐ |
| Integrated compressor control system | ☐ | ☐ |
| VFD controlled compressors | ☐ | ☐ |

B.3 Does your compressed air system contain any of the following systems?

| | Yes | No |
|---|---|---|
| Standalone compressor control system | ☐ | ☐ |
| Integrated compressor control system | ☐ | ☐ |
| VFD controlled compressors | ☐ | ☐ |
| Regular compressed air leak detection survey | ☐ | ☐ |
| Compressed air receiver tanks | ☐ | ☐ |
| Use outside air as make up air (answer only if compressor is air cooled) | ☐ | ☐ |
| Return exhaust air to heat building during winter (answer only if compressor is air cooled) | ☐ | ☐ |

B.4 Does your lighting system contain any of the following systems?

| | Yes | No |
|---|---|---|
| On/off timer settings | ☐ | ☐ |
| Occupancy sensors | ☐ | ☐ |
| Control of lighting system according to zones or separate production areas | ☐ | ☐ |

B.5 Do you operate your HVAC system with the following?

| | Yes | No |
|---|---|---|
| Different temperature setting for summer and winter | ☐ | ☐ |
| Different heating and cooling set points | ☐ | ☐ |
| Set back temperatures when facility is not occupied, for example during weekends | ☐ | ☐ |
| Recover heat from exhaust to heat make up air | ☐ | ☐ |

MARBEK
Resource Consultants Ltd.

# APPENDIX B

# Opportunity Profiles

## Opportunity Profile

### I1 – Cooling and Refrigeration/Freezing

***Overview:***

Cooling and refrigeration/freezing apply mainly to the Fishing and Fish Processing sub sector. The opportunity includes improving the efficiency of refrigeration equipment through system reconfiguration, such as optimizing the condenser size, and through technology applications, such as efficient compressors and condenser fans. Improving distribution piping requires a thorough analysis of the complex relationship between the flow of refrigerant, oil and pipe insulation.

***Target Technologies and Measures:***

- Premium efficiency refrigeration equipment including efficient compressors, optimized floating head pressure and equipment size optimization
- Improved distribution system

***Opportunity Costs and Savings Profile***:

- A typical cooling/refrigeration/freezing project has an implementation cost of $2,000 to $50,000
- The total economic potential for these measures is estimated to be 7.4 GWh/yr. by 2026
- Customer payback is in the range of 12 years
- The CCE for these opportunities is estimated to be $0.01 to $0.04/kWh

***Target Audience(s)& Potential Delivery Allies:***

- Fishing and Fish Processing sub sector
- Cooling and refrigeration/freezing equipment manufacturers and suppliers
- Provincial and federal government

***Constraints & Challenges:***

The most significant barriers are:

- Premium efficiency equipment has attractive energy savings but increased equipment costs
- Long payback periods
- Retrofitting main equipment and distribution system require systems to be out of operation and may interfere with production schedules

***Opportunities & Synergies:***

- To capitalize on all potential benefits, the feasibility of efficient refrigeration system opportunities are best evaluated during system expansion or as part of a system reliability and safety review.
- Improved cooling and freezing may improve product quality and ensure compliance with food safety requirements.

***Experience Related to Possible Participation Rates:***

## Opportunity Profile

### I2 – Compressed Air

***Overview:***

Premium efficiency compressed air equipment includes both the compressor and the air dryer. Premium efficiency air compressors come with built-in ASD control that allows the compressor output to match the plant air demand. These compressors may save as much as 40% over standard compressors which typically use modulated control. Premium efficiency air dryers are of the refrigerated type with dewpoint control. These dryers are typically at least 15% more efficient than regenerative desiccant dryers, which are still commonly used in industry. Industrial facilities typically have several air compressors. Sequencing control systems can operate the compressors so that the larger compressor is base loaded (always on), the mid-sized compressors are used as needed to increase supply and an ASD compressor acts as the trim compressor (provides for the variable component of the process air demand). This setup is intended to closely match the demand for compressed air, to maintain consistent pressure and flow and to reduce O&M costs. Improving the compressed air distribution system involves the addition of air storage to reduce pressure fluctuations, and air piping redesign to reduce friction losses.

***Target Technologies and Measures:***

- Efficient equipment including efficient compressors, air dryers and equipment size optimization
- Efficient control including ASD, sequencing and dryer dewpoint control
- Efficient distribution system including increased air storage and reduced piping friction losses

***Opportunity Costs and Savings Profile***:

- A typical compressed air project has an implementation cost of $5,000 to $65,000
- The total economic potential for these measures is estimated to be 7.7 GWh/yr. by 2026
- Customer payback is in the range of 6-13 years
- The CCE for these opportunities is estimated to be $0.01 to $0.08/kWh

***Target Audience(s)& Potential Delivery Allies:***

- All Industrial sub sectors
- Compressed air equipment manufacturers and suppliers
- Provincial and federal government

***Constraints & Challenges:***

The most significant barriers are:

- Perception by production personnel that existing system should not be changed
- Relatively long payback periods
- Retrofitting main equipment and distribution system require systems to be out of operation and may interfere with production schedules

***Opportunities & Synergies:***

- Heat recovery from air compressors can be used for space heating
- Replacing water cooled air compressors with air cooled compressors eliminates water usage

***Experience Related to Possible Participation Rates:***

## Opportunity Profile

### I3 – Pumps

***Overview:***

Pumps in industrial applications are often used for cooling tower sprays, spray cooler, water boosters, liquid transport, liquid recovery and liquid mixing. Energy savings can be gained by replacing older stock pumps with premium efficiency models that are application specific with premium efficiency impellers and motors. Pumps should be sized and selected based on their performance curve for the required flow. Impeller sizing is also an important consideration. Impellers should be sized specific for an application.

Pumps used for variable flow in industrial applications may be candidates for ASD. Currently, most pump installations are single speed and operate continuously independent of the actual load. Installing ASD on smaller pumps will result in significant energy savings in variable load applications where full operation may be required for less than 30% of the operating time. In these applications, 40% energy savings can be achieved. Modulating valves installed on by-pass lines will provide sufficient flow at all times allowing the pump to perform at maximum efficiency on the pump curve.

***Target Technologies and Measures:***

- Efficient and premium efficiency equipment including equipment size optimization
- Efficient control including ASD

***Opportunity Costs and Savings Profile***:

- A typical pump project has an implementation cost of $500 to $50,000
- The total economic potential for these measures is estimated to be 3.9 GWh/yr. by 2026
- Customer payback is in the range of 2-8 years
- The CCE for these opportunities is estimated to be $0.03 to $0.07/kWh

***Target Audience(s)& Potential Delivery Allies:***

- All Industrial sub sectors
- Pump manufacturers and suppliers
- Provincial and federal government

***Constraints & Challenges:***

The most significant barriers are:

- Relatively large capital investment in equipment for some projects; however, energy savings and production improvements will make this an attractive investment
- Retrofitting main processing pumps will require pumps to be out of operation and may interfere with production schedules

***Opportunities & Synergies:***

- Well accepted and proven technology.
- Improved pumping may result in improved product quality

***Experience Related to Possible Participation Rates:***

## Opportunity Profile

### I4 – Fans and Blowers

***Overview:***
Fans and blowers are often used for ventilation, exhaust, cooling, dust collection and aeration. Energy savings can be gained by replacing older stock fans and blowers with premium efficiency models that are application specific. Fans should be sized and selected for an application based on the performance curve of the fan at the required airflow.

Fans are widely used in industry for conveyance, drying and ventilation purposes. Operations requiring variable air delivery, such as drying, can benefit from premium control with ASD allowing air delivery to match process requirements. ASD save electricity and improve product quality by providing plant operators greater and finer control.

