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Site C Business Case Assumptions Review

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May 25, 2015

Mr. Ken Boon

President, Peace Valley Landowners Association
SS #2, Site 12, Comp 19
Fort St. John, BC V1J4M7

Dear Mr. Boon:

Please find attached our review of the pivotal assumptions behind the voluminous economic studies developed in the course of the Site C selection. Please note that we have not made a suggestion for the future energy plans of British Columbia. Instead, we did something that should have been done several years ago by comparing the pivotal assumptions that can "place a thumb on the scale" in the ultimate choice.

In the course of our review we have found evidence from the U.S. Bonneville Power Administration that suggests that British Columbia Hydro's choice of a discount rate may have differed from their usual practice. Since this is the single most important assumption in any cost benefit study, a careful review of BC Hydro's decision to use this discount rate is in order.

Yours,

Robert McCullough

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On December 16, 2014, the Government of British Columbia announced its decision to approve the Site C dam. For industry participants, it was a surprising conclusion that a relatively high-cost hydroelectric project was reported to be two-thirds the cost of the alternatives. Considering actual costs in the industry across North America, the decision implied a heavy "finger on the scale" in favor of Site C.

	Site C (2014)	IPPs (Industry Consultations)	IPPs (IRP)
Starting Cost	$58 - $61 / MWh	$85 / MWh	$96 / MWh
Additional Factors	Adds $6	Adds $25	Adds $34
Final Cost	**$64 - $67 / MWh**	**$110 / MWh - $130 / MWh**	

[1]

A month later, on January 16, 2015, Les MacLaren, the Assistant Deputy Minister of the Electricity and Alternative Energy Division of the Office of the Ministry of Energy and Mines issued a report entitled "Site C Clean Energy Project Due Diligence Review."[2] In a few pages the report summarized the justification of Site C, a major hydroelectric project on the Peace River.

The research in defense of this controversial project is comprised of hundreds, if not thousands, of documents totaling thousands of pages. Assistant Deputy Minister MacLaren summarized the analysis in a single table:

[1] Site C Final Investment Decision Technical Briefing, December 16, 2014, page 19.
[2] Site C Clean Energy Project Due Diligence Review, Les MacLaren, January 26, 2015.

Comparing Unit Energy Costs of Site C and IPPs

Unit Energy Cost (UEC) at Point of Interconnection:	Site C	IPPs *BCH 2013 IRP*	IPPs *CEBC 2014*
Rates Plan UEC at Point of Interconnection	**$58-61/MW.h**	**$96/MW.h**	**$85/MW.h**
Sunk Costs	Subtracts $4		
Line Losses	Adds $6	Adds $10	Adds $10
Area Transmission	$0	Adds $6	Adds $6
Cost of Firm Transmission	Adds $6	Adds $2	Adds $2
Foregone exports	Not Applicable	Adds $9	Adds $5
Firm Energy Adjustment (seasonal)	Subtracts $2	Subtracts $2	Subtracts $2
EA, permitting, FN and community benefit costs	Included	Adds $5	Included
Cost of Capacity Backup	Not applicable	Adds $5	Adds $5
Unit Energy Cost Delivered to Lower Mainland:	**$64-67/MW.h**	**$130/MW.h**	**$110/MW.h**

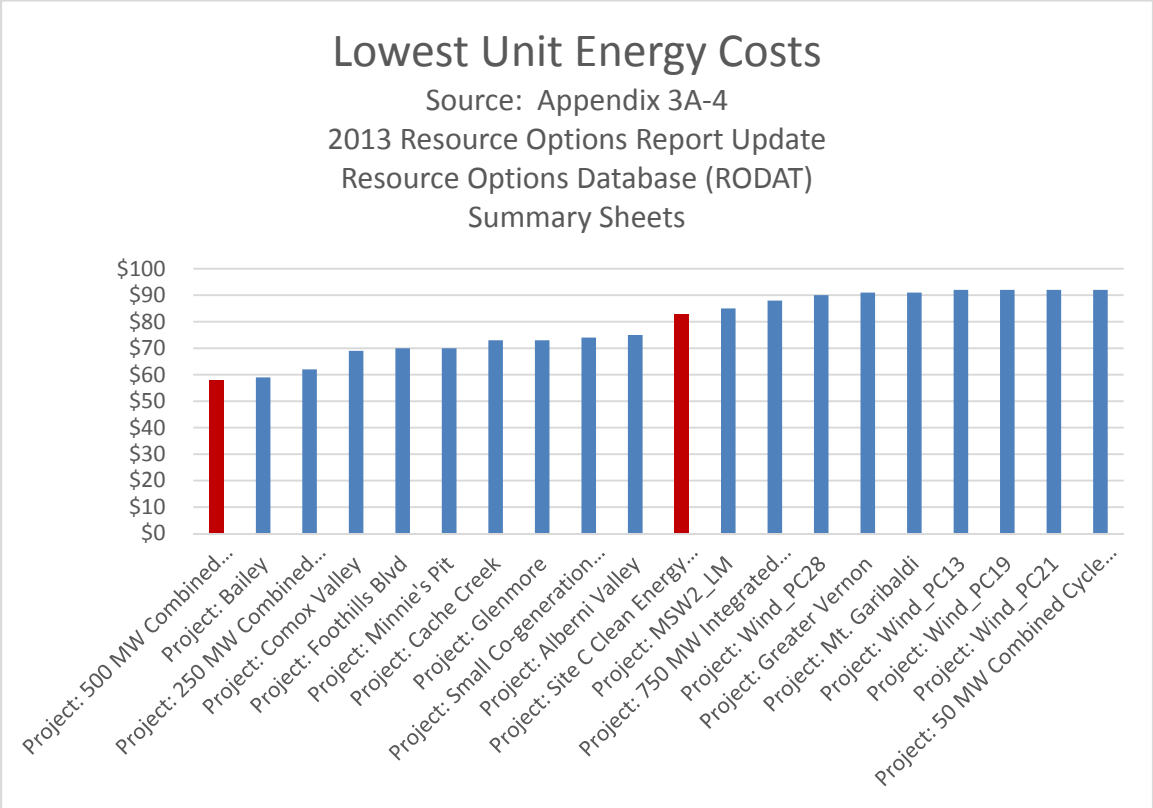
[3]

