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NFAT Review

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Econalysis Consulting Services, *NFAT Review of Manitoba Hydro's Preferred Development Plan: Evidence and Interrogatory Response Revisions*, April 22, 2014

NFAT REVIEW OF MANITOBA HYDRO'S PREFERRED DEVELOPMENT PLAN

ECONALYSIS CONSULTING SERVICES

EVIDENCE AND INTERROGATORY RESPONSE REVISIONS

April 22, 2014

ECS Table #4 (Revised April 22, 2014) – Results of Recent Generic Cost of Capital Proceedings

Jurisdiction	Reference	Allowed Return on Equity	Underlying Long Canada Bond Rate	Differential
BCUC – British Columbia Utilities Commission	Generic Cost of Capital Proceeding (Stage 1), Decision – May 2013	8.75%	3.8%	4.95%
Alberta – Alberta Utilities Commission	2009 Generic Cost of Capital (Decision 2009-216)	9.00%	4.32%	4.68%
Ontario – Ontario Energy Board	Report of the Board on Cost of Capital for Ontario's Regulated Utilities (EB-2009-0084)	9.75%	4.25%	5.50%

MIPUG/CAC-Harper 004 (Revised April 22, 2014)

Subject: Calculations

Question: Please provide the calculations/spreadsheets used to calculate Table #10, #11, #12 and #13.

Response:

An explanation for the calculations is provided below. In preparing the response an error was identified in the input data used in creating ECS Tables #12 and #13. Revised tables are provided below along with the implications the changes have for the conclusions presented in Mr. Harper's report.

ECS Table #12 (Revised April 22, 2014) – Probabilistic Analysis: Protect Conawapa In-Service with a 750 MW Intertie

Development Plan		6	15	12		6	12		5	14
	Path 4A	K19/Gas3 1/750MW	K19/C25/ 750MW	K19/C31/ 750MW	Path 4B	K19/Gas3 1/750MW	K19/C31/ 750MW	Path 5	K19/Gas25/750MW (WPS Sale & INV)	K19/C25/750MW (WPS Sale &Inv)
10th Percentile	-767	-767	-2033	-1760	-767	-767	-1760	-312	-403	-1398
25th Percentile	-26	-159	-625	-477	-117	-159	-477	344	14	-18
75th Percentile	2177	1054	2177	1876	1876	1054	1876	2425	1078	2425
90th Percentile	3631	1862	3631	3006	3006	1862	3006	3565	1646	3565
Expected Value	1155	564	804	644	926	564	644	1425	642	1129
Ref-Ref-Ref NPV	1460	955	1460	1210	1210	955	1210	1725	967	1725
50th Percentile	1160	779	1156	926	965	779	926	1470	839	1431

The revised results indicate that, from an economic perspective, it is beneficial to protect the in-service date for Conawapa under both variations of Pathway 4 and also under Pathway 5:

- For Pathway #4 A, protecting a mid 2020s in-service date yields a benefit of $591 M (i.e. $1155 M vs. $564 M) as compared to a cost of $308 M.
- For Pathway #4 B, protecting an early 2030s in-service date yields a benefit of $362 M (i.e. $926 M vs. $564 M) as compared to a cost of $87 M.
- For Pathway #5, protecting a mid-2020s in-service date yields a benefit of $783 M ($1425 M vs. $642 M) as compared to a cost of $308 M.

