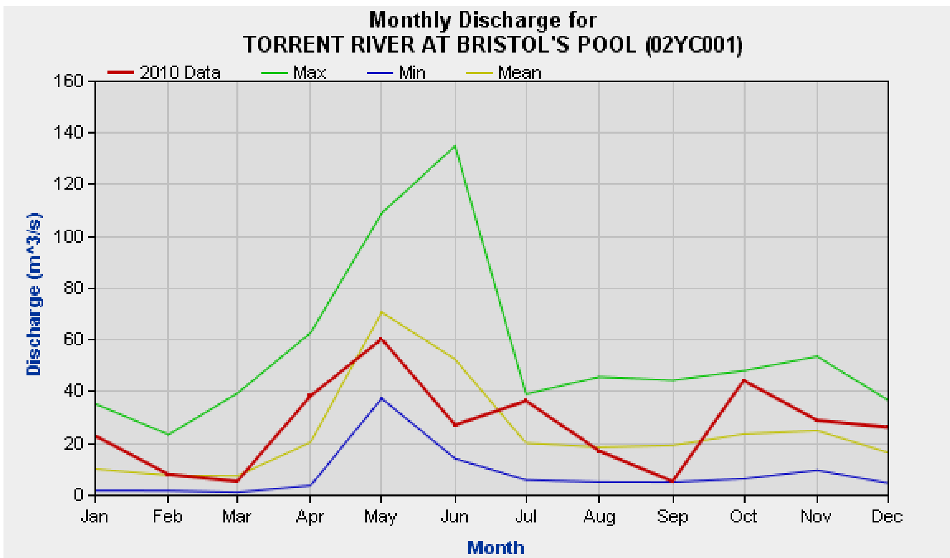
Q. CA/KPL-Nalcor-003 indicated only minor increase in installed capacity within the existing hydropower generation pool are possible. Please share the minor options. Has pumped storage been investigated?

A. The minor options are those made available through replacement of turbine runners with more efficient designs that can be optimized to marginally increase capacity and/or energy. Note that increases in efficiency to increase energy production are traded off against maximum capacity, so both gains are not generally available simultaneously.

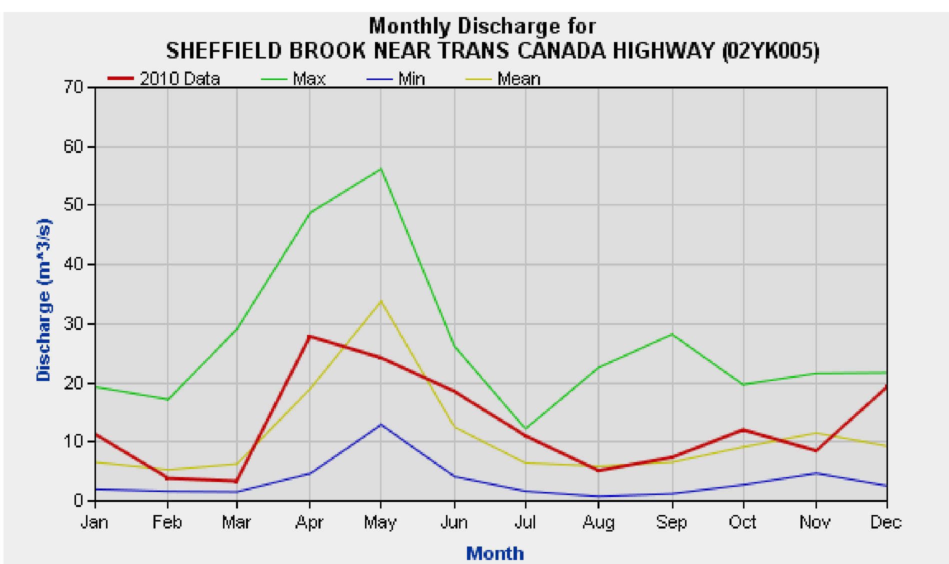
Pumped storage has not been investigated in detail for the island system because the load characteristics on the island are not well suited to pumped storage solutions. The system is energy constrained on an annual basis and capacity constrained on a seasonal basis. From a capacity perspective the system requires firm generation through the peak winter seasons, while pumped storage is better suited for daily on peak/off peak resource management. Pumped storage does not address annual system energy constraints.

