ANNEXE 4

COMPARAISON DES PRIX DE LA COMBINAISON SÉLECTIONNÉE AVEC LES PRIX DES PRINCIPAUX PRODUITS DISPONIBLES DANS LES MARCHÉS DU NORD-EST DE L'AMÉRIQUE ET LES COÛTS DE TRANSPORT APPLICABLES

The Competitive Cost of Smaller-Scale Wind Power

A/O 2009-02

Wind-Generated Electricity from Aboriginal Projects (250 MW) and Community Projects (250 MW)

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The Competitive Cost of Wind Power in Other Power Markets

1. Introduction

The Régie de l'énergie (Régie) requires that Hydro-Quebec Distribution undertake a comparative analysis of the cost of power from the bids selected through the A/O 2009-02 Wind-Generated Electricity from Aboriginal and Community Projects relative to the cost of power for similar products from neighboring Northeast markets. In this Call for Tenders since the maximum project size is 25 MW, the comparison will focus on smaller-scale wind projects where practical. Given the unique nature of wind-generated electricity as an intermittent resource with project economics based largely on location, this assessment focuses on comparing the cost of power from the bids selected in response to A/O 2009-02 with the cost of wind-generated electricity in other North American markets as a benchmark cost.[1]

Hydro-Quebec Distribution has selected 12 bids for a total of 291.4 MW from the Wind-Generated Electricity Call for Tenders for Aboriginal and Community Projects issued on April 30, 2009. Deliveries of the power from these projects are expected to come on-line on either December 1, 2013, December 1, 2014, or December 1, 2015. The maximum size of each project is also limited to 25 MW. Hydro-Quebec Distribution has reported that the average price of the accepted bids is $133/MWh in total, including $20/MWh to transmit the electricity generated.

Based on the maximum bid size of 25 MW, the focus of this assessment will be on the cost of smaller size wind projects, where such cost information is available. Also, given the importance of transmission costs in the selection of resources throughout Canada and the US, the analysis will also address the general level of transmission related costs included in the evaluation of wind projects in other jurisdictions, where available.

The timing of the changes in capital costs for wind turbines, capital and operating cost differences based on project size, any differences between subsidies for renewable resources in the US and Canada, transmission requirements, and other locational differences that influence the wind regime and project cost structure makes an accurate comparison between the costs of the wind resources selected by Hydro-Quebec Distribution and benchmark resources very challenging.[2] For example, it is not often clear when considering benchmark resources the amount of capital costs, interconnection

[1] Merrimack Energy has developed benchmarks based on a review of North American markets as opposed to focusing only on the cost of wind projects in neighboring Northeast markets due to the small sample size in these markets and the lack of available data. Merrimack Energy has served as Independent Evaluator or Independent Consultant for several recent high profile Request for Proposal processes for renewable resources over the past seven years in several regions of the US and Canada and has conducted studies for other utilities on wind project costs.

[2] Also, the parameters of Hydro-Quebec Distribution's Call for Tenders associated with manufacturer requirements and regional and local content requirements will serve to influence comparative project economics.

costs and system integration or reinforcement costs that are included in the contract or bid prices for select projects.

Although it is difficult to conduct a consistent and equivalent evaluation of wind projects, Merrimack Energy has attempted to develop a reasonable and consistent approach for conducting the comparative cost assessment required by the Régie. The methodology undertaken by Merrimack Energy is based on assessing the real levelized cost of wind generated electricity from smaller projects similar to the eligible bids in the Call for Tenders based on available information. While in past benchmark reports we have relied upon calculation of the levelized cost of power based on specific project costs, the recent development of Feed-in Tariffs has provided more transparent cost information based on estimates of generic costs for different renewable resources. In this analysis, Merrimack Energy will rely on such available cost information, other studies which provide levelized power costs for wind projects, and calculation of levelized costs based on specific project costs where available.