How did the decision to build Site C come down to the comparison of just two numbers – $58 to $61/MWh for Site C – to the surprisingly large value of $96/MWh for the alternatives?[4]

Decisions elsewhere in the U.S. and Canada have tended to rely on renewables – like wind, solar, and geothermal – for energy and natural gas for capacity. Hydro-Quebec, for example, recently announced resumed operations at Becancour, a 500 MW natural gas facility, to provide complementary capacity in support of its extensive wind development.[5] While the purpose of this report is to focus on assumptions and does not attempt to reproduce the full integrated resource plan, it is logical to assume that correcting the assumptions might well bring the plan back into conformity with similar plans elsewhere.

[3] Ibid., page 8.
[4] All dollar amounts in this report are 2013 Canadian dollars.
[5] Use of Bécancour generating station during peak hours: Hydro-Québec Distribution reaches agreements with TransCanada and Gaz Métro, Hydro-Quebec, May 8, 2015.

The 2013 Integrated Resource Plan (IRP) identified hundreds of different options and calculated a levelized per-megawatthour cost for each one. The twenty most cost-effective are:



The levelized real cost per megawatthour is called the "Unit Energy Cost" or UEC. Site C and a 500 MW combined cycle natural gas unit are indicated in red.[6]

The lowest cost resources are of a variety of types:

[6] The Site C costs reported in BC Hydro's publicity reflect a different issue. The 2013 Integrated Resource Plan reflects cost. Lower numbers, reported later, reflect rate design.

Plant types for 20 lowest cost RODAT options	
Name	Fuel
250 MW Combined	natural gas
50 MW Combined Cycle	natural gas
500 MW Combined	natural gas
750 MW Integrated	coal gasification
Alberni Valley	landfill biogas
Bailey	landfill biogas
Cache Creek	landfill biogas
Comox Valley	landfill biogas
Foothills Blvd	landfill biogas
Glenmore	landfill biogas
Greater Vernon	landfill biogas
Minnie's Pit	landfill biogas
MSW2_LM	mass burn incineration
Mt. Garibaldi	geothermal
Site C	hydro
Small Co-generation	combined heat and power
Wind_PC_21	wind
Wind_PC13	wind
Wind_PC19	wind
Wind_PC28	wind

The UEC for Site C is $83/MWh. This differs markedly from the value given by Assistant Deputy Minister MacLaren. The difference is that MacLaren was referencing a decision by the government of British Columbia to charge less than cost for a number of years. The actual cost, however, is a real cost and will be paid by taxpayers and ratepayers. The following chart shows the rate adjustment:

Impact on Ratepayers – Site C

Site C Cost to Ratepayers (before changes)	$83 / MWh
Under the 10 Year Plan, the amount of net income that BC Hydro is required to earn each year will now be tied to inflation and will no longer increase when new assets like Site C are added to the system.	- $26 / MWh
The 10 Year Plan also reduced water rental charges for BC Hydro.	- $1 / MWh
The capital cost estimate for Site C has been updated from $7.9 billion to $8.335 billion.	+ $2.25 / MWh
Government has established a project reserve of an additional $440 million to account for events outside of BC Hydro's control that could occur over an eight-year construction period, such as higher than forecast inflation or interest rates. The reserve will be managed by the provincial Treasury Board.	+ $2.50 / MWh (if fully utilized)
Updated Site C Cost to Ratepayers	**$58 - $61 / MWh**