ECS Table #13 (Revised) – Probabilistic Analysis: Protect Conawapa In-Service with a 250 MW Intertie

Development Plan			4	13	11
NPV 2014$ (Millions)	Path 3 A	Path 3B	K19/Gas2 4/250MW	K19/C25/ 250MW	K19/C31/ 250MW
10th Percentile	-477	-477	-477	-1784	-1621
25th Percentile	112	112	112	-499	-400
75th Percentile	1998	1744	1318	1998	1717
90th Percentile	3343	2734	2128	3343	2734
Expected Value	1141	977	832	767	571
Ref-Ref-Ref NPV	1345	1210	1210	1345	1081
50th Percentile	1146	1044	1044	1063	808

The revised results suggest that there is little to no net benefit, from an economic perspective, in protecting the in-service date for Conawapa:

- For Pathway 3A, protecting a mid-2020s in-service date provides a benefit of $309 M (i.e. $1141 M vs. $832 M) as compared to a cost of $308 M
- For Pathway 3B, protecting an early 2030s in-service date provides a benefit of $145 M (i.e. $977 M vs. $832 M) as compared to a cost of $87 M.

However, given choice of maintaining more flexibility for future as opposed to less at the same expected overall cost, it would seem reasonable to opt for the "path" that maintains as many options as possible and protect Conawapa's in-service date.

Explanation of Calculations Underlying Tables

ECS Table #10

For purposes of calculating the values in Table #10, the outcome for the Optimum 250 MW Plan under each of the 27 scenarios was established by assuming that Manitoba Hydro chooses for its next major generation resource decision after Keeyask from amongst Plans #4, #11 and #13 (i.e. those with a 250 MW intertie and K19) the plan with the highest NPV value and assigning that NPV value to the Optimum 250 MW Plan for that scenario. Using the probabilities Manitoba Hydro has established for each of the 27 scenarios reference values, expected values and a cumulative probability distribution was then calculated for the Optimum 250 MW Plan.

A similar approach was used for the Optimum 750 MW Plan, except in this case, for each of the 27 scenarios the Optimum 750 MW Plan was assigned the highest of the three NPV values associated with Plans #6, #12, and #15 (i.e. those plans with a 750 MW intertie and no WPS contract). The Table A sets out the probability quilt for each of the underlying plans and for the Optimum 250 MW and Optimum 750 MW (No WPS) Plans.

ECS Table #11

Table #11 was calculated in a similar manner to Table #10, except in this case the Optimum 750 MW Plan values were established by looking at each of the 27 scenarios, assuming that Manitoba Hydro chooses for its next major generation resource after Keeyask between Plans #5 and #14 (i.e. the two plans with a 750 MW intertie and a WPS contract) the one with the higher NPV and assigning that NPV value to Optimum 750 MW plan under that scenario. Table B sets out the probability quilt associated with the Optimum 250 MW Plan and the Optimum 750 MW Plan (With WPS).

ECS Table #12

Pathway 4A consists of Plan #15 (i.e., a 750 MW intertie, no WPS contract and Conawapa with an in-service date in the mid-2020's) along with those plans that represent alternatives to proceeding with Conawapa in the mid-2020s (i.e. Plans #6 and #12) under such circumstances. The Pathway 4A NPV values were established by assuming Conawapa has been protected for a mid-2020's in-service date and then, for each of the 27 scenarios, also assuming that Manitoba Hydro chooses the best (i.e. highest NPV value) Plan for that scenario. The result is that for each scenario Pathway 4A's NPV is the maximum of the three NPV associated Plans #6, #12 and #15. In order to avoid double counting the "cost of protecting the in-service date" was added to NPV values calculated for each Plan - $308 M for Plan #15 and $87 M for Plans #12 – per PUB/MH I-279. Table C sets out the resulting probability quilt for Pathway 4A and the associated plans. The NPV values for Plans #12 and #15 differ from those in Figure #9 of Mr. Harper's evidence by the amount of the "protection cost" referenced above.

The results for Pathway 4A (which protects a mid-2020s in-service date for Conawapa and therefore includes Plans #12 and #15) are then compared with Plan #6 which will be the default plan if the Conawapa in-service date is not protected) to determine the net benefit of protecting Conawapa for a mid-2020's in-service date.