2. Background

There are a number of factors that influence the cost of wind-generated power. These include the capital cost of the equipment, the cost of financing the project, operation, maintenance, and other administrative costs (e.g. property taxes and payments to land owners), the wind regime at the site, the size of the wind farm, configuration of the turbines, and government incentives such as production tax credits, accelerated depreciation and state subsidy programs.

The strength of the wind resource (i.e. wind regime), including wind speed and wind speed distribution over the course of the year, and the matching of the wind resource to the wind turbine power curve, is also a major determinant of project cost. These factors determine project output and the associated capacity factor of the wind system. Since most of the costs associated with a wind generation facility are fixed costs, the higher the capacity factor, the lower the per-unit cost. In general, wind farms require wind speeds in excess of 6 meters/second (m/s) or 13 miles per hour (mph) for cost effective applications.

However, since the cost of wind generation is highly site specific, it is very difficult to consistently and equitably compare the economics of various projects since each project has a unique set of local conditions. Unlike other generation technologies, such as combined cycle or combustion turbine facilities that generally have a standard design and fairly consistent cost characteristics, the economics of wind generation can vary considerably in a number of areas.

In addition, the penetration of wind projects into a specific market, the availability and cost of transmission, and the cost of banking and shaping service can have a major impact on overall project costs and relative economics.

Merrimack Energy has attempted to develop benchmark costs for wind projects in the US and Canada to serve as a comparison for the proposals bid into Hydro-Quebec's Call for Tenders for Wind-Generated Electricity from Aboriginal Projects and Community Projects. For comparative purposes, we have focused on assessing the costs of wind projects below 25 MW to ensure comparability with the size limits imposed in the Call for Tenders. While economies of scale may exist for wind projects there are other factors which have an impact on the relative economics of wind projects including wind speeds, capacity factor, turbine availability, project location, etc.

Benchmark costs for wind projects in his assessment will therefore be based on the following sources of information:

1. The estimated costs for wind included in the Feed-in Tariff programs in Canada and the US;
2. Information reported by utilities for wind projects in other Call for Tender processes, notably the cost information reported by BC Hydro;
3. Prices for smaller wind projects bid in Request For Proposal processes;[3]
4. Studies which provide estimated costs (levelized costs) for wind projects;[4]
5. Prices for projects built or under construction if reported in publicly available sources.

A. Feed-in Tariff Programs

The two primary Feed-in Tariff (FIT) programs of focus are the Ontario Power Authority Feed-in Tariff program and the Vermont Feed-in Tariff program. In addition, we include the estimated cost for small scale wind projects from legislation in other states which have attempted to identify the rate at which the feed-in tariff is expected to be established.

Ontario FIT Program

The Ontario FIT program has established prices for various renewable technologies at which power would be procured under an established tariff. The latest feed-in tariff price in Ontario for on-shore wind projects of any size is $135/MWh with 20% of the price escalating by the Ontario Consumer Price Index. Also, eligible aboriginal projects receive a price adder of $15/MWh, for a total price of $150/MWh.[5] Based on assumed annual CPI escalation of 2% and the Hydro-Quebec discount rate of 5.913%, the levelized price would be $139.21/MWh (or $118.95/MWh in real levelized costs) based on the feed-in tariff price and $154.68/MWh (or $132.20/MWh real levelized cost) with the Aboriginal price adder.

[3] The specific projects and exact references are confidential. The information presented is a weighted average of projects evaluated, all of which are under 25 MW.
[4] Generally, the results of the studies are not differentiated by project size.
[5] An on-shore wind project with an Aboriginal participation level greater than or equal to 50 percent would be eligible to receive the FIT contract price of $135/MWh plus an additional $15/MWh.

Vermont

Vermont had developed a price schedule for Standard Offer Contracts in its Feed-in Tariff Program in Docket 7533 (Attachment11). For wind projects of 1.5 MW the reported levelized price is $118.20/MWh (US$) based on a 20 year price schedule. The price stream starts at $112.50/MWh in year 1 and reaches $124.40/MWh in the last year of the 20 year term. The annual price stream established as of January 15, 2010 is presented in Exhibit 1. Based on this stream of prices discounted at Hydro-Quebec's discount rate yields a levelized price for small-scale wind projects of $117.03/MWh (US$) or $100/MWh on a real levelized cost basis in 2011 dollars. This would equate to $96.11/MWh in 2009 $.