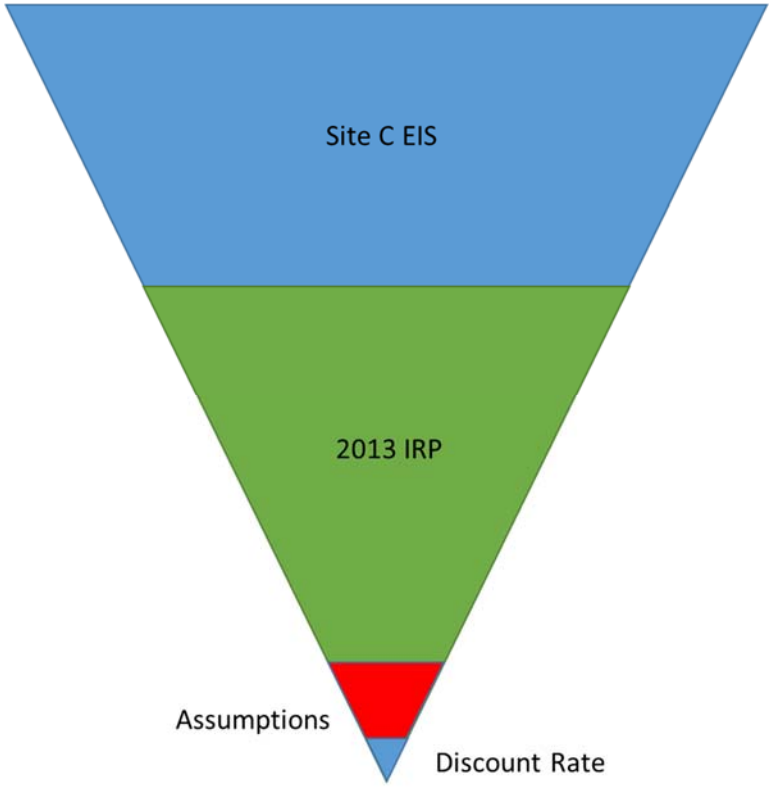
[7]

Thus, British Columbia will still pay $83/MWh, but will recover the cost more slowly and from a different set of its inhabitants. For example, the elimination of water rental means less money for British Columbia's general revenues and, eventually, higher taxes for taxpayers.

Ironically, the towering edifice of studies is built on a few significant assumptions made largely without justification. Each assumption is controversial. Some differ dramatically from estimates accepted throughout the industry; others are simply arbitrary.

The results of the assumptions are equally arbitrary, since changing the pivotal assumptions shifts the entire analysis. Assumptions concerning the cost of capital and the discount rate, the cost of alternatives, and the cost of fuel effectively determine the result regardless of the scale of the analysis that follows after these assumptions are made:

[7] Site C Final Investment Decision Technical Briefing, December 16, 2014, page 16.



The discount rate lies at the heart of any cost benefit study. In fact, the selection of a discount rate can drastically change the results of the rest of the analysis, overwhelming any other single assumption. The graphic above illustrates the critical importance of the discount rate to the entire edifice that balances upon this one critical assumption. The discussion of this critical component of the analysis in the 2013 IRP can only be described as sketchy and inadequate. The entire presentation on the discount rate is limited to one paragraph:

4.4.3.3 Discount Rate

> Discount rates reflect the market demand for, or opportunity cost of, the capital associated with projects of similar risk. This IRP used 5 per cent and 7 per cent discount rates to calculate levelized resource unit costs (UECs and UCCs) for BC Hydro and IPP resources respectively. The updated discount rates reflect the change in BC Hydro's WACC and the updated assumption of IPP's WACC. In the long-term planning context, the discount rate methodology is consistent with the WACC used to calculate cost streams of installed resources.[8,9]

BC Hydro commissioned a review of its methodology on September 23, 2014.[10] The review of the discount rate methodology was equally brief:

> BC Hydro utilizes two different values for weighted average cost of capital in its Integrated Resource Plan. The Company recommends a 5% real WACC for its own investments and 7% for IPPs and other third party developers; the 2% differential (and a sensitivity that reduces the differential to 1%) is set out in the Site C hydro project environmental assessment documentation and the IRP. The BC Hydro rate of 5% is reasonable, as BC Hydro's borrowing is guaranteed by the government, and the Company may also borrow directly from the Province. The British Columbia Utilities Commission recognizes this, stating that "With respect to the cost of capital, BC Hydro projects will

[8] 2013 Integrated Resource Plan, British Columbia Hydro, page 4-63.
[9] Utility planning documents often use idiosyncratic acronyms. UEC stands for Unit Energy Cost. UCC stands for Unit Capacity Cost. IRP stands for Integrated Resource Plan. WACC stands for the Weighted Average Cost of Capital.
[10] Review of BC Hydro's Alternatives Assessment Methodology, Rachel Wilson et al., Synapse Energy Economics, September 23, 2014.

> clearly have an advantage as a result of…access to the Province's high credit rating."
>
> Utilities similar to BC Hydro appear to be using comparable values for WACC. In its Needs For and Alternatives To Business Case submission, for example, Manitoba Hydro conducted its resource analysis using a WACC of 5.05% in its base case.[11]

The kindest thing to be said about the proposed discount rates is that they are not wrong. Unfortunately, they are also not right. Synapse points to a similar number used by Manitoba Hydro. Synapse could easily reference much higher numbers for hydro projects used by Hydro-Quebec and the Bonneville Power Administration.[12,13] Indeed, Bonneville makes an interesting statement in its own discount rate derivation:

> Recently, the Ibbotson data was complimented [sic] by a more intensive study performed by BPA Finance staff in which public utilities across North America were surveyed about their discount theory and practice. A few of the utilities that participated were Western Area Power Administration (WAPA), **BC Hydro**, BC Transmission, Tennessee Valley Authority (TVA), New York Power Authority (NYPA), and Sacramento Municipal Utility District (SMUD).
>
> BPA's current rates of 12% for Hydro capital investments and 9% for non-replacement Transmission capital investments are **reasonable in light of the**

[11] Ibid., page 2.
[12] Présentation augmentation capacité La Grande, Hydro-Quebec, October 2013, workpapers.
[13] Capital Investment Review, Bonneville Power Administration, April 8, 2014, page 4.