***Target Technologies and Measures:***
- Efficient and premium efficiency equipment, including equipment size optimization
- Efficient control, including timers and ASD

***Opportunity Costs and Savings Profile***:
- A typical fan/blower project has an implementation cost of $500 to $50,000
- The total economic potential for these measures is estimated to be 3.5 GWh/yr. by 2026
- Customer payback is in the range of 2-9 years
- The CCE for these opportunities is estimated to be $0.04 to $0.09/kWh

***Target Audience(s)& Potential Delivery Allies:***
- All Industrial sub sectors
- Fan/blower manufacturers and suppliers
- Provincial and federal government

***Constraints & Challenges:***
The most significant barriers are:
- Lack of understanding by production personnel of energy savings potential

***Opportunities & Synergies:***
- Well accepted and proven technology.
- Improved air quality and indoor climate control

***Experience Related to Possible Participation Rates:***

## Opportunity Profile

### I5 – Conveyors

***Overview:***
Conveyors often use gear boxes to isolate the motor and to provide better torque control. Opportunities include using higher-efficiency drives, couplings and gear/speed reducer alternatives. In older conveyor systems, or where process requirements have changed, it may be possible to resize a conveyor, upgrade the controls or re-engineer the system to improve layout and configuration, all of which will result in energy savings. Incorporating programmable logic controls (PLC) into the conveyor system will result in energy savings. PLC controls can shut down unloaded conveyors and control the conveyor based on load.

***Target Technologies and Measures:***
- Efficient and premium efficiency equipment, including equipment size optimization, low friction systems, and drive optimization
- Efficient control, including ASD

***Opportunity Costs and Savings Profile***:
- A typical conveyor project has an implementation cost of $4,000 to $20,000
- The total economic potential for these measures is estimated to be 2.5 GWh/yr. by 2026
- Customer payback is in the range of 4-7 years
- The CCE for these opportunities is estimated to be $0.07 to $0.10/kWh

***Target Audience(s)& Potential Delivery Allies:***
- Small conveyors in all Industrial sub sectors
- Conveyor manufacturers and suppliers
- Provincial and federal government

***Constraints & Challenges:***
The most significant barriers are:
- Perception by production personnel that existing system should not be changed
- Relatively long payback periods
- Retrofitting main equipment and distribution system require systems to be out of operation and may interfere with production schedules
- Barriers to implementing premium efficiency controls include additional maintenance costs due to increased number of components in the system

***Opportunities & Synergies:***
- Better controlled conveyance may result in improved product quality

***Experience Related to Possible Participation Rates:***

## Opportunity Profile

### I6 – Motors

***Overview:***

Electric motors convert approximately 85% of industrial plant electricity use to torque to drive industrial end uses such as fans, pumps, material handling and a large portion of process loads. These motors range in size from 75 Watts to more than 25,000 kW, with corresponding efficiencies of 40%-98%. While inherently efficient in converting electricity to shaft or motive power, on average 5%-8% of this power is lost in motor inefficiencies that occur before the driven equipment losses. The three motor efficiency levels included in this study are standard (93.5% efficient), high efficiency (94.5% efficient) and premium efficiency (95.5% efficient). Premium efficiency motors apply to all sub sectors and end uses.

Synchronous belts, also called timing, positive drive or high torque drive belts, apply to all sub sectors and end uses. Often, industrial end uses are driven by pulleys that use V-Belts. By replacing the pulley sheaves with synchronous belt pulleys and installing synchronous belts onto the end use (e.g., fan) an efficiency gain of 3%-5% can be achieved because of reduced slippage and friction between the pulley and belt. Synchronous belts may require motor vibration sensors to prevent damage from continuous operation following a system failure.

***Target Technologies and Measures:***

- Premium efficiency motors
- Synchronous belts

***Opportunity Costs and Savings Profile***:

- A typical motor project has an implementation cost of $500 to $75,000
- The total economic potential for these measures is estimated to be 8.7 GWh/yr. by 2026
- Customer payback is in the range of 5-13 years
- The CCE for these opportunities is estimated to be $0.01 to $0.08/kWh

***Target Audience(s)& Potential Delivery Allies:***

- All Industrial sub sectors
- Motor manufacturers and suppliers
- Provincial and federal government

***Constraints & Challenges:***

The most significant barriers are:

- Relatively long payback periods
- Retrofitting motors on main process equipment require systems to be out of operation and may interfere with production schedules

***Opportunities & Synergies:***

- Better operating motors require less maintenance

***Experience Related to Possible Participation Rates:***

# APPENDIX C

# Opportunity Profile Worksheets

## I1: Cooling / Refrigeration / Freezing

**Opportunities**
Premium efficiency equipment
Improved distribution system

| | |
|---|---|
| Typical project cost | $ 2,000 - $ 50,000 |
| Payback period | 12 years |
| CCE | $ 0.01 - 0.04 / kWh |
| Typical capacity | 50 HP |
| Estimated number of units | 400 - 550 |

**Retrofit**

| ***Milestone Year*** | ***Market Penetration Rate (%)*** | | | |
|---|---|---|---|---|
| | ***Reference Case*** | ***Achievable Lower*** | ***Achievable Upper*** | ***Economic Potential*** |
| ***2006*** | 10 | 10 | 10 | 10 |
| ***2016*** | 12 | | | 60 |
| ***2026*** | 15 | | | 100 |

## I2: Compressed Air

**Opportunities**
Premium efficiency equipment
Efficient control
Improved distribution system

| | |
|---|---|
| Typical project cost | $ 5,000 - $ 65,000 |
| Payback period | 6 - 13 years |
| CCE | $ 0.01 - 0.08 / kWh |
| Typical capacity | 200 HP |
| Estimated number of units | 351 - 400 |

**Retrofit**

| ***Milestone Year*** | ***Market Penetration Rate (%)*** | | | |
|---|---|---|---|---|
| | ***Reference Case*** | ***Achievable Lower*** | ***Achievable Upper*** | ***Economic Potential*** |
| ***2006*** | 15 | 15 | 15 | 15 |
| ***2016*** | 17 | | | 100 |
| ***2026*** | 20 | | | 100 |

## I3: Pumps

**Opportunities**
Premium efficiency equipment
Efficient control

| | |
|---|---|
| Typical project cost | $ 500 - $ 50,000 |
| Payback period | 2 - 8 years |
| CCE | $ 0.03 - 0.07 / kWh |
| Typical capacity | 50 - 200 HP |
| Estimated number of units | 2,500 - 3,000 |

**Retrofit**

| *Milestone Year* | *Market Penetration Rate (%)* | | | |
|---|---|---|---|---|
| | *Reference Case* | *Achievable Lower* | *Achievable Upper* | *Economic Potential* |
| ***2006*** | 20 | 20 | 20 | 20 |
| ***2016*** | 22 | | | 100 |
| ***2026*** | 25 | | | 100 |

## I4: Fans / Blowers

**Opportunities**
Premium efficiency equipment
Efficient control

| | |
|---|---|
| Typical project cost | $ 500 - $ 50,000 |
| Payback period | 2 - 9 years |
| CCE | $ 0.04 - 0.09 / kWh |
| Typical capacity | 50 - 200 HP |
| Estimated number of units | 800 – 1,800 |

**Retrofit**

| *Milestone Year* | *Market Penetration Rate (%)* | | | |
|---|---|---|---|---|
| | *Reference Case* | *Achievable Lower* | *Achievable Upper* | *Economic Potential* |
| ***2006*** | 20 | 20 | 20 | 20 |
| ***2016*** | 22 | | | 100 |
| ***2026*** | 25 | | | 100 |