Pathway 4B consists of those Plan #12 (i.e. a 750 MW intertie, no WPS contract and Conawapa with an in-service date in the early 2030s) along with those plans that represent alternatives to proceeding with Conawapa in the mid-2030s (i.e. Plan #6) under similar circumstances. Pathway 4B's NPV values were established in the same manner as described for Pathway 4A, except in this case it was assumed that for each

scenario Manitoba Hydro chose between Plans #6 and #12 the one with the higher NPV value and this value was assigned to Pathway 4B for that scenario. Again, the $87 M "cost of protecting the in-service date" was removed from the cost for Plan #12 in order to avoid double counting. The probabilistic quilt for Pathway 4B is also set out in Table C.

The results for Pathway 4B (which protects an early-2030s in-service date for Conawapa and therefore includes Plan #12) are then compared with Plan #6 (which will be the default plan if the Conawapa in-service date is not protected) to determine the net benefit of protecting Conawapa for an early 2030s in-service date.

Finally, Pathway 5 consists of Plan#14 (i.e., a 750 MW intertie, a WPS contract and Conwapa with an in-service date in the mid-2020s) along those plans that represent alternatives to Plan #14 under similar circumstances (i.e. Plan #5). Pathway 5's NPV value for each scenario was calculated in a manner similar to that for Pathways 4A and 4B except in this case it was assumed that for each scenario Manitoba Hydro chooses between Plans #5 and #14 the one with the higher NPV value and this value was assigned to Pathway 5 for that scenario. Again, the $308 M "cost of protecting the in-service date" was removed from the cost for Plan #14 in order to avoid double counting. The resulting probabilistic quilt for Pathway 5 is also set out in Table C.

ECS Table #13

Pathway 3A consists of Plan #13 (250 MW intertie and Conawapa with an in-service date in the mid-2020s) along with those plans that represent alternatives to proceeding with Conawapa in the mid-2020s under similar circumstances (i.e. Plans #4 and #11). Pathway 3A's NPV values were established in the same manner as described for the Table #12 Pathways, except in this case it was assumed that for each scenario Manitoba Hydro chooses between Plans #4, #11 and #13 the one with the highest NPV value and this value was assigned to Pathway 3A for that scenario. Again, the $308 M "cost of protecting the in-service date" was removed from the cost for Plan #13 and similarly the $87 M was removed from the cost of Plan #11 in order to avoid double counting. The probabilistic quilt for Pathway 3A is set out in Table #D.

The results for Pathway 3A (which protects a mid-2020s in-service date for Conawapa and therefore includes Plans #11 and #13) are then compared with Plan #4 which will be the default plan if the Conawapa in-service date is not protected) to determine the net benefit of protecting Conawapa for a mid-2020's in-service date.

Pathway 3B consists of Plan #11 (250 MW intertie and Conawapa with an in-service date in the early 2030s) along with those plans that represent alternatives to proceeding with Conawapa in the early 2030s under similar circumstances (i.e. Plan #4). Pathway 3B's NPV values were established in the same manner as described for the Table #12

Pathways, except in this case it was assumed that for each scenario Manitoba Hydro chooses between Plans #4 and #11 the one with the highest NPV value and this value was assigned to Pathway 3B for that scenario. Again, the $87 M "cost of protecting the in-service date" was removed from the cost for Plan #11 in order to avoid double counting. The probabilistic quilt for Pathway 3B is set out in Table #D.

The results for Pathway 3B (which protects an early 2030s in-service date for Conawapa and therefore includes Plan #11 are then compared with Plan #4 which will be the default plan if the Conawapa in-service date is not protected) to determine the net benefit of protecting Conawapa for an early 2030's in-service date.