Q. Please show the typical anticipated monthly generation profile from run-of-river and wind power sources in Newfoundland.

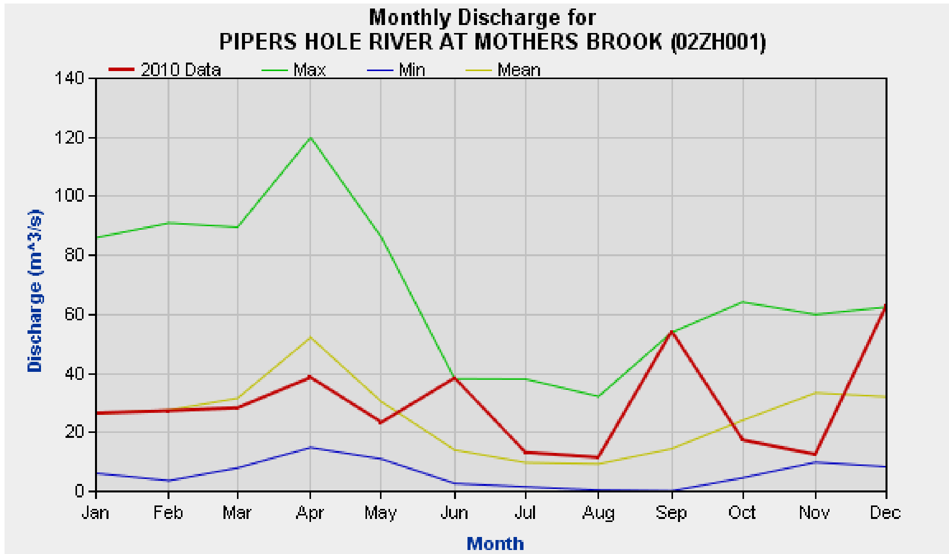
A. Following are discharge profiles for four different areas of Newfoundland:



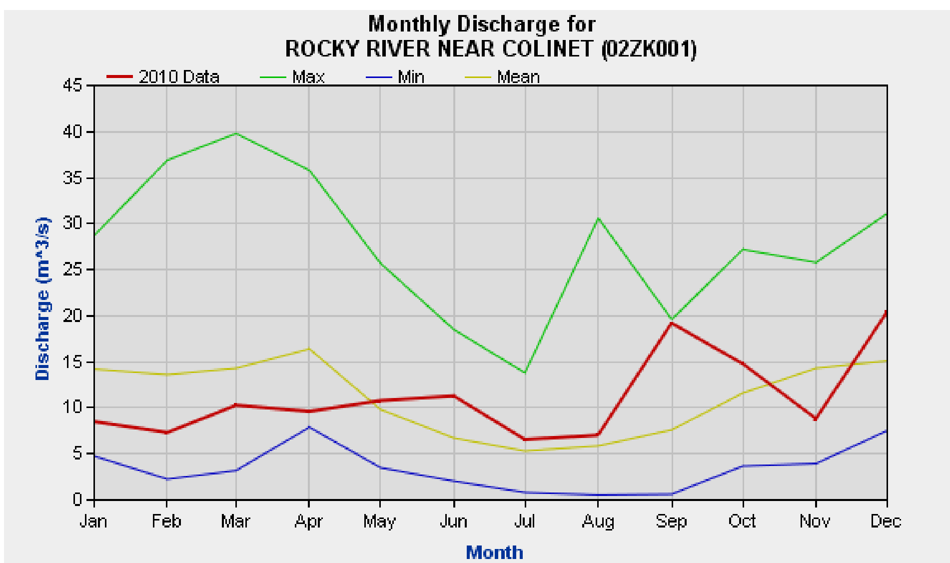
Statistics corresponding to 52 years of data recorded from 1959 to 2010.*