## I5: Conveyors

**Opportunities**
Premium efficiency equipment
Efficient control

| | |
|---|---|
| Typical project cost | $ 4,000 - $ 20,000 |
| Payback period | 4 - 7 years |
| CCE | $ 0.04 - 0.06 / kWh |
| Typical capacity | 50 - 200 HP |
| Estimated number of units | 1,000 – 1,800 |

**Retrofit**

| Milestone Year | Market Penetration Rate (%) | | | |
|---|---|---|---|---|
| | Reference Case | Achievable Lower | Achievable Upper | Economic Potential |
| **2006** | 20 | 20 | 20 | 20 |
| **2016** | 22 | | | 100 |
| **2026** | 25 | | | 100 |

## I6: Motors

**Opportunities**
Premium efficiency equipment
Synchronous belts and VFDs

| | |
|---|---|
| Typical project cost | $ 500 - $ 75,000 |
| Payback period | 5 - 13 years |
| CCE | $ 0.01 - 0.08 / kWh |
| Typical capacity | 50 - 200 HP |
| Estimated number of units | 5,000 – 6,500 |

**Retrofit**

| Milestone Year | Market Penetration Rate (%) | | | |
|---|---|---|---|---|
| | Reference Case | Achievable Lower | Achievable Upper | Economic Potential |
| **2006** | 20 | 20 | 20 | 20 |
| **2016** | 22 | | | 100 |
| **2026** | 25 | | | 100 |

# CONSERVATION AND DEMAND MANAGEMENT (CDM) POTENTIAL

## Newfoundland and Labrador

## –Program Evaluation Guidelines–

*Prepared for:*

**Newfoundland and Labrador Hydro &**
**Newfoundland Power**

*Prepared by:*

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*In association with:*

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*January 18, 2008*

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# 1. INTRODUCTION

## 1.1 BACKGROUND AND OBJECTIVES

Newfoundland and Labrador Hydro and Newfoundland Power (collectively the Utilities) have partnered to produce this study, recognizing the role that each has in energy conservation and least cost electric utility planning within the province. Increasing electricity costs and the expectations of a growing number of their customers and stakeholders have contributed to the increased focus on conservation and demand management (CDM) and resulted in a number of recent initiatives and projects targeting energy savings in the province. This study is the next step in the Utilities efforts to develop a comprehensive plan for CDM in Newfoundland and Labrador. The Utilities envision electricity conservation and demand management (CDM) to be a valuable component in meeting the province's future electricity requirements.

This study will also be a significant component in the further implementation of the Province's recently released Energy Plan. The Energy Plan establishes a long-term vision for how the province's energy resources will be developed and utilized to benefit the people of the province today as well as for future generations. Electricity conservation and demand management (CDM) are an important component of the provincial Energy Plan as are the conservation and demand management components for the other energy resources of the province.

This report meets, in part, the requirements of the Public Utilities Board Order PU 8 2007 requiring NLH to file this study and a five-year plan for implementation of CDM programs in 2008.

The objective of this study is to identify the potential contribution of specific CDM technologies and measures in the Residential, Commercial and Industrial sectors and to assess their economic costs and benefits. The Newfoundland and Labrador economy is expected to grow over the next 20 years, with an associated increase in energy consumption. The benefits of increased penetration of energy efficiency technologies include reduced energy costs for individuals and businesses, as well as environmental benefits through reduced pollution and greenhouse gas emissions.

The outputs from this study will assist the Utilities CDM planners and others to develop specific CDM programs for implementation and to optimize the contribution of CDM technologies and measures to the province's overall energy future.

## 1.2 STUDY ORGANIZATION AND REPORTS

This report is one of five that have been prepared for the *Newfoundland and Labrador Conservation and Demand Management (CDM) Potential Study*. It complements the three individual sector and summary reports, which provide a detailed analysis of CDM opportunities in, respectively, the Residential, Commercial and Industrial sectors. The results of those study components are presented under separate cover; they are titled:

- *Conservation and Demand Management Potential (2006 to 2026, Newfoundland and Labrador, Residential Sector*

- *Conservation and Demand Management Potential (2006 to 2026), Newfoundland and Labrador, Commercial Sector*

- *Conservation and Demand Management Potential (2006 to 2026), Newfoundland and Labrador, Industrial Sector*

- *Conservation and Demand Management Potential (2006 to 2026), Newfoundland and Labrador, Residential, Commercial and Industrial Sectors, Summary Report*

The technical and market analysis contained in the above reports provides a foundation for Utilities' personnel to design and implement CDM programs targeted to selected priority opportunities. Evaluation is an important component of the CDM program design and implementation cycle that is expected to follow the completion of this study. However, the identification of specific CDM programs is beyond the scope of this current study; consequently, it is not possible to present a program-specific evaluation plan at this time. Given these circumstances, this report provides program design personnel and program managers with high-level guidelines and points to consider when addressing evaluation issues as part of the detailed CDM program design process. More specifically, this report is organized and presented as follows:

- Section 2 provides an overview of the role of evaluation within the overall CDM program design and implementation cycle

- Section 3 provides high-level guidelines related to a number of specific program evaluation questions that were identified in consultation with Utilities' personnel

- Section 4 provides an overview of lessons learned for small markets related to selection of CDM program types and program evaluation priorities.

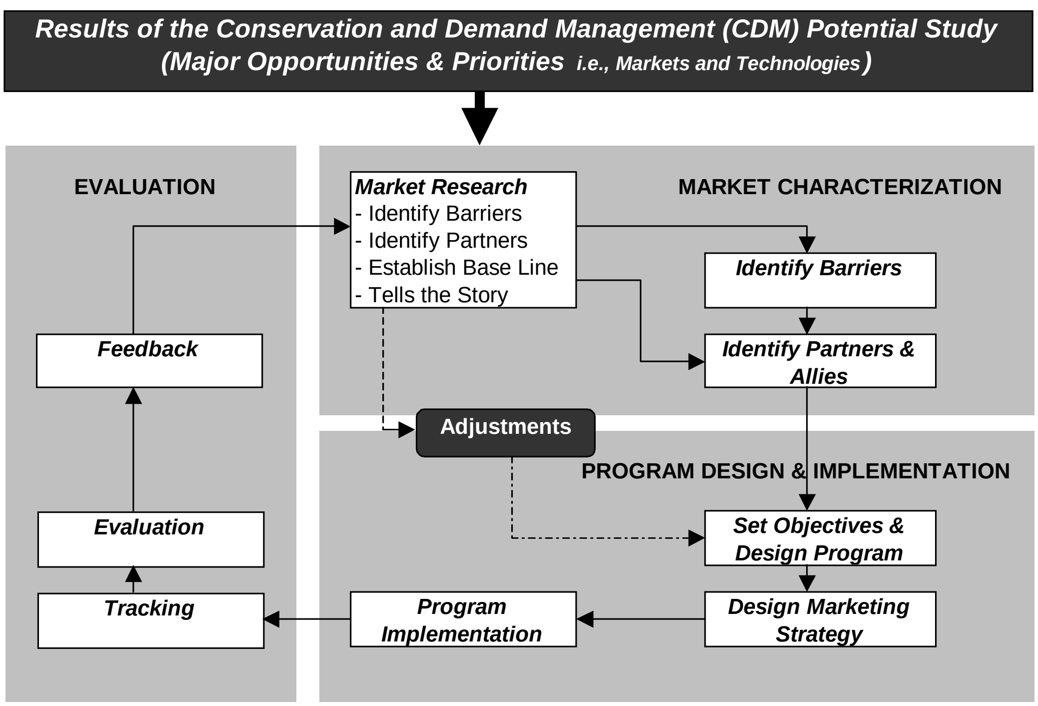
# 2. THE CDM PROGRAM DESIGN AND EVALUATION CYCLE

## 2.1 INTRODUCTION

Evaluation is part of an integrated CDM program cycle that combines effective program design and implementation with evaluation. Exhibit 2.1 provides an illustration of the three primary components of the CDM program cycle (market characterization, design and implementation, evaluation); it also illustrates the relationship of the CDM Potential Study to the CDM program cycle.