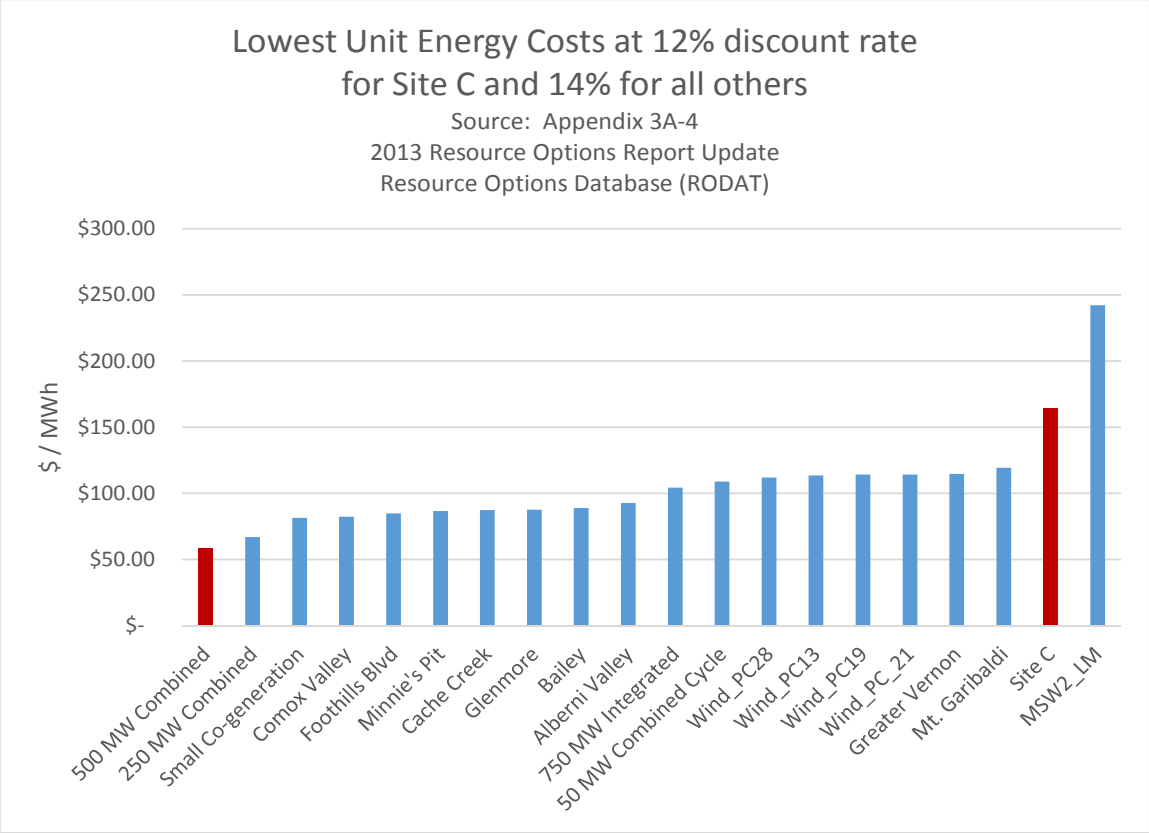
> **benchmarking study** and the benchmarking reinforced BPA's existing practice of using a risk adjusted discount rate.[14] (emphasis supplied)

Bonneville Power Administration has cited BC Hydro in defense of adopting a 12% discount rate for hydroelectric projects. Tennessee Valley Authority uses discount rates between 6% and 12% based on various factors.[15] The clear implication is that BC Hydro's choice of a discount rate might be opportunistically chosen to benefit the selection of Site C in the Integrated Resource Plan, but a different, higher value has been used internally.

While discount rates often sound academic to those who have not been schooled in energy economics, their impact on decision-making is immense. The situation revolves around the timing of investments. Hydroelectric projects require substantial capital investments. Their operating costs are very low. This means that they are relatively unaffected by discount rate assumptions. Thermal plants – especially those fueled by natural gas – have relatively low capital costs, but also relatively high operating costs. Their economic viability is greatly affected by the choice of a discount rate.

When we take the table of the twenty lowest UECs and use a discount rate of 12% for Site C, while leaving in a 200 basis point higher discount rate for other resources, the order changes dramatically as capital intensive resources are shifted to the right in the chart and those whose major cost is fuel are shifted left.

[14] Ibid., page 4.
[15] ENERGY VISION 2020, April 9, 2009, Tennessee Valley Authority, page T8.35.



