

## AUTHOR ASSUMPTION

All calculations provided assume a CAD:USD exchange rate of 0.79.

## APPENDIX 1: COST OF CAPITAL CALCULATIONS

**Table A1a: Average Yield on 30-year A-rated Canadian Corporate Bonds**

Name	Canadian Utilities Ltd.	FortisAlberta Inc.	FortisBC Energy Inc.	IGM Financial Inc.	IGM Financial Inc.	TransCanada PipeLines Ltd.
Issue date	11/22/2017	9/7/2017	10/30/2017	1/26/2017	12/7/2017	5/7/2018
Maturity date	11/22/2047	9/9/2047	10/30/2047	1/25/2047	12/9/2047	5/15/2048
Coupon	3.5480	3.6720	3.6900	4.5600	4.1150	4.8750
Moody's			A3			A3
Fitch						A-
S&P	A-	A-		A	A	
Note: Average cost of debt is 4.08 percent.						
Source: S&P Global.						

**Table A1b: Industry Beta Calculation**

Ticker	AQN.TO	ACO.X	BEP-UN. TO	BLX.TO	INE.TO	NPI.TO	RNW.TA	Average
Company Name	Algonquin Power	ATCO	Brookfield Renewable	Boralex	Innergex	Northland Power	TransAlta Renewables	
SNL Beta (3Y) <sup>[1]</sup>	0.66	0.82	0.78	0.56	0.74	0.72	0.7	<b>0.71</b>
Total Debt (2015 FY)	4,991,725	12,162	14,934	1,890	2,656,746	5,959,327	1,310	
Total Debt (2016 FY)	5,187,556	12,694	20,208	2,188	3,118,972	7,288,310	1,774	
Total Debt (2017 FY)	5,608,865	14,682	20,845	3,197	3,734,331	8,822,632	1,431	
<b>Average Debt</b>	<b>5,262,715</b>	<b>13,179</b>	<b>18,662</b>	<b>2,425</b>	<b>3,170,016</b>	<b>7,356,756</b>	<b>1,505</b>	
Total Equity (2015 FY)	2,291,864	6,893	12,181	559	471,557	1,407,068	2,026	
Total Equity (2016 FY)	2,485,921	7,055	16,998	514	485,232	1,375,120	2,061	
Total Equity (2017 FY)	4,165,037	7,109	17,911	729	456,125	1,457,885	2,197	
<b>Average Equity</b>	<b>2,980,941</b>	<b>7,019</b>	<b>15,697</b>	<b>601</b>	<b>470,971</b>	<b>1,413,358</b>	<b>2,095</b>	
Company Debt/ Equity	1.77	1.88	1.19	4.04	6.73	5.21	0.72	
Target Debt/Equity	2.33	2.33	2.33	2.33	2.33	2.33	2.33	
Unlevered Beta <sup>[2]</sup>	0.30	0.35	0.43	0.15	0.13	0.16	0.47	
<b>Relevered Beta<sup>[3]</sup></b>	<b>0.98</b>	<b>1.18</b>	<b>1.42</b>	<b>0.49</b>	<b>0.43</b>	<b>0.52</b>	<b>1.55</b>	<b>0.94</b>

## Notes:

Debt and equity values listed in thousands of CAD.

[1] SNL Beta 3Y = Covariance (company return, return on S&amp;P 500) / Variance (return on S&amp;P 500); using daily rates of return, measured over 750 day holding periods.

[2] Unlevered beta = Beta (levered) / 1 + (1 - Tax rate) (Debt/Equity); Tax rate of 30%

[3] Relevered beta = Unlevered Beta \* (1 + ((1 - Tax rate) (Debt/Equity))); Debt/Equity = 70/30; Tax rate = 0%

Sources: S&amp;P Global; Annual reports of Brookfield Renewable Partners, Boralex, Innergex, Northland Power, TransAlta, Algonquin Power.

**Table A1c: Cost of Equity Calculation**

Parameter	Value
Risk-free rate: Canada 30 Year Government Bond	2.42%
Beta: Average of 6 public Canadian IPPs	0.94
Equity risk premium	5.50%
<b>Cost of equity</b>	<b>7.58%</b>

Note: Cost of equity = Risk-free rate + (Beta \* Market risk premium)

Sources: MarketWatch; Grabowski, R., Nunes, C., and Harrington, J. 2017 Valuation Handbook - International Guide to Cost of Capital. July 2017.

**Table A1d: Weighted Average Cost of Capital Calculation**

Parameter	Value (percent)
Cost of debt	4.08
Leverage	70.00
Cost of equity	7.58
1 - Leverage	30.00
<b>WACC</b>	<b>5.13</b>

Note: WACC = Cost of debt \* (1 - Tax rate) \* Leverage + Cost of equity \* (1 - Leverage); Tax rate = 0%.