As illustrated in Exhibit 2.1, the results of the CDM Potential Study provide a foundation that supports the broader, on-going CDM program cycle. More specifically, the study identifies and provides a comprehensive assessment of the full range of potential CDM measures, including the identification of potential savings and costs by sub sector, end use and technology. These results assist the Utilities to identify priorities based on the availability of CDM program budgets or energy savings targets.

**Exhibit 2.1: CDM Program Cycle**




Once the Utilities have selected the first round of CDM priorities, the main components of the program cycle can be grouped into 3 categories:

- Market Characterization
- Program Design and Implementation
- Evaluation

The remainder of this section provides a brief overview of each component with particular emphasis on evaluation related considerations.

## 2.2 MARKET CHARACTERIZATION

For each of the selected CDM priorities, "market characterization" (MC) provides four important contributions to the CDM program cycle:

- It "tells the story" of the precise path of a given technology in a market from the manufacturer or importer to the end user.
- It identifies the types of barriers that prevent a given technology penetrating the market (e.g., financial, technological, commercial, informational or institutional barriers). Institutional barriers are, by far, the most difficult to overcome.
- It identifies the major partners who have a significant influence in that chain of acquisition in order to identify potential marketing or delivery partners or trade allies for a new program.
- It establishes a baseline and trends.

The story guides the marketing strategy for the new program. The *partners* will eventually be program delivery allies. Understanding the *barriers* will guide the type of supports that the program should offer and the *baseline* will help establish program objectives since it represents the starting point.

## 2.3 PROGRAM DESIGN AND IMPLEMENTATION

To support the evaluation process, there are two concepts that need to be defined during the program design phase, and be available for the evaluator's examination. They are: Program theory (PT) and logic model (LM). Each is briefly outlined below.

### 2.3.1 Program Theory

A program theory is a presentation of the goals of a program and the identification of the causal relationships between the activities and the program's effects. The theory describes, in detail, how the proposed activities will accomplish the program goals.

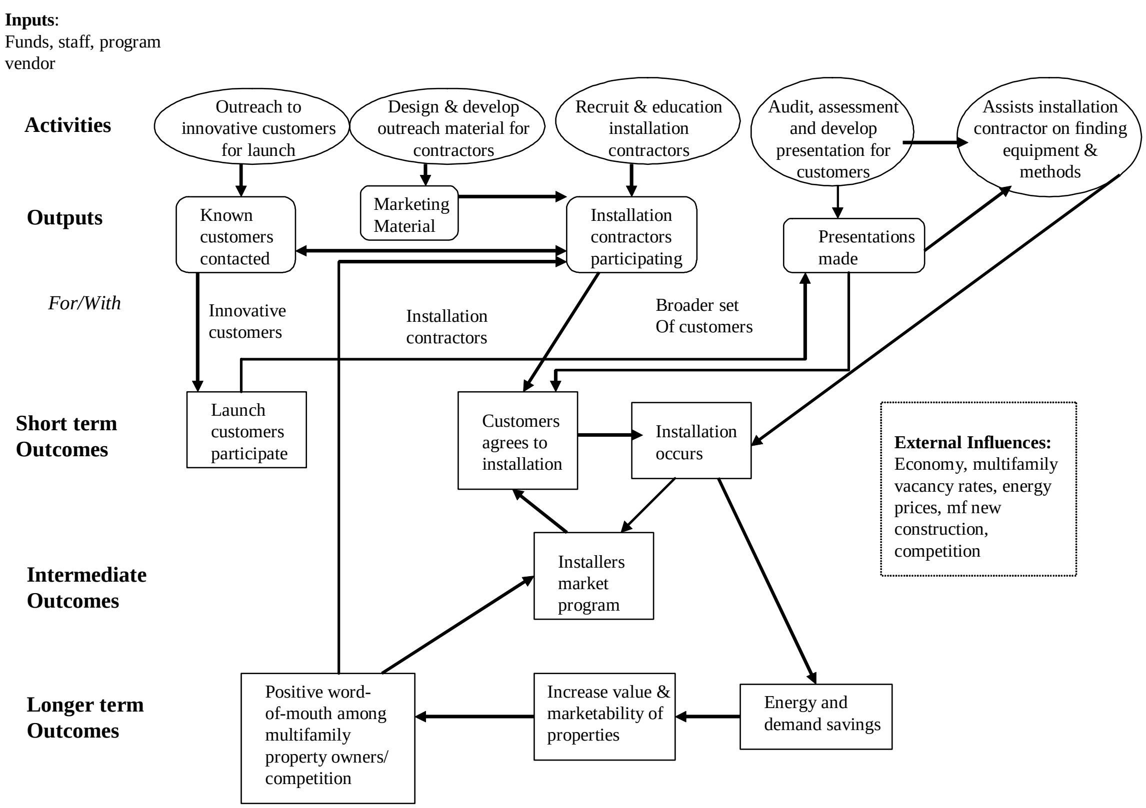
A well-developed PT should also describe the barriers to be overcome and how the program's activities are expected to overcome those barriers. A PT may also indicate (from the program developer's perspective) what progress and goal attainment metrics should be tracked to assess the program's effects.

### 2.3.2 Logic Model

PTs are sometimes called the program logic model (LM). A stricter definition would be to differentiate the PT as the textual description, while the LM is the graphical representation of the PT, showing the flow between activities, their outputs and subsequent short-term, intermediate and long-term outcomes.

The LM is often displayed with these elements in boxes with the causal flow shown by arrows from one to the others in the program logic. It can also be displayed as a table with the linear relationship presented by the rows in the table. The interactions between activities, outputs and outcomes are critical to understanding the program logic and argue for the need to have, or construct, both a program theory and a program logic model. Exhibit 2.2 is an example of a logic model diagram.

**Exhibit 2.2: CDM Program Logic Model[1]**




## 2.4 EVALUATION

The evaluation plan is also defined during the program design phase of the CDM program cycle. The evaluation plan defines how the evaluation will be implemented. Some utilities develop a detailed evaluation plan at the design phase of a given program; others simply define the pertinent evaluation information and data needs at the program's design phase to ensure that the necessary data will be available when the evaluation occurs at a later stage.

The latter approach is preferred since data availability, quality, precision and accuracy can seriously affect the evaluation methodology. It is important, however, to identify the necessary evaluation data and information as well as the collection method and sources. Program administers usually perform this task with the assistance of an experienced evaluator. At this

[1] California Evaluation Framework, op. cit., p. 48.

stage, the evaluator may identify program activity objectives that will be difficult or impossible to evaluate; such insight will provide the program designer with an opportunity to modify the proposed program framework and increase the likelihood of program success. Most of the data needs are related to the program theory, the baseline[2] or reference case and the implementation strategy's key performance indicators.