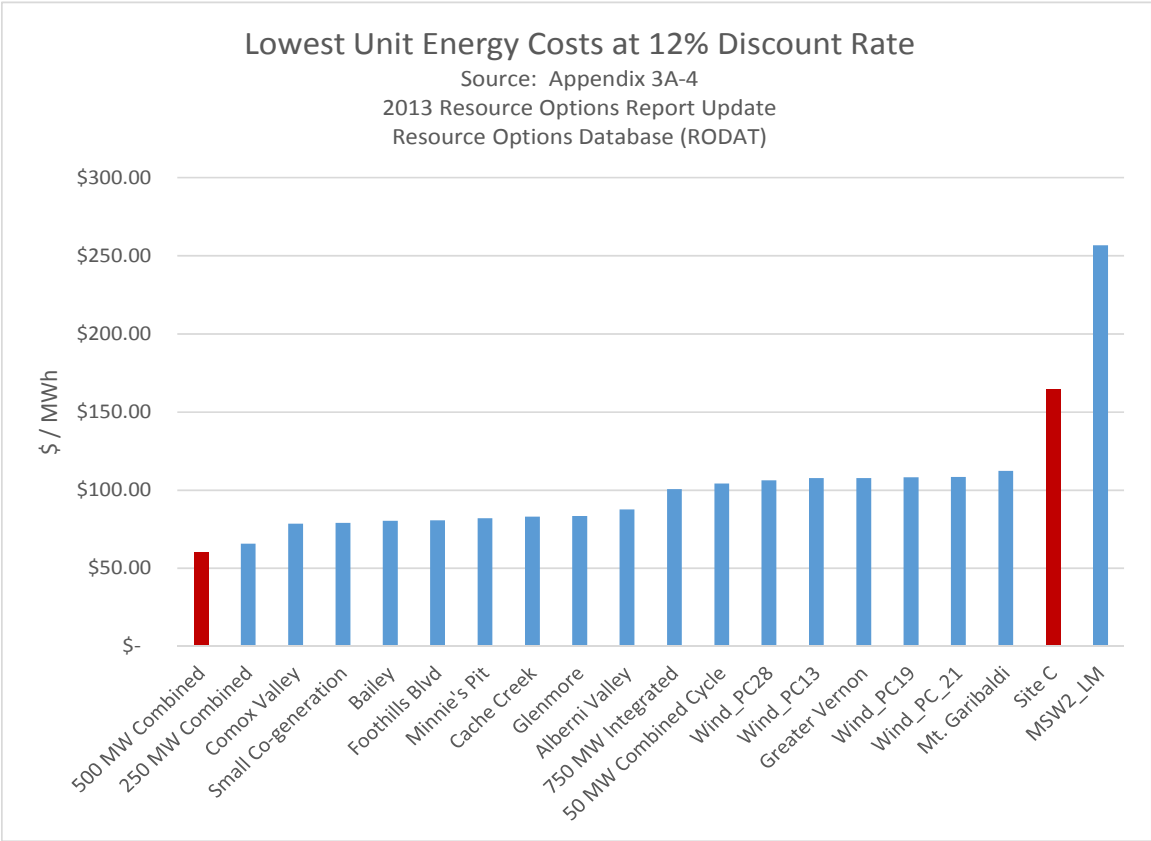
A follow-up question is why the discount rates used by major utilities are so high for hydroelectric facilities like Site C. If you ask a major utility, you are likely to receive a response similar to BPA:

> Risk Premium – This is the measure of the riskiness of the investment. Common elements of risk specific to BPA would be project construction risk, uncertain water and weather risk, and stranded cost risk. Neglecting to consider project risk could lead BPA to select poor investments and put an undue burden on ratepayers.[16]

[16] Ibid., page 3.

When I asked the identical question in negotiations with Hydro-Quebec last year, they replied that the high discount rate represented a substantial dedication of capital to produce a product in a market with dramatic price changes and high volatility.

BC Hydro has assumed that an additional 200 basis point should be added to the discount rate for projects built by independent power producers. This is an interesting hypothesis, although it seems somewhat arbitrary. The least expensive UEC in the chart above is a 500 MW combined cycle gas unit. The units are common choices for utilities. Depending on the utility, they are either purchased from third parties or built by the utility. In recent years, utilities have been building their own resources, so no such additional risk premium is necessary. Eliminating the 200 basis point penalty for non-Site C projects produces the following chart:



Some utilities like Hydro-Quebec even use lower discount rates for wind – even if there is an outside developer. For example, Hydro-Quebec's wind tariff specifies a discount rate of 3.5%.[17]

While the discount rate is the pivotal assumption in an analysis of this sort, a variety of other assumptions should be considered as well.

The U.S. Energy Information Administration (EIA) is an excellent source for basic data. A table frequently relied upon in the electric industry is EIA's summary of the cost of central station generating facilities:

AEO2015

Table 8.2. Cost and performance characteristics of new central station electricity generating technologies