## APPENDIX 2: HYDRO LCOE CALCULATIONS

**Table A2a: Site C, Keeyask, and Muskrat Falls LCOEs to Complete**

SITE C			
Parameter	Value	Formula	Source/Note
Latest Budget [\$ billion]	10.7	A	BC Hydro. <i>Quarterly Progress Report No. 10: F2018 Third Quarter – October 2017 to December 2017</i> . March 29, 2018.
Current expenditures [\$ billion]	2.1	B	BC Hydro. <i>Quarterly Progress Report No. 10: F2018 Third Quarter – October 2017 to December 2017</i> . March 29, 2018.
Go forward costs [\$ billion]	8.573	$C = A - B$	
Installed capacity [MW]	1,132	D	BC Hydro. <i>Quarterly Progress Report No. 10: F2018 Third Quarter – October 2017 to December 2017</i> . March 29, 2018.
Annual output [GWh]	5,268	E	BC Hydro. <i>Quarterly Progress Report No. 10: F2018 Third Quarter – October 2017 to December 2017</i> . March 29, 2018.
Capacity factor	53%	$F = E / (D * 8760 / 1000)$	
Unspent capital cost [\$ /kW]	7,573	$G = (C * 10^9) / (D * 1000)$	
Leverage [%]	70%	H	Author assumption
WACC [%]	5.13%	I	See Appendix 1
Project life [years]	60	J	Author assumption
Fixed O&M [\$ /kW / year]	50.70	$K = \$40.05 / 0.79$ (conversion to CAD)	EIA. <i>Annual Energy Outlook</i> . 2018.
Variable O&M [\$ / MWh]	1.68	$L = \$1.33 / 0.79$ (conversion to CAD)	EIA. <i>Annual Energy Outlook</i> . 2018.
Amortized capital cost [\$ /kW / year]	459.46	$M = -PMT(I, J, G) + K$	
Levelized cost of energy [\$ /MWh]	100.41	$N = M / (F * 8760 / 1000) + L$	

Table A2a: Continued

KEYYASK			
Parameter	Value	Formula	Source/Note
Latest Budget [\$ billion]	8.7	A	Keeyask Hydropower Limited Partnership. <i>Control budget for Keeyask Generating Station revised. 2017.</i>
Current expenditures [\$ billion]	4.2	B	Manitoba Hydro. Manitoba Hydro 2017/18 & 2018/19 <i>General Rate Application: Undertaking #57</i> . February 2018.
Go forward costs [\$ billion]	4.5	$C = A - B$	
Installed capacity [MW]	695	D	Keeyask Hydropower Limited Partnership. <i>Control budget for Keeyask Generating Station revised. 2017.</i>
Annual output [GWh]	4,400	E	“Keeyask Generating Station.” <i>Manitoba Hydro</i> . < <a href="https://www.hydro.mb.ca/projects/keeyask/index.shtml">https://www.hydro.mb.ca/projects/keeyask/index.shtml</a> >.
Capacity factor	72%	$F = E / (D * 8760 / 1000)$	
Unspent capital cost [\$/kW]	6,475	$G = (C * 10^9) / (D * 1000)$	
Leverage [%]	70%	H	Author assumption
WACC [%]	5.13%	I - (See Appendix 1)	See Appendix 1
Project life [years]	60	J	Author assumption
Fixed O&M [\$/kW/year]	50.70	$K = \$40.05 / 0.79$ (conversion to CAD)	EIA. <i>Annual Energy Outlook</i> . 2018.
Variable O&M [\$/MWh]	1.68	$L = \$1.33 / 0.79$ (conversion to CAD)	EIA. <i>Annual Energy Outlook</i> . 2018.
Amortized capital cost [\$/kW/year]	400.17	$M = -PMT(I, J, G) + K$	
Levelized cost of energy [\$/MWh]	64.89	$N = M / (F * 8760 / 1000) + L$	