MIPUG/CAC-Harper 4 – Table A – Probability Quilt for ECS Table #10

Development Plan			3	7	2	4	13	11	6	15	12	
Energy Prices	Inflation Rates	Capital Costs	Opt 250	Opt 750 (No WPS)	K22/Gas	K19/Gas2 4/250MW	K19/C25/ 250MW	K19/C31/ 250MW	K19/Gas3 1/750MW	K19/C25/ 750MW	K19/C31/ 750MW	Probability
		High	-823	-1120	-1112	-823	-2499	-2071	-1120	-2794	-2238	1.350%
	Low	Ref	116	-172	-241	116	-1406	-1019	-172	-1592	-1129	2.250%
		Low	806	516	396	806	-552	-196	516	-662	-269	0.900%
		High	-1010	-1293	-1288	-1010	-2682	-2301	-1293	-2993	-2469	4.500%
Low	Ref	Ref	-28	-308	-379	-28	-1555	-1209	-308	-1754	-1319	7.500%
		Low	697	409	289	697	-674	-351	409	-793	-426	3.000%
		High	-1153	-1437	-1432	-1153	-2852	-2478	-1437	-3174	-2650	3.150%
	High	Ref	-142	-425	-497	-142	-1697	-1356	-425	-1903	-1469	5.250%
		Low	604	312	190	604	-793	-474	312	-917	-551	2.100%
		High	393	162	21	393	48	94	122	62	162	2.475%
	Low	Ref	1332	1271	891	1332	1142	1145	1069	1263	1271	4.125%
		Low	2022	2193	1529	2022	1996	1969	1757	2193	2131	1.650%
		High	228	-27	-135	228	-90	-98	-30	-88	-27	8.250%
Ref	Ref	Ref	1210	1152	774	1210	1037	994	955	1152	1123	13.750%
		Low	1934	2112	1441	1934	1918	1852	1672	2112	2017	5.500%
		High	111	-146	-255	111	-204	-227	-146	-205	-154	5.775%
	High	Ref	1122	1066	680	1122	951	895	866	1066	1027	9.625%
		Low	1868	2052	1367	1868	1855	1777	1603	2052	1945	3.850%
		High	2527	2759	983	1423	2527	2198	1141	2759	2434	0.675%
	Low	Ref	3620	3960	1854	2362	3620	3250	2088	3960	3543	1.125%
		Low	4474	4890	2492	3052	4474	4073	2777	4890	4402	0.450%
		High	2433	2657	845	1276	2433	2043	1007	2657	2285	2.250%
High	Ref	Ref	3559	3896	1754	2258	3559	3136	1992	3896	3435	3.750%
		Low	4441	4857	2421	2982	4441	3994	2709	4857	4328	1.500%
		High	2374	2599	746	1182	2374	1961	913	2599	2208	1.575%
	High	Ref	3528	3870	1681	2193	3528	3083	1925	3870	3389	2.625%
		Low	4433	4856	2368	2939	4433	3965	2662	4856	4307	1.050%