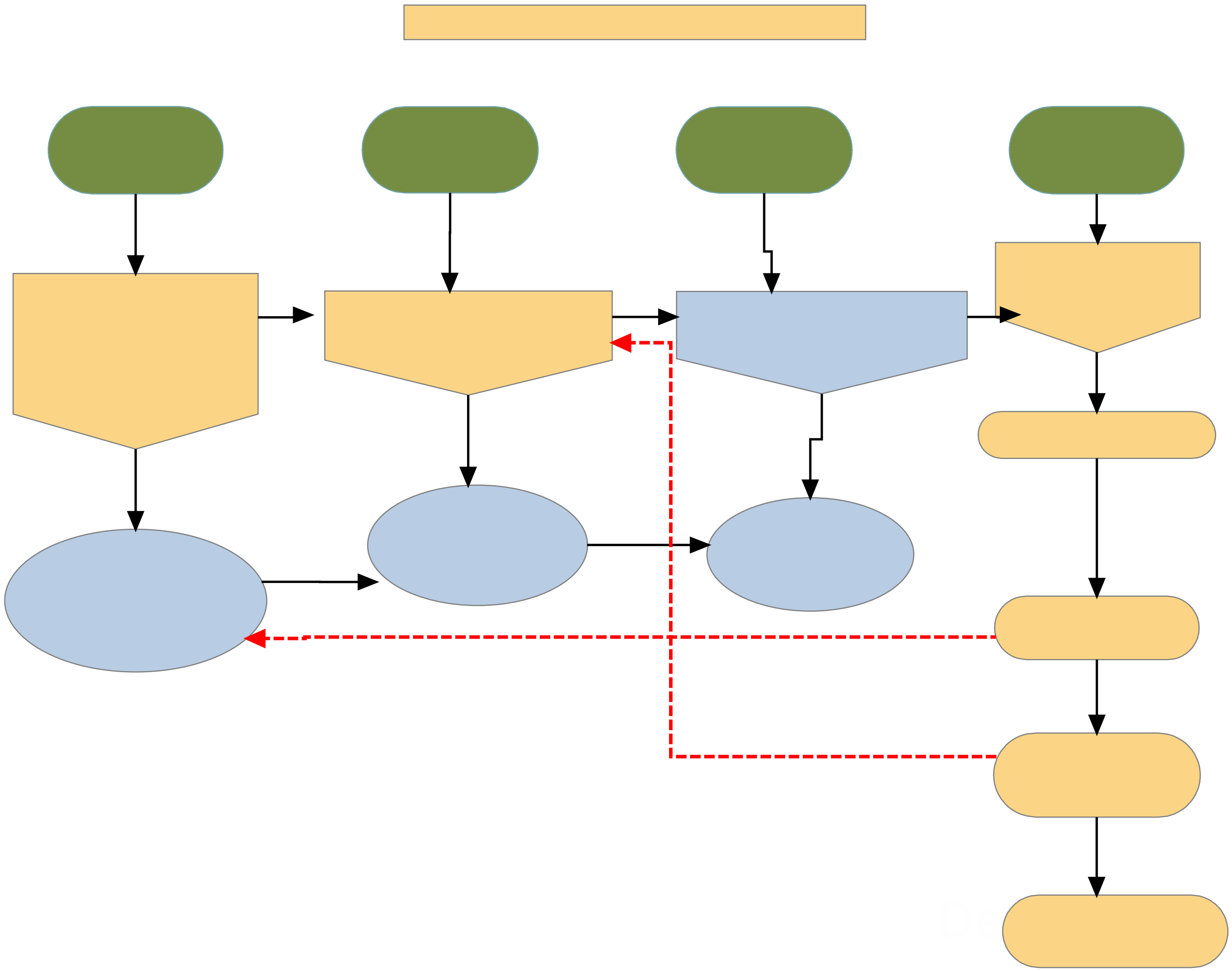
Exhibit 2.3 illustrates a typical program evaluation data-tracking plan. It describes the relationship between information needed from administrators and program evaluation. The key activities related to the data required from program administrators are shown in the oval-shaped boxes for each stage of the evaluation cycle. Typically, after examining the data provided by the administrators, the evaluator will define the researchable issues and develop a comprehensive research methodology. Tools to collect this information (mostly ex-post) will range from telephone surveys to focus groups, metering, billing analysis, simulations, site visits, mystery callers and mystery shoppers, etc. Most of the collection tools are usually pre-approved by utility CDM program staff, which allows them to be sure that specific subjects of concern are adequately addressed.

Energy-efficiency program evaluation is not an exact science. This is because consumer behavior can vary from the most accurate predictions and because the evaluation cannot measure something that does not exist (energy saved). Hence, the evaluator will try to find a particular answer by using more than one deduction method to establish reasonable and credible results. This technique is called cross validation or triangulation. The California Energy Efficiency Evaluation Protocols provides examples of such data for different types of programs.[3]

[2] A baseline is the starting point from which program staff set their objectives. It is usually dynamic and must be carefully monitored to differentiate between natural savings (savings that would have occurred anyway, without a strategic intervention such as a program), and the strategic savings that can be attributed to the program. Baseline is also an important tool for the evaluator.

[3] California Energy Efficiency Evaluation Protocols: Technical, Methodological, and Reporting Requirements for Evaluation Professionals. April 2006. p. 205.

**Exhibit 2.3: Data Tracking Plan for Program Evaluation**



# 3. EVALUATION GUIDELINES

## 3.1 INTRODUCTION

As noted in previously in Section 1, it is too early in the CDM program cycle to define a specific evaluation plan. Consequently, the consultant was asked to provide general guidelines or principles to be considered related to the following list of evaluation topics:

It is organized and presented in the following sub sections:

- Evaluation definitions and types
- Why evaluate and for whom?
- Who evaluates?
- When to evaluate?
- Evaluation budget, cost versus precision
- Program evaluation metrics.

***Caveat:*** The following sections provide some general information, based on best practices, related to the science of energy-efficiency program evaluation. It is expected that Utility CDM program staff (those who deliver the program) will select the most appropriate elements that apply to their particular context in terms of program types, market characteristics, available resources and the specific needs of stakeholders.

## 3.2 EVALUATION DEFINITION AND TYPES

Evaluation has two core functions: Summative and Formative. Summative refers to the documentation and measurement of the effects of a given program. Formative refers to understanding why those effects occurred and identifying ways to improve the program. Without these two functions, causal effects cannot be established and, therefore, no sound recommendations can be proposed.

- **Summative Evaluation**: Most parties agree that the single most important function of evaluation is to document and measure program effects. The impact of a program, or group of programs, is often a requirement for ensuring accountability of resources spent on the program. Summative evaluations are done once a program has been operating to document program impacts and are used to inform decisions on whether to continue, expand, cut back or end the program. Generally, impact evaluations in the energy-efficiency field are summative evaluations.

- **Formative Evaluation**: Formative evaluation provides understanding into why the observed effects occurred and identifies ways to improve program effectiveness. Formative evaluations are often conducted early in a program's operations, or in steady-state programs to obtain feedback and discover ways to improve a program. Process evaluations are typically used as formative evaluations.[4]

[4] California Evaluation Framework, prepared for the California Public Utilities Commission and the Project Advisory Group. June 2004. p. 28.

The importance of both evaluation functions can be seen through a simple example. Consider a situation where the observed impacts of a program are weak but the effect is due to an easily correctible problem in the program implementation. Reacting to the impact evaluation results alone might well lead to a technically accurate but policy-poor decision to terminate the program, whereas understanding why those results occurred and what can be done to improve the results can lead to improvements in the program implementation and ultimately a successful program.

Similarly, experts realize that new programs typically have to experience a "start-up" phase, where effectiveness is not yet optimized and initial costs are higher. It would be inappropriate to simply look at initial impact results and make a quick judgment about a program's potential without understanding where the program was in terms of its life cycle.

In summary, quality evaluation efforts incorporate both evaluation concepts into their energy program evaluation design:

- Summative or impact evaluation documents program impacts
- Formative or process evaluation provides for a better understanding of the observed results, the reasons for these results and identifies applicable opportunities for improving program performance.

### 3.1.1 Types of Program Evaluation

Technically, each energy-efficiency program requires a particular type of evaluation that is closely linked to its objectives. For example, a resource acquisition program requires a different type of evaluation than a market transformation program, a low-income program, a codes and standards program or a capacity building and awareness program. Although there are many types of evaluations,[5] they can be grouped into three broad categories:

- Process evaluation
- Market evaluation
- Impact evaluation.