**Table A2a: Continued**

<b>MUSKRAT FALLS</b>			
<b>Parameter</b>	<b>Value</b>	<b>Formula</b>	<b>Source/Note</b>
Latest Budget [\$ billion]	12.7	A	Nalcor Energy. <i>Muskrat Falls Project, Monthly Report – February 2018</i> . April 20, 2018.
Current expenditures [\$ billion]	8.2	B	Nalcor Energy. <i>Muskrat Falls Project, Monthly Report – February 2018</i> . April 20, 2018.
Go forward costs [\$ billion]	4.452	$C = A - B$	
Installed capacity [MW]	824	D	Nalcor Energy. <i>Muskrat Falls Project, Monthly Report – February 2018</i> . April 20, 2018.
Annual output [GWh]	4,900	E	Nalcor Energy. <i>Understanding Muskrat</i> . February 15, 2018.
Capacity factor	68%	$F = E / (D * 8760 / 1000)$	
Unspent capital cost [\$/kW]	5,403	$G = (C * 10^9) / (D * 1000)$	
Leverage [%]	70%	H	Author assumption
WACC [%]	5.13%	I - (See Appendix 1)	See Appendix 1
Project life [years]	60	J	Author assumption
Fixed O&M [\$/kW/year]	50.70	$K = \$40.05 / 0.79$ (conversion to CAD)	EIA. <i>Annual Energy Outlook</i> . 2018.
Variable O&M [\$/MWh]	1.68	$L = \$1.33 / 0.79$ (conversion to CAD)	EIA. <i>Annual Energy Outlook</i> . 2018.
Amortized capital cost [\$/kW/year]	342.32	$M = -PMT(I, J, G) + K$	
Levelized cost of energy [\$/MWh]	59.25	$N = M / (F * 8760 / 1000) + L$	

### APPENDIX 3: LEVELIZED CANCELLATION COSTS

Table A3a: Levelized Cancellation Cost Calculations			
SITE C CANCELLATION			
Parameter	Value	Formula	Source
Cancellation cost [\$ billion]	1.8	A	BCUC. <i>Inquiry Respecting Site C – Executive Summary of the Final Report to the Government of British Columbia</i> . 2017.
WACC [%]	3.47%	B	BC Hydro. <i>Fiscal 2017 to Fiscal 2019 – Revenue Requirements Applications</i> . August 17, 2016. p.576.
Ammortization period	60	C	
Annual cancellation cost [\$/year]	71,723,976	$D = -PMT(B,C,A*10^9)$	
Annual output	5,100	E	BC Hydro. <i>Quarterly Progress Report No. 10: F2018 Third Quarter – October 2017 to December 2017</i> . March 29, 2018.
Levelized cancellation cost [\$/MWh]	<b>14.06</b>	$F = D/(E*10^3)$	
KEYYASK CANCELLATION			
Parameter	Value	Formula	Source
Cancellation cost [\$ billion]	1.35	A	Manitoba Hydro. <i>Manitoba Hydro 2017/18 &amp; 2018/19 General Rate Application: GSS/GSM/MH I-4</i> . September 2017.
WACC [%]	5.13%	B	See Appendix 1
Ammortization period	60	C	
Annual cancellation cost [\$/year]	73,600,180	$D = -PMT(B,C,A*10^9)$	
Annual output [GWh]	4,400	E	“Keeyask Generating Station.” <i>Manitoba Hydro</i> . < <a href="https://www.hydro.mb.ca/projects/keeyask/index.shtml">https://www.hydro.mb.ca/projects/keeyask/index.shtml</a> >.
Levelized cancellation cost	<b>16.56</b>	$F = D/(E*10^3)$	

**Table A3a: Continued**
**MUSKRAT FALLS CANCELLATION**

Parameter	Value	Formula	Source
Cancellation cost [\$ billion]	1.46	See [1]	
WACC [%]	6.82%	B	Newfoundland & Labrador Board of Commissioners of Public Utilities. <i>Order No.</i> P.U. 49. 2016.
Ammortization period	60	C	
Annual cancellation cost [\$/year]	101,190,973	$D = -PMT(B,C,A*10^9)$	
Annual output [GWh]	4,900	E	Nalcor Energy. <i>Understanding Muskrat</i> . February 15, 2018.
Levelized cancellation cost	20.65	$F = D/(E*10^3)$	

Notes:

[1] Muskrat falls cancellation costs were calculated using the average cancellation cost per MW of Site C and Keeyask. i.e.  $824 \text{ MW} * \left[ \frac{(1.8/1132) + (1.35/695)}{2} \right]$ .



## APPENDIX 4: LEVELIZED GAS PRICE

**Table A4a: Levelized Natural Gas Price Calculation**

Year	[1] Installed capacity [MW]	[2] Capacity factor (percent)	[3] Output [GWh]	[4] Heat rate [Btu/kWh]	[5] Fuel consumption [MMBtu]	[6] Henry Hub [USD/ MMBtu]	[7] Fuel cost [USD]
2018	645	85	4,803	6,300	30,256,821	3.06	\$92,633,254
2019	645	85	4,803	6,313	30,317,335	3.40	\$102,937,447
2020	645	85	4,803	6,325	30,377,969	3.69	\$112,118,796
2021	645	85	4,803	6,338	30,438,725	3.66	\$111,285,349
2022	645	85	4,803	6,351	30,499,603	3.69	\$112,661,110
2023	645	85	4,803	6,363	30,560,602	3.83	\$117,025,499
2024	645	85	4,803	6,376	30,621,723	3.94	\$120,740,168
2025	645	85	4,803	6,389	30,682,967	4.07	\$125,011,519
2026	645	85	4,803	6,402	30,744,332	4.12	\$126,576,262
2027	645	85	4,803	6,414	30,805,821	4.17	\$128,474,845
2028	645	85	4,803	6,427	30,867,433	4.19	\$129,311,022
2029	645	85	4,803	6,440	30,929,168	4.26	\$131,680,715
2030	645	85	4,803	6,453	30,991,026	4.26	\$132,075,075
2031	645	85	4,803	6,466	31,053,008	4.27	\$132,450,395
2032	645	85	4,803	6,479	31,115,114	4.27	\$133,003,173
2033	645	85	4,803	6,492	31,177,344	4.27	\$133,084,952
2034	645	85	4,803	6,505	31,239,699	4.27	\$133,342,719
2035	645	85	4,803	6,518	31,302,178	4.26	\$133,229,208
2036	645	85	4,803	6,531	31,364,783	4.35	\$136,409,267
2037	645	85	4,803	6,544	31,427,512	4.36	\$137,085,457