					Contingency Factors						
Technology	Online Year[1]	Size (MW)	Lead time (years)	Base Overnight Cost in 2014 (2013 $/kW)	Project Contin-gency Factor[2]	Techno-logical Optimism Factor[3]	Total Overnight Cost in 2014[4] (2013 $/kW)	Variable O&M[5] (2013 $/mWh)	Fixed O&M (2013 $/ kW/yr.)	Heatrate[6] in 2014 (Btu/ kWh)	nth-of-a-kind Heatrate (Btu/kWh
Scrubbed Coal New	2018	1300	4	2,726	1.07	1.00	2,917	4.47	31.16	8,800	8,740
Coal-Gasification Integrated Comb Cycle (IGCC)	2018	1200	4	3,483	1.07	1.00	3,727	7.22	51.37	8,700	7,450
IGCC with Carbon sequestion	2018	520	4	5,891	1.07	1.03	6,492	8.44	72.80	10,700	8,307
Conv Gas/Oil Comb Cycle	2017	620	3	869	1.05	1.00	912	3.60	13.16	7.050	6.800
Adv Gas/Oil Comb Cycle (CC)	2017	400	3	942	1.08	1.00	1,017	3.27	15.36	6,430	6,333
Adv CC with Carbon sequestration	2017	340	3	1,845	1.08	1.04	2,072	6.78	31.77	7,525	7,493
Conv Comb Turbine[8]	2016	85	2	922	1.05	1.00	968	15.44	7.34	10,783	10,450
Adv Comb Turbine	2016	210	2	639	1.05	1.00	671	10.37	7.04	9,750	8,550
Fuel Cells	2017	10	3	6,042	1.05	1.10	6,978	42.97	0.00	9,500	6,960
Adv Nuclear	2022	2234	6	4.646	1.10	1.05	5.366	2.14	93.23	10.479	10.479
Distributed Generation-Base	2017	2	3	1,407	1.05	1.00	1,477	7.75	17.44	9,015	8,900
Distributed Generation - Peak	2016	1	2	1,689	1.05	1.00	1,774	7.75	17.44	10,015	9,880
Biomass	2018	50	4	3,399	1.07	1.01	3,659	5.26	105.58	13,500	13,500
Geothermal[7,9]	2018	50	4	2,331	1.05	1.00	2,448	0.00	112.85	9,516	9,516
Municipal Solid Waste Conventional	2017	50	3	7,730	1.07	1.00	8,271	8.74	392.60	14,878	18,000
Hydropower[9]	2018	500	4	2,410	1.10	1.00	2,651	5.76	15.15	9,516	9,516
Wind	2017	100	3	1,850	1.07	1.00	1,980	0.00	39.53	9,516	9,516
Wind Offshore	2018	400	4	4,476	1.10	1.25	6,154	0.00	73.96	9,516	9,516
Solar Thermal[7]	2017	100	3	3,787	1.07	1.00	4,052	0.00	67.23	9,516	9,516
Photovoltaic[7,10]	2016	150	2	3,123	1.05	1.00	3,279	0.00	24.68	9,516	9,516

[18]

[17] Terms of Reference for the Siting of Wind Farms on Farmland and in Woodlands, Hydro-Quebec, November 17, 2013.

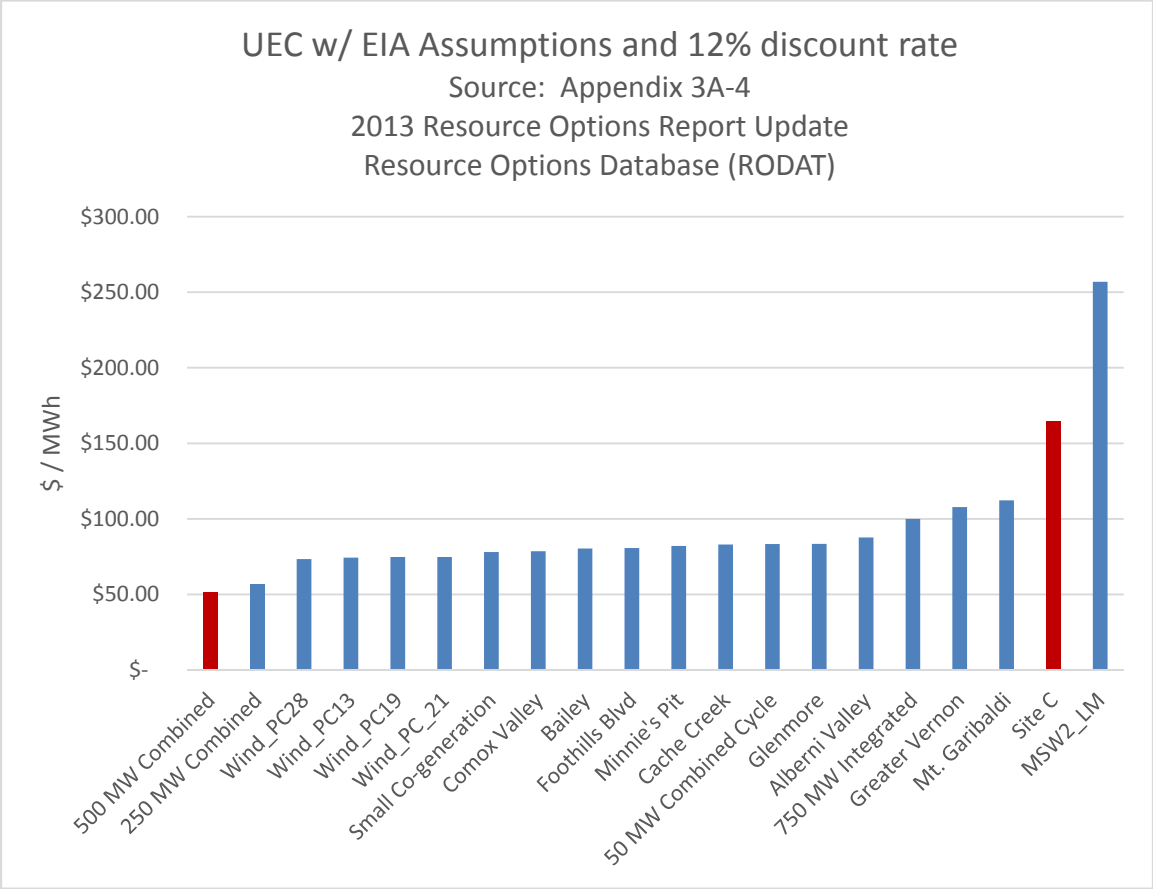
[18] Energy Information Agency. Annual Energy Outlook 2015. http://www.eia.gov/forecasts/aeo/assumptions/pdf/table_8.2.pdf