Statistics corresponding to 39 years of data recorded from 1972 to 2010.*

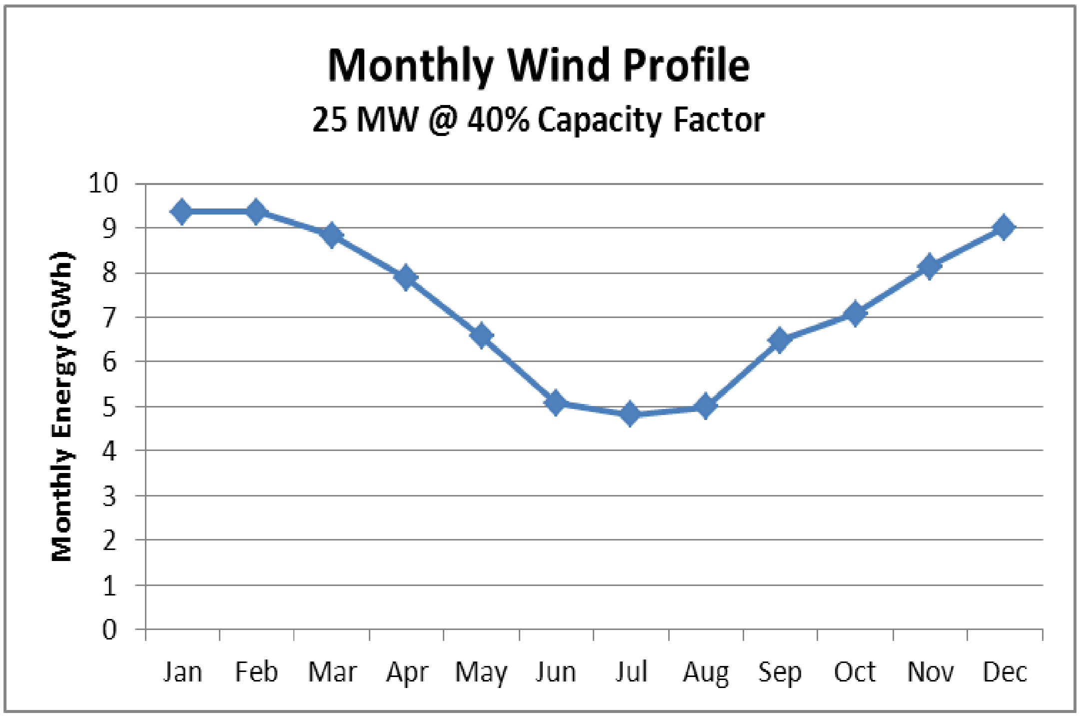


Statistics corresponding to 59 years of data recorded from 1952 to 2010.*



Statistics corresponding to 63 years of data recorded from 1948 to 2010.*

Following is an an expected monthly generation profile for a 25 MW wind farm with a 40% annual capacity factor. Please refer to Nalcor's response to MHI-Nalcor-87 for the rationale for using a 40% capacity factor.



Q. Nalcor's Submission to the Board of Commissioners of Public Utilities with respect to the Reference from the Lieutenant-Governor in Council on the Muskrat Falls Project p. 27 of 159 states:

"Nalcor has not directly considered a sensitivity case to gauge the impact of CDM on the CPW for the Interconnected Island alternative because, in such an instance, NLH would have opportunities to monetize any conserved energy through short term sales into regional export markets."

The Terms of Reference and Reference Question specifically states:

"The Board shall assume that any power from the Projects which is in excess of the needs of the Province is not monetized or utilized."

Could Nalcor indicate the sensitivity of the CPW under various Energy Conservation Scenarios? For example: Upper Achievable Estimate of 951 GWh, Lower Achievable Estimate of 556 GWh, and 750 GWh per year by 2031, as per p.26 of 159 of the submission. Please indicate the change in PPA rate of Muskrat Falls sourced energy, as a result of conservation.

A. Nalcor has provided representative CDM sensitivity analyses in its Submission to the Board for 375 GWh and 750 GWh by 2031. The CPW preferences of $1,711 million and $1,283 million respectively are presented in Table 29 Revision 1 in Nalcor's Submission.

As indicated in Nalcor's response to PUB-Nalcor-149, annual payments under the PPA were assumed not to change in Nalcor's DG2 analysis.

Q. With respect to PUB-Nalcor-36, there are no existing legislative or regulatory requirements for Holyrood environmental upgrades. Please provide a CPW sensitivity analysis assuming no environmental improvements at Holyrood.