WACC	5.13%
Levelized gas price [USD/MMBtu]	\$3.93
CAD:USD exchange rate	0.79
Levelized gas price [C\$/MMBtu]	<b>\$4.97</b>

Notes:

- [1] Average size of the 3 replacement CCGTs is used.
- [2] Author assumption.
- [3] Calculated as: Installed capacity\*Capacity factor\*8760/1000.
- [4] Heat rate starts at 6,300 Btu/kWh and degrades by 0.2% per year.
- [5] Calculated as: Output\*Heat rate\*1000/10<sup>6</sup>.
- [6] Henry Hub forecast based on AEO 2018.
- [7] Calculated as: Fuel consumption\*Henry Hub price.

Sources:

Annual heat rate degradation of 0.2%- <https://sciencing.com/heat-rate-power-generators-7958684.html>.

**Table A4b: Price Differential Adjustments**

Date	BC		MB	NL	Differentials		
	Henry Hub	Kingsgate	Emerson	Iroquois Waddington	HH - BC	HH - MB	HH - NL
(\$)							
1/1/2015	3.00	2.65	3.10	6.75	0.35	-0.10	-3.75
2/1/2015	2.85	2.33	4.26	12.08	0.52	-1.41	-9.23
3/1/2015	2.83	2.27	3.24	4.20	0.56	-0.40	-1.36
4/1/2015	2.61	2.24	2.72	2.86	0.37	-0.11	-0.24
5/1/2015	2.84	2.51	2.87	2.92	0.33	-0.03	-0.08
6/1/2015	2.77	2.37	2.66	2.60	0.41	0.11	0.17
7/1/2015	2.84	2.61	2.75	2.84	0.23	0.09	0.00
8/1/2015	2.78	2.46	2.85	2.95	0.31	-0.07	-0.17
9/1/2015	2.67	2.45	2.77	2.96	0.22	-0.10	-0.29
10/1/2015	2.37	2.17	2.52	2.71	0.20	-0.15	-0.34
11/1/2015	2.09	2.06	2.17	2.30	0.03	-0.09	-0.21
12/1/2015	1.93	2.04	1.98	2.01	-0.10	-0.05	-0.08
1/1/2016	2.29	2.10	2.36	2.86	0.19	-0.08	-0.57
2/1/2016	2.01	1.63	2.04	2.44	0.38	-0.04	-0.44
3/1/2016	1.71	1.30	1.79	1.87	0.41	-0.08	-0.16
4/1/2016	1.92	1.43	1.86	2.19	0.49	0.06	-0.26
5/1/2016	1.92	1.52	1.79	2.04	0.40	0.13	-0.12
6/1/2016	2.55	2.12	2.25	2.44	0.43	0.29	0.11
7/1/2016	2.81	2.36	2.51	2.80	0.45	0.29	0.01
8/1/2016	2.82	2.45	2.59	2.90	0.36	0.23	-0.08
9/1/2016	3.00	2.47	2.71	2.71	0.53	0.29	0.29
10/1/2016	2.98	2.52	2.79	2.45	0.46	0.20	0.53
11/1/2016	2.49	2.12	2.25	2.58	0.37	0.24	-0.08
12/1/2016	3.59	3.31	3.47	5.15	0.28	0.13	-1.56
1/1/2017	3.32	3.14	3.03	4.08	0.18	0.29	-0.76
2/1/2017	2.87	2.50	2.56	3.29	0.37	0.31	-0.42
3/1/2017	2.86	2.36	2.62	3.61	0.50	0.24	-0.75
4/1/2017	3.10	2.51	2.78	3.17	0.59	0.31	-0.07
5/1/2017	3.16	2.53	2.75	3.10	0.63	0.40	0.06
6/1/2017	2.98	2.29	2.63	2.58	0.69	0.34	0.39