#### Process Evaluation

A process evaluation is a systematic assessment of an energy-efficiency program for the purposes of (1) documenting program operations at the time of the examination, and (2) identifying and recommending improvements that can be made to the program to increase the program's efficiency or effectiveness for acquiring energy resources, while maintaining high levels of participant satisfaction.[6] This definition specifically excludes

[5] Examples include: process, direct market, indirect market, energy impact, demand impact, market transformation, non-energy benefits evaluations, etc.

[6] California Evaluation Framework, op. cit., p. 207.

the assessment of energy programs for purposes other than increasing the efficiency or effectiveness of the program to acquire energy resources, either directly or indirectly.[7]

In practice, the process evaluation is like a "pit stop" to check important program delivery issues that will help to inform whether and how adjustments may need to be made. The process evaluation will identify and recommend changes in a program's operational procedures or systems that can be expected to improve the program's efficiency or cost effectiveness.

**Market Evaluation**

The market effect of a program is defined as "a change in the structure of a market or the behavior of participants in a market that is reflective of an increase in the adoption of energy efficient products, services, or practices and is causally related to market intervention(s)."[8] Consequently, a market evaluation assesses a program's short- and long-term market effects.

Strategically, a market evaluation will be a key part of an industry program evaluation plan because the program is designed to foster market transformation.

The program evaluation literature suggests that market evaluations be designed and implemented at the market level, rather than in relation to a specific program (i.e., the anticipated impacts of such a program are usually expected at the market level). However, in the case of a market transformation program, there is a direct relationship between the program's activities and an anticipated market level effect, so it is defensible to conduct a market evaluation for the program.

**Impact Evaluation**

An impact evaluation estimates the "net" energy and demand savings of a program and its cost effectiveness to verify whether the expected program energy and demand savings are actually occurring in the field. Strategically, an industry program impact evaluation can also measure the possible non-energy benefits of the program, e.g., reduction of waste in the production of a given good, the reduction of inventory of raw or finished goods, the air quality in the plant and worker productivity, reduction of other valuable resources such as water, etc.

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[7] For example, this definition excludes conducting management audits or evaluations for the purposes of supplementing a financial audit of a program unless these examinations, at least in part, are conducted for the purposes of reducing the net cost of acquiring the energy impacts.

[8] California Evaluation Framework, op. cit., p. 263.

An impact evaluation generates two types of energy savings estimates:

- Gross savings, which are calculated for program participants relative to their prior participation usage

- Net savings, which control for savings that would have occurred for these participants over the same time period whether the program was offered or not. As noted in the California Evaluation Protocols, “estimating net savings generally requires the use of a comparison group as a proxy for what the participants would have done absent the program, or self-reported information on what would have happened in the absence of the program when comparison groups cannot be reasonably identified.”[9]

## 3.3 WHY EVALUATE AND FOR WHOM?

The primary purpose of program evaluation is to help ensure that good decisions are made regarding the investment of energy program resources by providing rigorous, independent evaluation studies and study results.

One of the primary ways in which evaluations provide information for making good decisions is by testing the implicit and explicit assumptions within the program theory and its marketing strategy. If the assumptions of a program theory are not validated in a real market context and/or if the program implementation strategy fails, the program will perform poorly, and vice versa.

Evaluation results are useful to different stakeholders, such as:

- Regulatory staff and policy makers
- Consultative groups
- Program partners
- Evaluation oversight managers and reviewers
- Program administrators and or program implementers
- Cost-effectiveness and avoided cost personnel
- Evaluation designers and managers
- Evaluators for all types of evaluation—impact, metering and monitoring, process, information and education programs, market transformation and market effects, and non-energy effects
- Statisticians and research data managers
- Portfolio managers.

All of these stakeholders are not necessarily present or active in every jurisdiction. Once the stakeholders are identified, the next step is to identify the “need to know” issues confronting them. This information is essential to guide and optimize evaluation efforts. Examples of common utility-specific issues that are addressed by evaluation results include:

- Was the specified work completed?

[9] California Evaluation Framework, op. cit., p. 96.

- Were the expected savings achieved?
- Did we get what we paid for?
- Is the customer satisfied?
- Will the savings persist?
- How should we direct future offerings?

Examples of common regulatory issues that are addressed by evaluation results include:

- Is the program meeting its objectives?
- Are efficiency funds being used responsibly?
- Is the public interest being met?
- Is it consistent with public policy?
- Are there economic development impacts?

Once again, these are examples of stakeholders and what they expect from a program delivery. Each jurisdiction should identify the stakeholders involved and their needs or specific expectations.

## 3.4 WHO EVALUATES?

To optimize credibility, post-implementation program evaluation should be conducted by an independent, experienced evaluator. That being said, if resources are limited, program staff should determine if some evaluation activities could be done internally. In such a case, an experienced staff member (who was not involved in the design and development of the program) should conduct the process evaluation.

Assigning different evaluators to do different types of evaluation at different times for the same program is neither cost effective nor efficient. To be effective, an evaluator needs to have a broad understanding of the program, including its progression and adjustments over time. Ideally, the evaluator serves as an ally to the utility CDM program staff, guiding them in a process of continuous program performance improvement over the program's life.

Any program research activities conducted throughout the program's life should be contracted to the same evaluator (assuming that his/her quality of work is satisfactory). This approach avoids discrepancies in research methods. For example, if the program authority needs to conduct research on a baseline or a survey in between two evaluations, these tasks should be given to the same program evaluator who will use the information as an input to the evaluation. Relying on the same evaluator allows the performance of the evaluator's recommendations to be measured over time, ensures greater depth of understanding of the issues and avoids a "hit and run" approach. Some may argue that by evaluating his/her own recommendations, the evaluator will be in a conflict of interest, but close monitoring of the evaluator's work by program staff should prevent any such conflict.

In addition, evaluators should be involved in the very early stage of any program design in order to avoid situations that could affect the evaluation cost or precision. Evaluators should have hands-on experience in the design, development, marketing and tracking of utility based energy-efficiency programs, not just evaluation of the program. This type of expertise offers a better understanding of the characteristics and specific difficulties related to energy-efficiency programs.

## 3.5 WHEN TO EVALUATE?

There is no strict agenda for the timing of program evaluation. However, the following principles provide useful guidelines:

- Process evaluation should be carried out in the early stages of program implementation when few participants or trade allies are involved. This early input will identify any necessary adjustments and ensure that the program is on track.

- Market and impact evaluation is typically conducted every two or three years, depending on the issues identified through the tracking process. For example:

  - A statistically significant number of participants
  - Ratio of actual number of participants vs. forecast number of participants for a given period
  - Actual spending versus predicted spending ratio for a given period
  - Actual savings versus predicted savings for a given period
  - A high or low level of customer service calls
  - Any other performance indicators that, in the opinion of the program managers, requires an evaluation to clarify or explain a given situation.

- A comprehensive evaluation should be performed at the end of a program's life cycle.[10]

## 3.6 EVALUATION BUDGET, COST VERSUS PRECISION

As noted previously, energy-efficiency program evaluation is not an exact science. The more precision that is required, the more the evaluation will cost. Program evaluation cost and precision also depends on the quality and quantity of data provided by the program administrator (see Exhibit 2.2).

Evaluation budgets can vary widely depending on the researchable issues and the type of program being evaluated. Among delivery agencies that run aggressive CDM programs (e.g., California public- or privately-owned utilities, U.S. northwest utilities and some U.S. midwest utilities), costs vary from about 3% to 8% of total program expenditures.