Exhibit 1: Price Stream for Small Wind Projects – Vermont Feed-in Tariff

Year	Price ($/MWh US$))
2011	$112.5
2012	$113.1
2013	$113.6
2014	$114.2
2015	$114.8
2016	$115.3
2017	$115.9
2018	$116.5
2019	$117.1
2020	$117.7
2021	$118.3
2022	$119.0
2023	$119.6
2024	$120.3
2025	$120.9
2026	$121.6
2027	$122.3
2028	$123.0
2029	$123.7
2030	$124.4

Rhode Island

Several other states, including Rhode Island had proposed legislation establishing a feed-in tariff program. Although the feed-in tariff legislation in Rhode Island was not passed, the price for electricity generated by wind-powered plants (determined to be the rate needed for development plus a reasonable profit) was to be set at $115/MWh (US$) for projects with a capacity no greater than 20 MW and $105/MWh for projects with a capacity of greater than 20 MW. On a real levelized cost basis, the equivalent prices are

$98.25/MWh for a project less than 20 MW and $89.72/MWh for a project greater than 20 MW.

B. Bids From Small Wind Projects

We have also reviewed information from other solicitations, including the information included in a report prepared by BC Hydro in August 2010 on their Clean Power Call Request for Proposals, Report on the RFP Process. The BC Hydro report includes summary information on BC Hydro's Clean Power Call as well as information on the RFPs conducted by both Portland General Electric and Puget Sound Energy. The information reported by BC Hydro for the proposals received in response to the Clean Power Call as well as the information presented for Portland General Electric and Puget Sound Energy reflects the offers received only. Therefore, it is unlikely that the higher cost options were actually selected for contract award. No specific information is presented on the average cost for those projects awarded contracts similar to the information presented by Hydro-Quebec Distribution. The information included in the BC Hydro report for wind projects is presented in Exhibit 2.

Exhibit 2: Information on Wind Projects from Other Solicitations – BC Hydro Report

Price Information	Wind Projects
BC Hydro Clean Power Call[6]	
Firm Energy Price ($/MWh cdn$)	
Final Bid Price (Jan. 2009$)	$99.0 to $143.9
Weighted Average Bid Price	$116.6
Levelized Plant Gate Price	$90.0 to $121.2
Weighted-Average Plant Gate Price	$103.1[7]
Levelized Adjusted FEP[8]	$117.4 to $132.9
Weighted-Average Adjusted FEP	$126.5
Portland General Electric 2007 Renewable RFP (Short-listed bids – mostly wind)	

[6] BC Hydro received six wind bids for a total of 1,528 firm GWh/year. Five of the six projects were selected for contract award. All projects selected exceeded 25 MW.

[7] BC Hydro's price referenced in this section is a real levelized price. The real levelized price is the initial year price escalated by inflation which provides the same Net Present Value stream as the price stream offered.

[8] The levelized Firm Energy Price (FEP) is the levelized price adjusted for differences in project location relative to the Lower Mainland, hourly firm energy, wind integration, network upgrade costs borne by BC Hydro, Cost of Incremental Firm Transmission and energy losses.

Stated Energy Price ($/MWh US)	$85 to $110
Energy Price Levelized (2009 Cdn $/MWh)	$91 to $118
Puget Sound Energy 2008 All-Source RFP (bids received)	
Stated Energy Price ($/MWh)	$104 to $155
Energy Price Levelized (2009 Cdn $/MWh)	$112 to $166

The levelized cost methodology applied by BC Hydro is provided on its website for the Clean Power Call. BC Hydro's levelized price based on the reported real levelized price of $103.1/MWh would be $120.66/MWh (cdn $).