Table A4b: Continued

Date	BC		MB	NL	Differentials		
	Henry Hub	Kingsgate	Emerson	Iroquois Waddington	HH – BC	HH – MB	HH – NL
				(\$)			
7/1/2017	2.99	2.33	2.65	2.86	0.66	0.34	0.13
8/1/2017	2.90	2.45	2.46	2.66	0.45	0.44	0.24
9/1/2017	2.98	2.41	2.46	2.38	0.57	0.53	0.60
10/1/2017	2.89	1.93	2.38	2.84	0.95	0.51	0.04
11/1/2017	3.00	2.58	2.90	3.13	0.43	0.10	-0.13
12/1/2017	2.78	2.46	2.89	4.64	0.33	-0.10	-1.86
<b>AVERAGE [C/MMBtu]</b>					<b>0.40</b>	<b>0.09</b>	<b>-0.57</b>
<b>AVERAGE [C/MMBtu] [1]</b>					<b>0.51</b>	<b>0.11</b>	<b>-0.72</b>
Motor Fuel Tax adder of 1.10¢ per 810.32 litres [C/MMBtu] [2]					0.38		
<b>Adjusted gas price (HH = 4.97) [C/MMBtu]</b>					<b>4.85</b>	<b>4.87</b>	<b>5.69</b>

[1] CAD:USD exchange rate of 0.79.

[2] Source: Government of British Columbia. *Tax Rates on Fuels: Motor Fuel Tax Act and Carbon Tax Act*. November 2017.

APPENDIX 5:  
CURRENT REPLACEMENT CCGT LCOES

Table A5a: Site C CCGT Replacement LCOE Calculation

SITE C			
Parameter	Value	Formula	Source/Note
Capital cost [\$/kW]	1,500	A	AESO. <i>Cost of New Entry Document for Adequacy Demand Curve Working Group</i> . November 22, 2017.
Installed capacity [MW]	707	$B = C / (D * 8760 / 1000)$	
Annual output [GWh]	5,268	C	BC Hydro. <i>Quarterly Progress Report No. 10: F2018 Third Quarter - October 2017 to December 2017</i> . March 29, 2018.
Capacity factor	85%	D	Author assumption
Leverage [%]	70%	E	Author assumption
WACC [%]	5.13%	F	See Appendix 1
Project life [years]	20	G	Author assumption
Nominal fixed O&M [\$/kW/year]	31.3	H	AESO. <i>Cost of New Entry Document for Adequacy Demand Curve Working Group</i> . November 22, 2017; PJM. <i>Cost of New Entry - Combustion Turbines and Combined-Cycle Plants with June 1, 2022 Online Date</i> . April 19, 2018.
Nominal variable O&M [\$/MWh]	5.3	I	AESO. <i>Cost of New Entry Document for Adequacy Demand Curve Working Group</i> . November 22, 2017; PJM. <i>Cost of New Entry - Combustion Turbines and Combined-Cycle Plants with June 1, 2022 Online Date</i> . April 19, 2018.
Heat rate [Btu/kWh]	6,300	J	PJM. <i>Cost of New Entry - Combustion Turbines and Combined-Cycle Plants with June 1, 2022 Online Date</i> . April 19, 2018.
CO2 content [lb/MMBtu]	120	K	"How much carbon dioxide is produced when different fuels are burned?" EIA. < <a href="https://www.eia.gov/tools/faqs/faq.php?id=73&amp;ct=11">https://www.eia.gov/tools/faqs/faq.php?id=73&amp;ct=11</a> >.
Carbon cost [\$/ton]	50	L	"British Columbia's Carbon Tax." <i>Government of British Columbia</i> . < <a href="https://www2.gov.bc.ca/gov/content/environment/climate-change/planning-and-action/carbon-tax">https://www2.gov.bc.ca/gov/content/environment/climate-change/planning-and-action/carbon-tax</a> >.
CO2 adder [\$/MWh]	17	$M = (K / 2204) * L * (J / 1000)$	
Fuel price [\$/MMBtu]	4.85	N	See Appendix 4
Amortized capital cost [\$/kW/year]	153	$O = -PMT(F, G, A) + H$	
Levelized non-fuel cost of new entry [\$/MWh]	43.00	$P = O / (D * 8760 / 10^3) + I + M$	
<b>Levelized cost of energy [\$/MWh]</b>	<b>73.54</b>	<b><math>Q = P + N * J / 10^3</math></b>	