MIPUG/CAC-Harper 4 – Table B – Probability Quilt for ECS Table #11

Development Plan			1	3	7	2	4	13	11	6	15	12	5	14	
				Opt 250	Opt 750 (WPS)	K19/Gas2 4/250MW	K19/C25/ 250MW	K19/C31/ 250MW	K19/Gas3 1/750MW	K19/C25/ 750MW	K19/C31/ 750MW	K19/Gas2 5/750MW (WPS Sale & INV)	K19/C25/ 750MW (WPS Sale &Inv)	Probability
Energy Prices	Inflation Rates	Capital Costs													
		High		-823	-650	-823	-2499	-2071	-1120	-2794	-2238	-650	-2155	1.350%
	Low	Ref		116	274	116	-1406	-1019	-172	-1592	-1129	274	-984	2.250%
		Low		806	943	806	-552	-196	516	-662	-269	943	-79	0.900%
		High		-1010	-840	-1010	-2682	-2301	-1293	-2993	-2469	-840	-2344	4.500%
Low	Ref	Ref		-28	128	-28	-1555	-1209	-308	-1754	-1319	128	-1135	7.500%
		Low		697	829	697	-674	-351	409	-793	-426	829	-200	3.000%
		High		-1153	-982	-1153	-2852	-2478	-1437	-3174	-2650	-982	-2510	3.150%
	High	Ref		-142	15	-142	-1697	-1356	-425	-1903	-1469	15	-1270	5.250%
		Low		604	738	604	-793	-474	312	-917	-551	738	-311	2.100%
		High		393	352	393	48	94	122	62	162	175	352	2.475%
	Low	Ref		1332	1524	1332	1142	1145	1069	1263	1271	1099	1524	4.125%
		Low		2022	2428	2022	1996	1969	1757	2193	2131	1767	2428	1.650%
		High		228	208	228	-90	-98	-30	-88	-27	-1	208	8.250%
Ref	Ref	Ref		1210	1417	1210	1037	994	955	1152	1123	967	1417	13.750%
		Low		1934	2352	1934	1918	1852	1672	2112	2017	1669	2352	5.500%
		High		111	97	111	-204	-227	-146	-205	-154	-124	97	5.775%
	High	Ref		1122	1337	1122	951	895	866	1066	1027	873	1337	9.625%
		Low		1868	2296	1868	1855	1777	1603	2052	1945	1596	2296	3.850%
		High		2527	2709	1423	2527	2198	1141	2759	2434	775	2709	0.675%
	Low	Ref		3620	3880	2362	3620	3250	2088	3960	3543	1699	3880	1.125%
		Low		4474	4785	3052	4474	4073	2777	4890	4402	2368	4785	0.450%
		High		2433	2607	1276	2433	2043	1007	2657	2285	610	2607	2.250%
High	Ref	Ref		3559	3815	2258	3559	3136	1992	3896	3435	1578	3815	3.750%
		Low		4441	4750	2982	4441	3994	2709	4857	4328	2280	4750	1.500%
		High		2374	2548	1182	2374	1961	913	2599	2208	500	2548	1.575%
	High	Ref		3528	3788	2193	3528	3083	1925	3870	3389	1497	3788	2.625%
		Low		4433	4747	2939	4433	3965	2662	4856	4307	2220	4747	1.050%

MIPUG/CAC-Harper 4 – Table C (Revised April 22, 2014) – Probability Quilt for ECS Table #12