Merrimack Energy also reviewed the offers submitted in other solicitations for smaller scale wind projects (under 25 MW). The results of modeling thirteen such options illustrate a wide price range, with the lowest levelized price at $73.47/MWh and the highest price at $145.07/MWh (US$). With the exception of the high and low offer, the other offers ranged from $95/MWh to $125/MWh. The weighted average of the offers is $110.16/MWh (US$) or $94.13 on a real levelized cost basis in 2010 dollars. This equates to $92.28/MWh in 2009 dollars.

C. Price of Wind Projects Based on Industry Studies

Several power generation cost studies have provided estimates of wind generation costs. The estimates of wind-generated electricity costs are summarized below.

New Brunswick Department of Energy

The New Brunswick Department of Energy completed a study of the potential costs of developing and operating a 15 MW wind project in a typical New Brunswick community.[9] The study included detailed project cost estimates to derive an estimate of annual revenues from a wind project. Based on the information identified in the report, the New Brunswick Department of Energy estimates an annual price of wind energy of $101.40 in year 1 escalating at 1.4% per year. Based on the projected price stream, the levelized cost of the project is estimated to be $113.09 at Hydro-Quebec's discount rate or $96.62/MWh on a real levelized cost basis.

California Energy Commission

The California Energy Commission study entitled "Comparative Cost of California Central Station Electricity Generation", August 2009 provides levelized cost estimates for a large number of conventional and renewable generation technologies for three

[9] New Brunswick Community Wind Projects Getting to the Tipping Point, August 2010.

project structures; merchant projects, utility-owned generation, and publicly-owned utility project. The report provides an estimated levelized cost in nominal 2009$ (assuming an in-service date of 2009) of $80.52/MWh for a class 3/4 wind project or $68.80 on a real levelized cost basis. The assumed project size is 50 MW.

E3 Study for Bonneville Power

The consulting firm E3 prepared a study for Bonneville Power on the demand and supply for renewable resources in the Pacific Northwest and western Canada, entitled "Remote Renewable and Low Carbon Resource Options for Bonneville Power Authority", May 22, 2008. The report included an assessment of the levelized busbar cost ranges for several renewable technologies. The levelized busbar cost range reported for wind was $73/MWh to $131/MWh or $62.40/MWh to $111.95/MWh on a real levelized cost basis.

Congressional Research Service Report to Congress

The Congressional Research Service Report to Congress entitled "Power Plants: Characteristics and Costs", November 13, 2008 presents cost information for a number of conventional and renewable generating technologies. The reported levelized cost for wind projects is $80.74/MWh in 2008 US dollars.

The experience of Merrimack Energy with two recent utility wind RFPs in the western US is consistent with these studies. While there are outlier projects in terms of the costs, we have found that the levelized costs of projects generally range from about $80/MWh to $120/MWh, with most of the projects in the $90-$100/MWh range. The caveat is that these projects are generally larger projects (50 – 100 MW) with no requirements for community involvement.

D. Methodology for Estimating Wind Generation Costs

In Merrimack Energy's 2008 Report on the Competitive Cost of Wind-Generated Electricity prepared for the 2000 MW Wind Call for Tenders, we provided a comparison of the cost of wind power based on a disaggregated cost approach. The methodology and general assumptions for the analysis were derived from presentations by Charles Vaughn of Clipper Windpower Inc. entitled "The Economics of Wind" and a presentation by Mark Eilers of GE Energy entitled "Current Status of Wind: Market Update in the Context of the Economics of Wind".

In his presentation, Mr. Vaughn presents the formula for calculating the cost of wind energy as Cost of Energy = ((Capital Cost x Capital Cost Recovery Factor) + Operating Costs))/Energy Production. Mr. Vaughn estimates a 10% Capital Cost Recovery Factor which generally represents the annualized capital cost recovered for the return on and of investment.