Table A5b: Keeyask CCGT Replacement LCOE Calculation

KEYYASK			
Parameter	Value	Formula	Source/Note
Capital cost [\$/kW]	1,500	A	AESO. <i>Cost of New Entry Document for Adequacy Demand Curve Working Group</i> . November 22, 2017.
Installed capacity [MW]	591	$B = C / (D * 8760 / 1000)$	
Annual output [GWh]	4,400	C	“Keeyask Generating Station.” <i>Manitoba Hydro</i> . < <a href="https://www.hydro.mb.ca/projects/keeyask/index.shtml">https://www.hydro.mb.ca/projects/keeyask/index.shtml</a> >.
Capacity factor	85%	D	
Leverage [%]	70%	E	Author assumption
WACC [%]	5.13%	F	See Appendix 1
Project life [years]	20	G	Author assumption
Nominal fixed O&M [\$/kW/year]	31.3	H	AESO. <i>Cost of New Entry Document for Adequacy Demand Curve Working Group</i> . November 22, 2017; PJM. <i>Cost of New Entry – Combustion Turbines and Combined-Cycle Plants with June 1, 2022 Online Date</i> . April 19, 2018.
Nominal variable O&M [\$/MWh]	5.3	I	AESO. <i>Cost of New Entry Document for Adequacy Demand Curve Working Group</i> . November 22, 2017; PJM. <i>Cost of New Entry – Combustion Turbines and Combined-Cycle Plants with June 1, 2022 Online Date</i> . April 19, 2018.
Heat rate [Btu/kWh]	6,300	J	PJM. <i>Cost of New Entry – Combustion Turbines and Combined-Cycle Plants with June 1, 2022 Online Date</i> . April 19, 2018.
CO2 content [lb/MMBtu]	120	K	“How much carbon dioxide is produced when different fuels are burned?” EIA. < <a href="https://www.eia.gov/tools/faqs/faq.php?id=73&amp;ct=11">https://www.eia.gov/tools/faqs/faq.php?id=73&amp;ct=11</a> >
Carbon cost [\$/ton]	25	L	Government of Manitoba. <i>Made-In Manitoba Climate and Green Plan</i> . March 2018.
CO2 adder [\$/MWh]	9	$M = (K / 2204) * L * (J / 1000)$	
Fuel price [\$/MMBtu]	4.87	N	See Appendix 4
Amortized capital cost [\$/kW/year]	153	$O = - \text{PMT}(F, G, A) + H$	
Levelized non-fuel cost of new entry [\$/MWh]	34.42	$P = O / (D * 8760 / 10^3) + I + M$	
<b>Levelized cost of energy [\$/MWh]</b>	<b>65.08</b>	<b><math>Q = P + N * J / 10^3</math></b>	

**Table A5c: Muskrat Falls CCGT Replacement LCOE Calculation**

<b>MUSKRAT FALLS</b>			
<b>Parameter</b>	<b>Value</b>	<b>Formula</b>	<b>Source/Note</b>
Capital cost [\$/kW]	1,500	A	AESO. <i>Cost of New Entry Document for Adequacy Demand Curve Working Group</i> . November 22, 2017.
Installed capacity [MW]	658	$B = C / (D * 8760 / 1000)$	
Annual output [GWh]	4,900	C	Nalcor Energy. <i>Understanding Muskrat</i> . February 15, 2018.
Capacity factor	85%	D	
Leverage [%]	70%	E	Author assumption
WACC [%]	5.13%	F	See Appendix 1
Project life [years]	20	G	Author assumption
Nominal fixed O&M [\$/kW/year]	31.3	H	AESO. <i>Cost of New Entry Document for Adequacy Demand Curve Working Group</i> . November 22, 2017; PJM. <i>Cost of New Entry – Combustion Turbines and Combined-Cycle Plants with June 1, 2022 Online Date</i> . April 19, 2018.
Nominal variable O&M [\$/MWh]	5.3	I	AESO. <i>Cost of New Entry Document for Adequacy Demand Curve Working Group</i> . November 22, 2017; PJM. <i>Cost of New Entry – Combustion Turbines and Combined-Cycle Plants with June 1, 2022 Online Date</i> . April 19, 2018.
Heat rate [Btu/kWh]	6,300	J	PJM. <i>Cost of New Entry – Combustion Turbines and Combined-Cycle Plants with June 1, 2022 Online Date</i> . April 19, 2018.
CO2 content [lb/MMBtu]	120	K	“How much carbon dioxide is produced when different fuels are burned?” EIA. < <a href="https://www.eia.gov/tools/faqs/faq.php?id=73&amp;ct=11">https://www.eia.gov/tools/faqs/faq.php?id=73&amp;ct=11</a> >.
Carbon cost [\$/ton]	40	L	Environment and Climate Change Canada. <i>Technical Paper on the Federal Carbon Price Backstop</i> . May 18, 2017.
CO2 adder [\$/MWh]	14	$M = (K / 2204) * L * (J / 1000)$	
Fuel price [\$/MMBtu]	5.69	N	See Appendix 4
Amortized capital cost [\$/kW/year]	153	$O = - \text{PMT}(F, G, A) + H$	
Levelized non-fuel cost of new entry [\$/MWh]	39.57	$P = O / (D * 8760 / 10^3) + I + M$	
<b>Levelized cost of energy [\$/MWh]</b>	<b>75.44</b>	<b><math>Q = P + N * J / 10^3</math></b>	

## APPENDIX 6: CCGT DEFERRED REPLACEMENT LCOE

In the deferral scenario, capital costs were escalated at 1.5 percent, reflecting inflation of 2 percent net of 0.5 percent assumed technological improvement, consistent with NREL's 2017 Annual Technology Baseline. O&M costs were escalated at 2 percent.