A. The following table shows the requested sensitivity analysis.

	Cumulative Present Worth (2010 $M)		
	Base Isolated	Isolated CA/KPR-Nalcor-74	Difference
Fixed charges	1,402	982	(420)
Fuel expense	6,049	6,227	178
Power purchases	743	743	0
Operating costs	616	516	(100)
	8,810	8,468	(342)

For this analysis, the electrostatic precipitators ($582 million in 2015) and associated operating costs were eliminated, as well as the Low NO_x Burner project ($20 million in 2017). With the elimination of the electrostatic precipitators, the cost of fuel was increased to reflect the lower sulphur content of 0.7%.

The Interconnected Island alternative, with a CPW of $6,652 million (2010 $) still has a CPW preference of $1,816 million over the Isolated Island alternative with no pollution controls at Holyrood.

Q. Table 22 at p. 1069 of the Submission lists Holyrood's upgrades for M$582 in 2015, M$100 in 2016, M$20 in 2017. New CCCT based on Exhibit 5 at 1,611$/kW for 465.5 MW = 750 M$ in 2010, without any benefits for scale. Please show a side by side project unit cost of energy for a Green Field CCCT and Holyrood Energy with the upgrades.

A. As indicated in the question, the in-service cost for a new CCCT to replace Holyrood is greater than the upgrades for the Holyrood facility. Also, Nalcor's response to PUB-Nalcor-158 provides a comparison of the heat rate for Holyrood and that of a CCCT unit. Although a CCCT unit would have greater thermal efficiency than Holyrood, the improved efficiency is offset by a higher forecasted fuel cost.

With higher in-service capital costs and higher fuel costs, there is no economic basis for the early replacement of Holyrood with a CCCT plant.

Comparison of the Cost of Electricity Produced From A Diesel Fired CCCT versus #6 Fired Holyrood

	CCCT					Holyrood			
				Cost of Electricity Produced				Cost of Electricity Produced	
				@ Minimum Efficiency 8.63 MMBTU per MWh	@ Maximum Efficiency 7.64 MMBTU per MWh			@ Minimum Efficiency 10.39 MMBTU per MWh	@ Maximum Efficiency 9.78 MMBTU per MWh
	Diesel ($/litre)	**Diesel ($/bbl)**	**Diesel ($/MMBTU)**	**($/MWh)**	**($/MWh)**	**#6 2.2%s ($/bbl)**	**#6 2.2%s ($/MMBTU)**	**($/MWh)**	**($/MWh)**
2010	0.674	107.12	18.39	158.70	140.49	79.60	12.66	131.55	123.83
2011	0.700	111.29	19.11	164.88	145.97	80.50	12.80	133.04	125.23
2012	0.760	120.83	20.74	179.02	158.48	88.00	14.00	145.43	136.89
2013	0.815	129.57	22.24	191.97	169.95	95.50	15.19	157.82	148.56
2014	0.850	135.14	23.20	200.21	177.25	99.00	15.75	163.61	154.00
2015	0.905	143.88	24.70	213.17	188.72	103.00	16.38	170.22	160.23
2016	0.945	150.24	25.79	222.59	197.06	107.00	17.02	176.83	166.45
2017	0.990	157.40	27.02	233.19	206.44	111.50	17.74	184.27	173.45
2018	1.030	163.76	28.11	242.61	214.78	115.60	18.39	191.04	179.83
2019	1.065	169.32	29.07	250.86	222.08	118.60	18.86	196.00	184.49
2020	1.100	174.89	30.02	259.10	229.38	120.30	19.13	198.81	187.14
2021	1.155	183.63	31.52	272.06	240.85	123.10	19.58	203.44	191.49
2022	1.195	189.99	32.62	281.48	249.19	125.80	20.01	207.90	195.69
2023	1.235	196.35	33.71	290.90	257.53	128.50	20.44	212.36	199.89
2024	1.275	202.71	34.80	300.32	265.87	131.10	20.85	216.66	203.94
2025	1.315	209.07	35.89	309.74	274.21	133.70	21.27	220.95	207.98
2026	1.340	213.04	36.57	315.63	279.42	136.40	21.70	225.42	212.18
2027	1.365	217.02	37.26	321.52	284.64	139.10	22.13	229.88	216.38
2028	1.395	221.79	38.07	328.59	290.89	141.90	22.57	234.51	220.74
2029	1.425	226.56	38.89	335.65	297.15	144.80	23.03	239.30	225.25
2030	1.450	230.53	39.58	341.54	302.36	147.70	23.49	244.09	229.76
2031	1.480	235.30	40.39	348.61	308.62	150.60	23.95	248.88	234.27
2032	1.510	240.07	41.21	355.68	314.87	153.60	24.43	253.84	238.94
2033	1.540	244.84	42.03	362.74	321.13	156.70	24.92	258.97	243.76
2034	1.570	249.61	42.85	369.81	327.38	159.80	25.42	264.09	248.58
2035	1.600	254.38	43.67	376.87	333.64	163.00	25.93	269.38	253.56
2036	1.635	259.94	44.63	385.12	340.94	166.30	26.45	274.83	258.69
2037	1.665	264.71	45.44	392.18	347.19	169.60	26.98	280.28	263.83
2038	1.700	270.28	46.40	400.43	354.49	173.00	27.52	285.90	269.12
2039	1.735	275.84	47.35	408.67	361.79	176.40	28.06	291.52	274.41
2040	1.770	281.41	48.31	416.92	369.09	180.00	28.63	297.47	280.01
2041	1.805	286.97	49.27	425.16	376.39	183.60	29.20	303.42	285.61
2042	1.840	292.54	50.22	433.41	383.69	187.20	29.78	309.37	291.21
2043	1.875	298.10	51.18	441.65	390.99	191.00	30.38	315.65	297.12