In a report prepared by KEMA, Inc. for the California Energy Commission in August 2009 entitled "Renewable Energy Cost of Generation Update", KEMA presents high,

mid, and low cost cases for installed costs, fixed O&M costs and variable O&M costs. As a very conservative estimate, Merrimack Energy has used the high cost scenario for all wind project costs for purposes of estimating the unit cost of energy. Exhibit 3 provides a list of the assumptions used in the analysis.

Exhibit 3: Cost Parameters for a Higher Cost Wind Project

Parameter	Assumption
Capital Cost (2009)	$3,025/kw installed
Fixed O&M Cost (2009)	$17.13/kW-year escalating at inflation
Variable O&M (2009)	$7.66/MWh escalating at inflation
Capacity Factor	33%
Project Size	25 MW
Capital Cost Recovery Factor	10%
Inflation rate	2%/year

Based on the above assumptions, the real levelized cost of wind power using the above assumptions and Hydro-Quebec Distribution's discount rate would be $103/MWh, with a levelized cost of $120.54/MWh.

E. Transmission Costs

The majority of the cost information presented in the previous section of the report includes only the plant-gate costs and do not include transmission costs or wind integration costs that are sometimes included in bid evaluation. These costs are important because the evaluation of offers generally includes both plant-gate or busbar costs plus transmission costs. Unfortunately, transmission costs vary by project and location.

As previously noted, BC Hydro adds several cost adjustments to the plant-gate price for purposes of calculating a Firm Energy Price for comparing bids with different attributes and project location. The price adjustments used by BC Hydro for bid evaluation purposes include:

- Cost to deliver the power to the Lower Mainland;
- Hourly firm price adjuster for projects that deliver flat hourly firm energy (negative adjuster from the price bid);
- Wind integration charge of $10/MWh;
- Network upgrades based on interconnection studies;
- Cost of incremental firm transmission;
- Energy losses.

Based on Exhibit 2, the difference between the weighted average Levelized Firm Energy Price and the weighted average Levelized Plant Gate Price is $23.40/MWh. If the

$10/MWh wind integration cost is subtracted out of this total, transmission related costs would be $13.40/MWh.[10]

Also, based on transmission cost reports in California, it is estimated that a reasonable estimate of transmission related costs is approximately $14.50/MWh. Based on Merrimack Energy's involvement as Independent Evaluator on utility solicitations, we are not aware of many wind projects which incur over $20/MWh for transmission related costs and are successful in competing in such processes.

F. Conclusions

Exhibit 4 provides a compilation of the real levelized costs wind projects based on benchmark cost data. Some of the studies/reports referenced earlier in this report are not included based on the reported information reflecting outlier costs. In addition, we are adding a high end transmission cost of $20/MWh to establish a total cost benchmark for wind.[11]

Exhibit 4: Benchmark Costs for Wind Projects - Real Levelized Cost

Example	Plant-Gate Price ($/MWh)	Transmission Charge ($/MWh)	Total Cost ($/MWh)
Ontario FIT	$118.95	$15.00 - $20.00	$133.95 - $138.95
Vermont FIT	$96.11	$15.00 - $20.00	$111.10 – $116.10
Rhode Island FIT	$98.25	$15.00 - $20.00	$113.25 - $118.25
BC Hydro Plan Gate	$103.10	$15.00 - $20.00	$118.10 - $123.10
Portland General Mid-point	$104.50	$15.00 - $20.00	$119.50 - $124.50
Weighted Average of Small Wind Proposals	$92.28	$15.00 - $20.00	$107.28 - $112.28
NB Power	$96.62	$15.00 - $20.00	$116.62 - $121.62
Generic Cost Analysis	$103.00	$15.00 - $20.00	$118.00 - $123.00

As the results presented in Exhibit 4 illustrate, the majority of the plant gate costs for wind projects is in the $90 to $105/MWh range. If the high end transmission cost is added, total costs for wind would be in the $110 to $125/MWh range. The FIT rates in Ontario are outside the range and therefore offer a high end estimate.

[10] The hourly firm energy price adjuster is assumed to be $0 for wind.
[11] The analysis assumes that the Canada/US exchange rate is at parity, which has been the case during preparation of this report.