In general, the EIA is quite a bit more optimistic on plant costs than BC Hydro's Resource Operations Database (RODAT).[19] For example, a conventional combined cycle gas unit is $869/kW (U.S.) versus the RODAT's $1,137/kW.[20] The standard unit is also significantly more efficient. The EIA has a heat rate of 7,050 btu/kWh versus the RODAT's 7,362 btu/kWh.

BC Hydro's pessimism on plant costs is not restricted to thermal units. Wind farm equipment is usually highly standardized. Major manufacturers sell thousands of virtually identical wind turbines throughout North America. The EIA data indicates that wind turbines will cost $1,850/kW for a 100 MW utility scale project. This is consistent with industry experience. The RODAT's three cheapest wind projects – PC13, PC19, and PC21 – are $2,857/kW (U.S.). Since the underlying equipment is most likely the same, the only explanation would be that wind farms in British Columbia are extremely more remote than those in Washington State and that transportation costs are almost $1,000/kW more. Since these projects are in the Peace River area, this seems unlikely. Correcting the RODAT data using EIA plant assumptions shows the following rankings for the twenty cheapest alternatives:

[19] RODAT's assumptions concerning the 750 MW Integrated Gasification Combined Cycle option are far more optimistic than the EIA's and do not match industry experience. Substantial doubt exists that this is a viable option under any foreseeable set of assumptions. It has been kept in the chart for comparison purposes only – using RODAT's low capital cost estimate.

[20] The 2013 BC Hydro assumes a long term exchange rate of .9693 U.S. dollars to the Canadian dollar at page 4-63. This value has been used in adjusting RODAT with U.S. financial values.

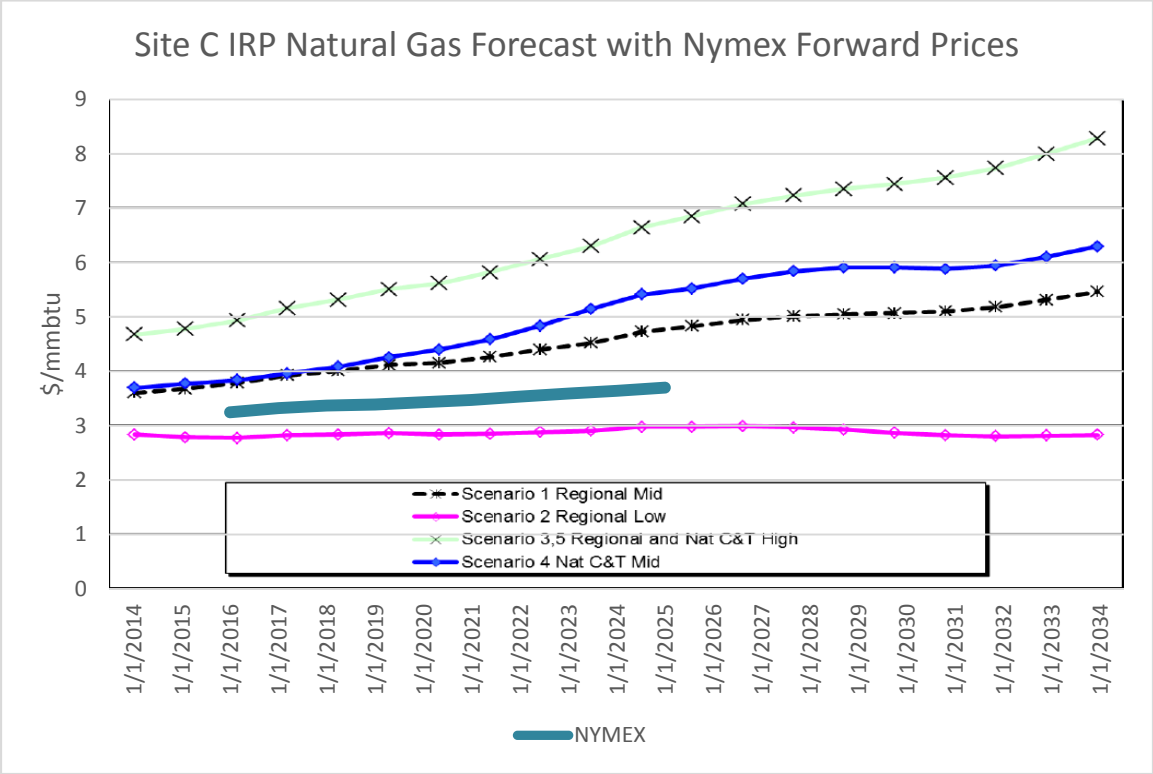


Again, Site C continues to look like an increasingly expensive choice compared to wind, natural gas, and other alternatives.