Notes
(1) Diesel is fuel source for CCCT
(2) 158.987 litres / bbl
(3) 1 barrel of diesel equivalent to 5.825 MMBTU
(4) 1 barrel of #6 equivalent to 6.287 MMBTU
(5) Forecasted fuel prices are reproduced from Exhibit 4

Q. Please provide an electronic daily streamflow file for Muskrat Falls with current upstream regulation. (Flow exceedance probability curves would be acceptable if they are seasonal)

A. Flow data for the Muskrat Falls site is available at the following link: http://www.wsc.ec.gc.ca/applications/H2O/graph-eng.cfm?station=03OE001&report=daily&year=2010

Q. Please show the generation profile from Muskrat Falls on a monthly basis for the period of synthetic record used to determine the average generation.

A. Exhibit CE-28 Rev. 1 (Public) provides a representative generation profile for the Muskrat Falls plant. This profile was updated in Confidential Exhibit CE-21.

Q. Please show the generation profile from Muskrat Falls on a monthly basis for the period of synthetic record used to determine the average generation, in the absence of an agreement with Churchill Falls.

A. The *Electrical Power Control Act, 1994* requires that a water management agreement be in place between facility operators on a river system. By way of Board Order P.U. 8 (2010), the terms of a water management agreement for the Churchill Falls and lower Churchill facilities have been established.

Since operating Muskrat Falls without a water management agreement is not permissible under provincial legislation, and the terms have been established by the Board, evaluation of production in the absence of a water management agreement does not assist consideration of the Reference Question.

Q. The Firm capability for the hydroelectric resource was defined by the most adverse three year sequence of reservoir inflows. Please indicate the anticipated Muskrat Falls generation for the most adverse year of record. Please describe the portion of FIRM energy attributable to Churchill Falls.

A. Nalcor understands this question to be in the context of the following statement in Nalcor's Submission:

> Firm capability for the hydroelectric resources is the firm energy capability of those resources under the most adverse three-year sequence of reservoir inflows occurring within the historical record.[1]

The definition of firm energy used for Nalcor's and NL Hydro's modeling is consistent with this definition:

> The definition of firm energy used for this study is the maximum average energy that can be produced during the most severe dry sequence of the hydrological record. The dry sequence begins after the last period when secondary energy was generated and ends when the reservoirs are just empty.[2]

or this very similar version:

> The value of firm is specifically determined based on the critical hydrologic period which covers a sequential set of years defined by the seasonal reservoir (Smallwood) being at full supply level (FSL) at

[1] Nalcor's Submission, page 30
[2] CE-28 (Public) Revision 1, page 34

the beginning of the critical period and at Low Supply Level (LSL) at the end of the period.[3]

When the Island system's production is evaluated against this definition, the critical sequence is three years in duration. This three year duration is the result of application of the definition, not the definition itself. Production during the "most adverse year of record" is represented by the annual production at the end of the critical hydrological period, and therefore the value of 4.47 TWh/year[4], as reported in Exhibit CE-27 Rev. 1 (Public), accurately represents, in Nalcor's view, Muskrat Falls' firm production.