Some evaluation techniques are more capital intensive than others. For example, on-site metering, on-site visits and energy use simulations are more expensive than surveys or discussion groups. Similarly, homogeneous markets, such as the residential sector, typically have

[10] Program life cycle is the number of years a specific program will be offered in a given market. Technology life cycle refers to useful life duration of a given technology or product and is usually expressed in number of years. This is useful to calculate cumulative savings for cost-effectiveness tests in particular.

a much lower evaluation expenditure-to-program budget ratio than exogenous markets, such as the industrial sector.

### 3.6.1 California Energy Efficiency Evaluation Protocol

The California Energy Efficiency Evaluation Protocol[11] offers a set of technical, methodological and reporting requirements for evaluation professionals.

For each type of evaluation, the protocol outlines three levels of rigor: basic, standard and enhanced.

Each level defines a set of program evaluation methodologies; some of the methods refer to the different measurement scenarios (A to D) of the International Program Measurement and Verification Protocol (IPMVP).[12] The higher the rigor level scale, the more expensive the evaluation.

## 3.7 PROGRAM EVALUATION METRICS

**Two particularly important evaluation metrics are** net-to-gross energy savings and cost effectiveness.

### 3.7.1 Net-to-Gross Energy Savings

Gross demand or energy savings is the change in energy consumption and/or demand that results directly from program-related actions taken by participants in the CDM program, regardless of why they participated.

Net demand or energy impact is the total change in load that is attributable to the utility CDM program. This change in load or energy may include, implicitly or explicitly, the effects of free drivers, free riders[13], provincial or federal energy-efficiency standards, changes in the level of energy service and natural savings effects.

Net-to-gross ratio is a factor representing net program load impacts divided by gross program load impacts. It is also sometimes used to convert gross measure costs to net measure costs.

Hence, for attribution purposes, it is the net savings that are of greatest importance to the utility sponsoring a given program, as they are used to calculate the different cost-effectiveness tests. Exhibit 3.1 presents a sample illustration of the net-to-gross savings calculation before applying any distortion effect such as free riders.

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[11] California Energy Efficiency Evaluation Protocols, op. cit.

[12] International Performance Measurement and Verification Protocol. U.S. Department of Energy.

[13] "Free riders" typically refers to those who participate in a CDM program but would have implemented the CDM measures even in the absence of program's incentives. Free drivers, on the other hand, refers to those who implement the CDM measures being promoted by the CDM program without taking advantage of available incentives.

### Exhibit 3.1: Sample Illustration of Net-to-Gross Savings Calculation

Assume the following situation:

- A customer has an old furnace with a seasonal energy efficiency of 70%.
- In the current market, most new furnace sales (standard market practice) have an average seasonal energy efficiency of 82%, either because it's the only type available on the market or it is imposed by regulation.
- The CDM program promotes condensing furnaces with an efficiency of 93% or more.

In the above example:

- The participant baseline (and the gross savings calculation) start at the consumption level associated with a furnace having an efficiency of 70%.
- The natural energy savings are calculated based on the efficiency improvement from 70% (baseline) to 82%.
- The net savings attributed to the program are calculated based on the efficiency improvement from 82% to 93%.

The objective is to encourage implementation of energy-efficiency measures or technologies that are over and above the market standard practices. The principle in this approach is that any level of efficiency considered as a standard practice should not be subsidized since this will reduce program savings and program attribution.

### 3.7.2 Cost-Effectiveness Tests

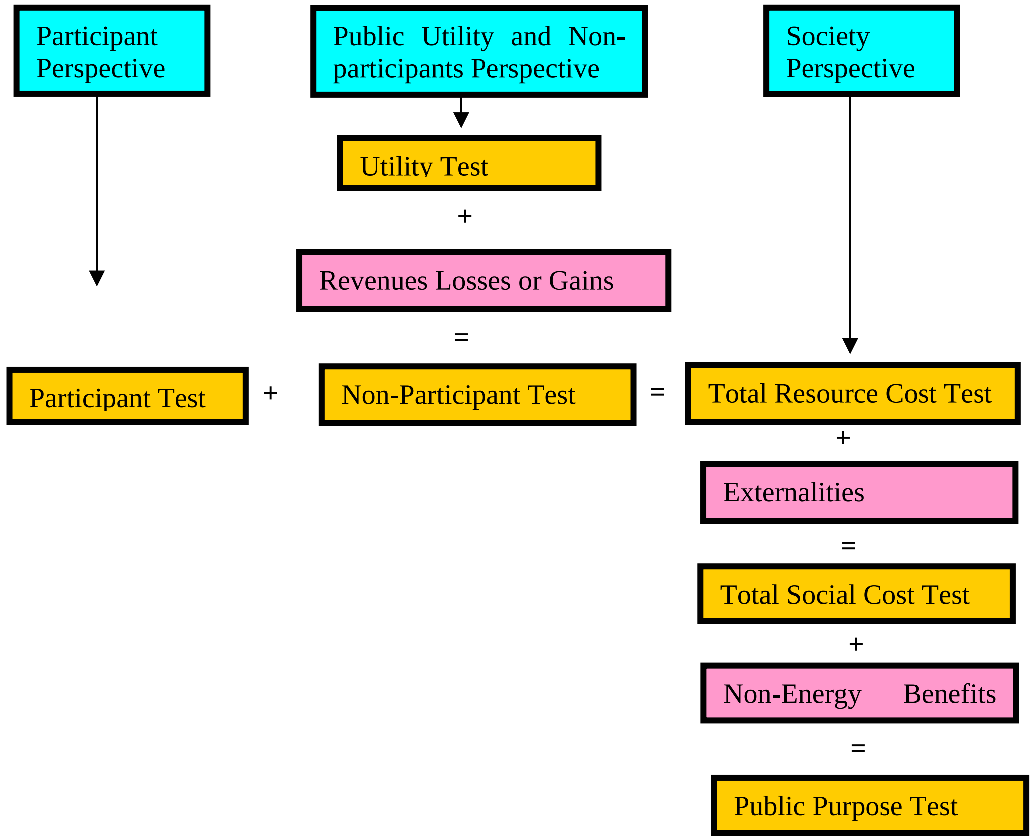
Cost-effectiveness tests are indicators of the relative performance or economic attractiveness of any energy-efficiency investment or practice when compared to the costs of energy produced and delivered in the absence of such an investment.

The different tests calculate the net present value (NPV) of the estimated benefits or losses produced by an energy-efficiency program as compared to the estimated total program's costs, from different perspectives:

- Participant perspective
- Utility perspective
- Non-participant perspective
- Both the utility and the participant perspective
- Society perspective.

Exhibit 3.2 illustrates the relationship between the different tests.

**Exhibit 3.2: Program Cost-Effectiveness Tests**




It is recommended that the primary metric for assessing a program's cost effectiveness be a hybrid of the Total Resource Cost (TRC) and the Societal Cost Test (SCT), defined below.

The TRC test, as defined in the California Standard Practice Manual, "measures the net costs of a demand-side management program as a resource option based on the total costs of the program, including both the participants' and the utility's costs. The test is applicable to conservation, load management, and fuel substitution programs."[14] A program assessed using the TRC test is considered cost effective if the ratio of benefits to costs is greater than or equal to one. The SCT is a variant on the TRC test in that it includes the effects of externalities (e.g., environmental) and uses a different (societal) discount rate.

The Rate Impact Measure (RIM) test measures the impact of CDM programs on a utility's rates; it is also used to assess the potential impacts that a CDM program may have on non-participants in the program. In this case, non-participants who do not implement energy saving measures could experience increased rates, and hence increased

[14] California Standard Practice Manual, Economic Analysis of Demand-Side Programs and Projects, October 2001. pg. 18.

electricity costs, as a result of the CDM program costs without realizing the benefits of a reduced demand for electricity.