Table A6a: Site C deferred CCGT Replacement			
SITE C (deferred 2 years until 2020)			
Parameter	Value	Formula	Source/Note
Capital cost [\$/kW]	1,545	$A = 1500 * (1.015^2)$	AESO. <i>Cost of New Entry Document for Adequacy Demand Curve Working Group</i> . November 22, 2017.
Installed capacity [MW]	707	$B = C / (D * 8760 / 1000)$	
Annual output [GWh]	5,268	C	BC Hydro. <i>Quarterly Progress Report No. 10: F2018 Third Quarter – October 2017 to December 2017</i> . March 29, 2018.
Capacity factor	85%	D	
Leverage [%]	70%	E	Author assumption
WACC [%]	5.13%	F	See Appendix 1
Project life [years]	20	G	Author assumption
Nominal fixed O&M [\$/kW/year]	32.6	$H = 31.3 * (1.02^2)$	AESO. <i>Cost of New Entry Document for Adequacy Demand Curve Working Group</i> . November 22, 2017; PJM. <i>Cost of New Entry – Combustion Turbines and Combined-Cycle Plants with June 1, 2022 Online Date</i> . April 19, 2018.
Nominal variable O&M [\$/MWh]	5.5	$I = 5.3 * (1.02^2)$	AESO. <i>Cost of New Entry Document for Adequacy Demand Curve Working Group</i> . November 22, 2017; PJM. <i>Cost of New Entry – Combustion Turbines and Combined-Cycle Plants with June 1, 2022 Online Date</i> . April 19, 2018.
Heat rate [Btu/kWh]	6,300	J	PJM. <i>Cost of New Entry – Combustion Turbines and Combined-Cycle Plants with June 1, 2022 Online Date</i> . April 19, 2018.
CO2 content [lb/MMBtu]	120	K	“How much carbon dioxide is produced when different fuels are burned?” EIA. < <a href="https://www.eia.gov/tools/faqs/faq.php?id=73&amp;ct=11">https://www.eia.gov/tools/faqs/faq.php?id=73&amp;ct=11</a> >.
Carbon cost [\$/ton]	50	L	“British Columbia's Carbon Tax.” <i>Government of British Columbia</i> . < <a href="https://www2.gov.bc.ca/gov/content/environment/climate-change/planning-and-action/carbon-tax">https://www2.gov.bc.ca/gov/content/environment/climate-change/planning-and-action/carbon-tax</a> >.
CO2 adder [\$/MWh]	17	$M = (K / 2204) * L * (J / 1000)$	
Fuel price [\$/MMBtu]	4.85	N	See Appendix 4
Amortized capital cost [\$/kW/year]	158	$O = -PMT(F, G, A) + H$	
Levelized non-fuel cost of new entry [\$/MWh]	43.87	$P = O / (D * 8760 / 10^3) + I + M$	
Levelized cost of energy [\$/MWh]	74.42	$Q = P + N * J / 10^3$	
<b>Discounted LCOE [\$/MWh]</b>	<b>67.33</b>	<b><math>R = Q * ((1 + F)^{-2})</math></b>	