Please note Nalcor's latest modeling[5] includes both the Churchill Falls and Muskrat Falls facilities and reservoirs, and Churchill Falls production has been based on the terms of the Hydro Quebec Power Contract that will be in effect when Muskrat Falls is in service. More specifically, Nalcor's power and energy modeling assumes that Churchill Falls will be receiving Continuous Energy, as defined in Schedule III, Article 1.1 (II) of the Hydro Quebec power contract[6]:

"Continuous Energy" means, in respect of any month, the number of kilowatt hours obtainable, calculated to the nearest 1/100 of a billion kilowatt-hours, when the Annual Energy Base is multiplied by the number which corresponds

[3] CE-21, page 11
[4] Exhibit CE-27 Rev. 1 (Public), page 3
[5] as represented in Confidential Exhibit CE-21
[6] http://www.pub.nl.ca/applications/Nalcor2009Water/files/applic/Application-VolumeII-Revised.pdf, pg. 99

to the number of days in the month concerned and the result is then divided by the number which corresponds to the number of days in the year concerned.

Under these conditions, Churchill Falls monthly production is approximately constant.

Analysis by Hatch indicates the critical period to be from 1984 to 1996 in the 50 year record used for analysis. The inflows can be found in CE-28, Rev. 1 (Public), beginning at page 73. Analysis contained in Confidential Exhibit CE-21 indicates firm production from CF over this critical period to be approximately 4,170 MW.

The tailrace flow at Churchill Falls corresponding to this rating is approximately 1,450 m^3/s.

Based on this outflow over the critical period, the contribution from Churchill Falls would be as follows:

Year	Churchill Falls Flow (m^3/s) (Note 1)	Gull Island Local Inflow (m^3/s) (Note 2)	Muskrat Falls Local Inflow (m^3/s) (Note 3)	Total Flow at Muskrat Falls (m^3/s)	% From Churchill Falls
1984	1450.0	390.9	64.2	1905.1	76.1
1985	1450.0	373.3	61.3	1884.5	76.9
1986	1450.0	364.2	59.8	1874.0	77.4
1987	1450.0	370.6	60.8	1881.5	77.1
1988	1450.0	390.2	64.0	1904.2	76.1
1989	1450.0	306.2	50.2	1806.5	80.3
1990	1450.0	163.8	26.9	1640.7	88.4
1991	1450.0	294.8	48.4	1793.2	80.9
1992	1450.0	348.5	57.2	1855.6	78.1
1993	1450.0	375.6	61.6	1887.2	76.8
1994	1450.0	412.9	67.8	1930.7	75.1
1995	1450.0	331.3	54.4	1835.6	79.0
1996	1450.0	369.4	60.6	1880.0	77.1

Note 1: Churchill Falls flow estimated based on 4,170 MW firm output as per CE-21.
Note 2: as per CE-28 Rev. 1 (Public) page 79
Note 3: as per CE-28 Rev. 1 (Public) page 80

Q. What is the sedimentation anticipation and what is the associated loss of storage capacity and energy?

A. Based on sedimentation and morphodynamics modeling, the anticipated net sediment loading in the Muskrat Falls reservoir is conservatively estimated to be approximately 1 million m^3 annually. This volume would be deposited upstream of the Muskrat Falls dam. This volume is negligible compared to the overall volume of the reservoir of 1,600 million m^3.

Considering this sediment would be deposited on the bottom of the reservoir, it would represent a loss of dead storage volume as opposed to live storage volume. The Muskrat Falls reservoir's 50 million m^3 live storage capacity would remain unchanged. The energy output of the plant is determined by the head of the facility, or the difference in water elevation between the upstream and downstream water levels. Since sedimentation upstream of the dam would not alter the full supply level (upstream water level) or the tail water level (downstream water level), the energy output of the plant would not be affected.