The Ontario Energy Board (OEB) indicates that the RIM test is useful to ensure that a utility's portfolio of energy conservation programs do not impose an undue rate increase on an individual or class of customers.

# 4. PROGRAM AND EVALUATION LESSONS LEARNED

## 4.1 INTRODUCTION

This final section provides an overview of lessons learned for small markets and/or markets such as Newfoundland and Labrador where the Utilities are in a CDM program start-up mode. The information provided is based primarily on prior experience of study team members and is not necessarily comprehensive. Two areas are addressed:

- CDM Program Lessons Learned
- CDM Evaluation Lessons Learned

## 4.2 CDM PROGRAM LESSONS LEARNED

The Newfoundland and Labrador CDM market is relatively small and CDM program managers are likely to be confronted with a number of constraints, such as:

- Financial resource constraints
- Relatively small potential market (population of 500,000 people and 250,000 customers)
- Need to develop new programs
- Multiple delivery partners
- Limited trade ally networks
- Limited human resources.

The following CDM program design guidelines are provided based on the prior evaluation experience of study team members.

❑ **Some types of CDM programs are better suited to small markets**

A small team with limited financial resources can manage the following types of programs:

- Resource acquisition programs with a financial incentive that covers part of the incremental cost. Participant contribution is important to reduce free ridership (i.e., do not give away measures). The incentive is typically processed through a rebate coupon at the point of purchase with the collaboration of retailers, who then send the coupons to utility CDM program staff once a month with appropriate metrics for evaluation and tracking purposes.

- Awareness, educational and training programs. These can include labeling, youth education, capacity building sessions for professionals and Web sites that offer consumers energy-efficiency recommendations and references to energy-efficiency programs offered by the utility or other institutions.

- Codes, standards and building codes programs. These programs take time because they involve multiple parties. However, they are not capital intensive and the results are worth the efforts. Some codes and standards can also be adopted or adapted from other jurisdictions.

- **Some types of markets are easier to address**

Markets range from homogeneous to heterogeneous. Programs that address homogeneous markets, such as the Residential sector, are less capital and labour intensive than programs in the Industrial sector, which are heterogonous and need case-by-case attention.

- **Some programs require more resources to design and implement than others**

Experience has shown that the following types of programs are capital and labor intensive and require a well-established trade ally network:

- Renovation or retrofit programs. These programs require case-by-case analysis and are difficult to standardize.
- Savings by design programs. These types of programs, designed for new construction, require computer simulation with sophisticated software, such as DOE-2,[15] and some efforts for commissioning.
- Large industrial programs. These programs require a case-by-case approach and in-depth expertise of industrial processes.
- Performance type programs with multiple interactive measures. These types of programs require expertise in different systems interactions and are designed for existing installations.
- Programs that require the involvement of professionals for installation (as opposed to owner install).

- **Trade allies can be valuable program delivery partners**

Choosing the right partners or trade allies to assist in the delivery of a program reduces the workload for program staff. The right partner is one that has the most influence and credibility in a given market to encourage participation. Industry associations are typically very good delivery partners since members tend to be more influenced by their own association rather than by a utility. Professional electricians and plumbers, retail distributors and manufacturers are also good allies since the program represents additional sales for them, creating a "win-win" situation.

[15] http://www.doe2.com.

- **Institutions can be valuable program delivery partners**

Involving institutions as program partners is a good way to increase impact. For example, energy-intensive government buildings such as hospitals and schools could develop their own efficiency program with the guidance of the program managers.

- **Program administration is typically most effective when vertically integrated**

For any given program, all phases (e.g., research, design, development, implementation, tracking and evaluation) should be the responsibility of one program manager. This enables the program manager to have a comprehensive picture of the program and allows him/her to react rapidly if a problem arises. It is also necessary if the program manager is accountable for the program's performance. Allocating some of these tasks among different teams is not recommended.

## 4.3 CDM EVALUATION LESSONS LEARNED

The following presents a summary of the key lessons learned from CDM program evaluations.

- **Define evaluation data collection needs in the design phase**

Evaluation costs and efforts will be reduced if evaluation data needs are defined in the design phase and data are collected and validated as the program progresses.

- **Identify stakeholder information requirements early**

Identifying precisely what information is required by all the program stakeholders will avoid the need for research and evaluation on matters that are of no interest to them, thus reducing effort and cost.

- **Match types of evaluation with program timetable**

Three types of evaluation will eventually be needed: process, market and impact, and energy or load impact.

Process is essential in the early stages of the program for reasons described earlier. However, market and impact can wait until the program has a statistically significant number of participants, or fast-tracked if a given performance indicator shows that there is a particular problem. In the latter case, evaluation will focus on the particular problem.

When impact evaluation is required, both process and market evaluation are recommended. Impact evaluation will be summative, while process and market evaluation will inform why a given summative value has occurred. Doing one type of evaluation without the other will prevent the evaluator from establishing proper causal effects.

- **Track performance indicators**

Collection of key performance indicators is essential to determine when and what kind of evaluation is required. If the indicators show that the program is on target, there will be no urgency to conduct an evaluation.

- **When CDM programs are jointly implemented, attribute savings to the entity with revenue losses**

In some jurisdictions, multiple institutions offer a CDM program as partners. In such cases, overlapping can be avoided if one organization takes charge of the program evaluation, just as Hydro Québec is doing with the Agence de l'efficacité énergétique and Gas Métro.

For attribution considerations, the organization with no avoided costs or revenue losses is acknowledged for its support. Utilities, on the other hand, get credit for the energy savings that they provide, e.g., Hydro Québec will get attribution of electricity savings, and Gas Métro will get attribution for gas savings.

### 4.3.1 Additional Considerations

Once an initial portfolio of CDM programs is launched, the level of activity required to meet program evaluation needs can be constrained by establishing a program risk profile that enables evaluation resources to focus primarily on high-risk situations. This involves two steps:

The first step is to identify programs with the following characteristics or a combination of characteristics:

- Highest budget
- Highest savings
- Programs with highest cost to savings ratio. These program should be carefully monitored since, in theory they are less cost effective than others
- Highest number of participants
- Programs with highest non-participants test results: Since this test can impact electricity rates
- A high level of complaints from participants or trade allies in a given program.

The second step is to use the program tracking system to monitor ratios such as the following:

- Actual spending versus the predicted budget for a given program in a given period
- Actual savings versus the predicted savings in a given period
- Actual number of participants versus the predicted number of participants in a given period.

The above ratios can be examined to determine how far they are from 1 and, if there is a substantial gap, to determine the magnitude of the absolute value? Application of this approach results in four outcomes, only one of which would suggest additional short term evaluation effort.

***No concern:***

- If the gap is high but the absolute figure is low, there is no immediate concern.
- If the gap is low and the absolute figure is also low, there is no immediate concern.

***Concern:***

- If the gap is low but the absolute figure is high, there should be concern but an evaluation is not necessarily needed.
- If the gap and the absolute value are both high, then there should be concern, and an evaluation should be considered.

Exhibit 4.1 provides an illustration of the above approach.

**Exhibit 4.1 Illustration of Program Risk Screening Using Participant Ratios**

**Program 1:**

- Predicted number of participants for a given period: 100
- Monitored number of participants for the same period: 80
- The participant ratio is 80/100 or .8
- That 0.8 represents 20 participants as an absolute value

**Program 2:**

- Predicted number of participants for a given period: 1 600
- Monitored number of participants for the same period: 1 280
- The participant ratio is 1 280/1 600 or .8
- That 0.8 represents 320 participants as an absolute value

In this example, the participants ratio is the same (.8) for both programs. However, the absolute value in Program 2 is 16 times larger than in Program 1 (320 participants versus 20 participants). If these participants are in a similar market, or have the same weight, Program 2 should be of more concern and accorded higher evaluation priority.