Development Plan			1	3	7	2	4	13	11	6	15	12	5	14	
			All Gas	Path 4A	Path 4B	Path 5	K19/Gas2 4/250MW	K19/C25/ 250MW	K19/C31/ 250MW	K19/Gas3 1/750MW	K19/C25/ 750MW	K19/C31/ 750MW	K19/Gas2 5/750MW (WPS Sale & INV)	K19/C25/ 750MW (WPS Sale &Inv)	Probability
Energy Prices	Discount Rates	Capital Costs													
		High	-307	-1120	-1120	-650	-823	-2191	-1984	-1120	-2486	-2151	-650	-1847	1.350%
	Low	Ref	303	-172	-172	274	116	-1098	-932	-172	-1284	-1042	274	-676	2.250%
		Low	796	516	516	943	806	-244	-109	516	-354	-182	943	229	0.900%
		High	-482	-1293	-1293	-840	-1010	-2374	-2214	-1293	-2685	-2382	-840	-2036	4.500%
Low	Ref	Ref	166	-308	-308	128	-28	-1247	-1122	-308	-1446	-1232	128	-827	7.500%
		Low	688	409	409	829	697	-366	-264	409	-485	-339	829	108	3.000%
		High	-613	-1437	-1437	-982	-1153	-2544	-2391	-1437	-2866	-2563	-982	-2202	3.150%
	High	Ref	56	-425	-425	15	-142	-1389	-1269	-425	-1595	-1382	15	-962	5.250%
		Low	597	312	312	738	604	-485	-387	312	-609	-464	738	-3	2.100%
		High	-470	370	249	660	393	356	181	122	370	249	175	660	2.475%
	Low	Ref	141	1571	1358	1832	1332	1450	1232	1069	1571	1358	1099	1832	4.125%
		Low	633	2501	2218	2736	2022	2304	2056	1757	2501	2218	1767	2736	1.650%
		High	-648	220	60	516	228	218	-11	-30	220	60	-1	516	8.250%
Ref	Ref	Ref	0	1460	1210	1725	1210	1345	1081	955	1460	1210	967	1725	13.750%
		Low	523	2420	2104	2660	1934	2226	1939	1672	2420	2104	1669	2660	5.500%
		High	-782	103	-67	405	111	104	-140	-146	103	-67	-124	405	5.775%
	High	Ref	-113	1374	1114	1645	1122	1259	982	866	1374	1114	873	1645	9.625%
		Low	427	2360	2032	2604	1868	2163	1864	1603	2360	2032	1596	2604	3.850%
		High	-895	3067	2521	3017	1423	2835	2285	1141	3067	2521	775	3017	0.675%
	Low	Ref	-285	4268	3630	4188	2362	3928	3337	2088	4268	3630	1699	4188	1.125%
		Low	207	5198	4489	5093	3052	4782	4160	2777	5198	4489	2368	5093	0.450%
		High	-1081	2965	2372	2915	1276	2741	2130	1007	2965	2372	610	2915	2.250%
High	Ref	Ref	-433	4204	3522	4123	2258	3867	3223	1992	4204	3522	1578	4123	3.750%
		Low	89	5165	4415	5058	2982	4749	4081	2709	5165	4415	2280	5058	1.500%
		High	-1225	2907	2295	2856	1182	2682	2048	913	2907	2295	500	2856	1.575%
	High	Ref	-556	4178	3476	4096	2193	3836	3170	1925	4178	3476	1497	4096	2.625%
		Low	-16	5164	4394	5055	2939	4741	4052	2662	5164	4394	2220	5055	1.050%

MIPUG/CAC-Harper 4 – Table D – Probability Quilt for ECS Table #13

Development Plan			3	7	4	13	11	
			Path 3 A	Path 3B	K19/Gas2 4/250MW	K19/C25/ 250MW	K19/C31/ 250MW	Probability
Energy Prices	Discount Rates	Capital Costs						
		High	-823	-823	-823	-2191	-1984	1.350%
	Low	Ref	116	116	116	-1098	-932	2.250%
		Low	806	806	806	-244	-109	0.900%
		High	-1010	-1010	-1010	-2374	-2214	4.500%
Low	Ref	Ref	-28	-28	-28	-1247	-1122	7.500%
		Low	697	697	697	-366	-264	3.000%
		High	-1153	-1153	-1153	-2544	-2391	3.150%
	High	Ref	-142	-142	-142	-1389	-1269	5.250%
		Low	604	604	604	-485	-387	2.100%
		High	393	393	393	356	181	2.475%
	Low	Ref	1450	1332	1332	1450	1232	4.125%
		Low	2304	2056	2022	2304	2056	1.650%
		High	228	228	228	218	-11	8.250%
Ref	Ref	Ref	1345	1210	1210	1345	1081	13.750%
		Low	2226	1939	1934	2226	1939	5.500%
		High	111	111	111	104	-140	5.775%
	High	Ref	1259	1122	1122	1259	982	9.625%
		Low	2163	1868	1868	2163	1864	3.850%
		High	2835	2285	1423	2835	2285	0.675%
	Low	Ref	3928	3337	2362	3928	3337	1.125%
		Low	4782	4160	3052	4782	4160	0.450%
		High	2741	2130	1276	2741	2130	2.250%
High	Ref	Ref	3867	3223	2258	3867	3223	3.750%
		Low	4749	4081	2982	4749	4081	1.500%
		High	2682	2048	1182	2682	2048	1.575%
	High	Ref	3836	3170	2193	3836	3170	2.625%
		Low	4741	4052	2939	4741	4052	1.050%