**Table A6b: Keeyask Deferred CCGT Replacement**

<b>KEEYASK (deferred 12 years until 2030)</b>			
<b>Parameter</b>	<b>Value</b>	<b>Formula</b>	<b>Source/Note</b>
Capital cost [\$/kW]	1,793	$A = 1500 * (1.015^{12})$	AESO. <i>Cost of New Entry Document for Adequacy Demand Curve Working Group</i> . November 22, 2017.
Installed capacity [MW]	591	$B = C / (D * 8760 / 1000)$	
Annual output [GWh]	4,400	C	“Keeyask Generating Station.” <i>Manitoba Hydro</i> . < <a href="https://www.hydro.mb.ca/projects/keeyask/index.shtml">https://www.hydro.mb.ca/projects/keeyask/index.shtml</a> >.
Capacity factor	85%	D	
Leverage [%]	70%	E	Author assumption
WACC [%]	5.13%	F	See Appendix 1
Project life [years]	20	G	Author assumption
Nominal fixed O&M [\$/kW/year]	39.7	$H = 31.3 * (1.02^{12})$	AESO. <i>Cost of New Entry Document for Adequacy Demand Curve Working Group</i> . November 22, 2017; PJM. <i>Cost of New Entry – Combustion Turbines and Combined-Cycle Plants with June 1, 2022 Online Date</i> . April 19, 2018.
Nominal variable O&M [\$/MWh]	6.7	$I = 5.3 * (1.02^{12})$	AESO. <i>Cost of New Entry Document for Adequacy Demand Curve Working Group</i> . November 22, 2017; PJM. <i>Cost of New Entry – Combustion Turbines and Combined-Cycle Plants with June 1, 2022 Online Date</i> . April 19, 2018.
Heat rate [Btu/kWh]	6,300	J	PJM. <i>Cost of New Entry – Combustion Turbines and Combined-Cycle Plants with June 1, 2022 Online Date</i> . April 19, 2018.
CO2 content [lb/MMBtu]	120	K	“How much carbon dioxide is produced when different fuels are burned?” EIA. < <a href="https://www.eia.gov/tools/faqs/faq.php?id=73&amp;ct=11">https://www.eia.gov/tools/faqs/faq.php?id=73&amp;ct=11</a> >.
Carbon cost [\$/ton]	50	L	Environment and Climate Change Canada. Technical Paper on the Federal Carbon Price Backstop. May 18, 2017.
CO2 adder [\$/MWh]	17	$M = (K / 2204) * L * (J / 1000)$	
Fuel price [\$/MMBtu]	4.87	N	See Appendix 4
Amortized capital cost [\$/kW/year]	185	$O = -PMT(F, G, A) + H$	
Levelized non-fuel cost of new entry [\$/MWh]	48.74	$P = O / (D * 8760 / 10^3) + I + M$	
Levelized cost of energy [\$/MWh]	79.40	$Q = P + N * J / 10^3$	
<b>Discounted LCOE [\$/MWh]</b>	<b>43.57</b>	<b><math>R = Q * ((1 + F)^{-2})</math></b>	



Table A6c: Muskrat Falls Deferred CCGT Replacement LCOE

MUSKRAT FALLS (deferred 2 years until 2023)			
Parameter	Value	Formula	Source/Note
Capital cost [\$/kW]	1,545	$A = 1500 * (1.015^2)$	AESO. <i>Cost of New Entry Document for Adequacy Demand Curve Working Group</i> . November 22, 2017.
Installed capacity [MW]	658	$B = C / (D * 8760 / 1000)$	
Annual output [GWh]	4,900	C	Nalcor Energy. <i>Understanding Muskrat</i> . February 15, 2018.
Capacity factor	85%	D	
Leverage [%]	70%	E	Author assumption
WACC [%]	5.13%	F	See Appendix 1
Project life [years]	20	G	Author assumption
Nominal fixed O&M [\$/kW/year]	32.6	$H = 31.3 * (1.02^2)$	AESO. <i>Cost of New Entry Document for Adequacy Demand Curve Working Group</i> . November 22, 2017; PJM. <i>Cost of New Entry – Combustion Turbines and Combined-Cycle Plants with June 1, 2022 Online Date</i> . April 19, 2018.
Nominal variable O&M [\$/MWh]	5.5	$I = 5.3 * (1.02^2)$	AESO. <i>Cost of New Entry Document for Adequacy Demand Curve Working Group</i> . November 22, 2017; PJM. <i>Cost of New Entry – Combustion Turbines and Combined-Cycle Plants with June 1, 2022 Online Date</i> . April 19, 2018.
Heat rate [Btu/kWh]	6,300	J	PJM. <i>Cost of New Entry – Combustion Turbines and Combined-Cycle Plants with June 1, 2022 Online Date</i> . April 19, 2018.
CO2 content [lb/MMBtu]	120	K	“How much carbon dioxide is produced when different fuels are burned?” EIA. < <a href="https://www.eia.gov/tools/faqs/faq.php?id=73&amp;t=11">https://www.eia.gov/tools/faqs/faq.php?id=73&amp;t=11</a> >.
Carbon cost [\$/ton]	50	L	Environment and Climate Change Canada. <i>Technical Paper on the Federal Carbon Price Backstop</i> . May 18, 2017.
CO2 adder [\$/MWh]	17	$M = (K / 2204) * L * (J / 1000)$	
Fuel price [\$/MMBtu]	5.69	N	See Appendix 4
Amortized capital cost [\$/kW/year]	158	$O = -PMT(F, G, A) + H$	
Levelized non-fuel cost of new entry [\$/MWh]	43.87	$P = O / (D * 8760 / 10^3) + I + M$	
Levelized cost of energy [\$/MWh]	79.74	$Q = P + N * J / 10^3$	
<b>Discounted LCOE [\$/MWh]</b>	<b>72.15</b>	<b><math>R = Q * ((1 + F)^{-2})</math></b>	