Yet another issue is fuel costs. Our ability to forecast fossil fuels is limited. Over the last decade we have gone from a widespread perception that oil and gas were reaching "peak" levels. This Malthusian view has fallen victim to technological change. In reality, production is up and prices have fallen. Recently the highly respected bond rating firm, Moody's, has predicted that world natural gas prices have fallen so low that LNG export terminals in Canada and the U.S. are increasingly unlikely.[21]

[21] Global supply glut threatens British Columbia's LNG projects, Brent Jang, Globe and Mail, April 7, 2015.

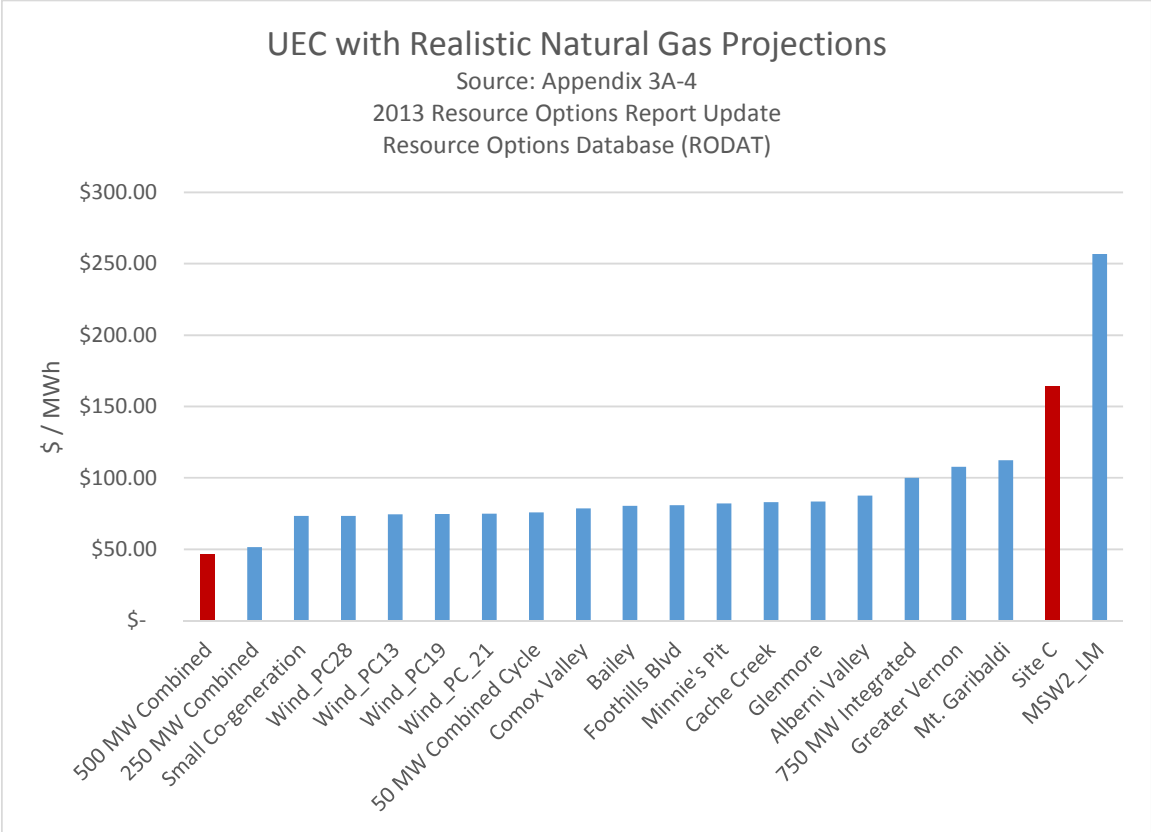
While the change in technology has confounded forecasters, it is still logical to compare the forecast to real markets. Natural gas has robust forward markets on a variety of exchanges. The following chart compares the forecasts in the 2013 Integrated Resource Plan with today's NYMEX forward prices:



The thick blue line represents current quotes on the NYMEX. Scenario 1 represents the natural gas price BC Hydro has modelled in the RODAT. The actual price is considerably lower and is available for purchase through 2025.[22]

This adjustment should also be made to the RODAT data. The cumulative set of adjustments is telling:

[22] NYMEX prices have been adjusted to Canadian dollars using the assumption contained in the 2013 Integrated Resource Plan. Real price escalation after 2025 is assumed to continue at the 2020 to 2025 rate.



In summary, adopting realistic changes from standard and well respected sources makes an enormous difference. Using BC Hydro's assumptions, the difference in cost between the least expensive option and Site C is minimized. Using industry standard assumptions, Site C is more than three times as costly as the least expensive option. In fact, Site C fares poorly when compared to cogeneration, wind, landfill, and coal gasification.

Type of Plant	Average $/MWh
Natural gas	$ 58.04
Combined Heat & Power	$ 73.33
Wind	$ 74.36
Landfill biogas	$ 85.50
Coal gasification	$ 99.97
Geothermal	$ 112.30
Hydro	$ 164.35
Mass Burn incineration	$ 256.85

While the cost and choice of options deserve further analysis, the simple conclusion is that Site C is more expensive – dramatically so – than the renewable/natural gas portfolios elsewhere in the U.S. and Canada. Our analysis indicates that the Site C portfolio may well be twice as costly as the renewable/natural gas portfolio adopted elsewhere.