

**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 Wind Power***

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# The Competitive Cost of Wind Power in Other Power Markets

## 1. Introduction

The Regie de l'energie (Regie) requires that Hydro-Quebec Distribution undertake a comparative analysis of the cost of power from the bids selected through the A/O 2003-02 Wind-Generated Electricity Call for Tenders process relative to the cost of power for similar products from neighboring Northeast markets. 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 2003-02 with the cost of wind-generated electricity in other North American markets as a benchmark cost plus the cost of transmission for delivering power from neighboring markets to Quebec.

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), 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.

According to the United States Federal Energy Regulatory Commission (Assessing the State of Wind Energy in Wholesale Interstate Markets; Docket No. AD04-13-000, November 22, 2004), the installed capital cost for wind energy systems has decreased significantly since the early 1980's, from over \$2,000/kW to the current level of approximately \$800 to \$1,100/kW in US dollars. The installed capital cost depends upon the size of the wind installation, the difficulty of construction, and the cost of any supporting infrastructure. Larger wind farms can take advantage of economies of scale, thus lowering the installed costs. Wind facilities located at more remote sites with the need for transmission upgrades or at more mountainous sites are likely to have higher capital cost.

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 have generally standard design and consistent cost characteristics, the economics of wind generation can vary considerably.

The recent Staff Briefing Paper by the Federal Energy Regulatory Commission on wind (Assessing the State of Wind Energy in Wholesale Electricity Markets) highlights the variability of wind project costs:

Projecting revenues for wind generation is harder than for typical generation sources because of higher variability of production. The variability of production is highly dependent on wind speed – a 2 mph difference can change the economics of a facility significantly. For example, according to the American Wind Energy Association, a change in wind speed from 16 to 18.07 mph would result in a 144 percent increase in output and a 25 percent reduction in cost per MWh. (Page 23)

A number of recent studies, reports and articles in the US and Canada on wind power economics have estimated the real levelized cost of wind generated electricity within a fairly wide range from \$46-\$70/MWh (\$US) range with no Production Tax Credit and approximately \$35-\$50/MWh (\$US) with the Production Tax Credit (PTC). With no PTC, this translates to about \$62.50 to \$95/MWh in Canadian dollars (CAD), based on the exchange rate described in Section 2 of this report. For example, the American Wind Energy Association (AWEA) claims that state-of-the-art wind power plants can generate electricity for less than \$50/MWh \$US (i.e. \$48/MWh based on wind speeds of 7.15 m/s) or approximately \$68/MWh (CAD). Likewise, the Canadian Wind Energy Association pegs the cost of wind power between \$60/MWh to \$120/MWh (CAD).

As another example, a recent draft study by the Maine Public Utilities Commission entitled Report on the Viability of Wind Power Development in Maine (November 2004) concluded that the all-in, life-cycle cost for a moderately sized, wind generation facility is between \$60 and \$70/MWh (\$US) without the PTC (or \$81 to \$95/MWh CAD). With the PTC, however, the effective cost to a developer is likely to be between \$40 and \$50/MWh (\$US) or \$54 to \$67.50/MWh (CAD).

In addition, a number of general articles on wind power economics quote the cost of wind-generated electricity using existing wind generation technology at approximately \$50/MWh (\$US), which is equivalent to about \$68/MWh (CAD).

The American Wind Energy Association also estimated that the cost of wind power in New England would range between \$60 to \$70/MWh (\$US). AWEA stated that wind farms in New England are likely to be smaller, experience lower wind speeds, and cost more to install due to the terrain in the region.

Although it is difficult to conduct a consistent and equivalent evaluation of wind projects, Merrimack Energy has developed a reasonable approach for conducting the comparative cost assessment required by the Regie. The methodology undertaken by Merrimack Energy assesses the competitive cost of long-term power from the winning bids from Hydro-Quebec Distribution's Call for Tenders for wind-generated electricity (including transmission costs) with general industry cost data as well as a sample of other wind projects proposed and developed in other North American markets on a real levelized

cost basis over a 20 year term. The analysis also includes the cost of transmission from neighboring Northeast markets to Quebec.

## **2. Methodology/Approach**

As noted, the competitive cost analysis includes two assessments: (1) an assessment of the reported cost of wind power from recently completed reports, studies and other public information; and (2) calculation of the real levelized cost for a sample of wind projects located in North America, only a few of which are located in the Northeast. The latter analysis is based on modeling the bid price or contract price formulas for sample bids based on the assumptions used by Hydro-Quebec Distribution in evaluating the bids received in response to the Wind-Generated Electricity Call for Tenders. For wind project prices quoted in US dollars, the prices have been converted to Canadian dollars using the average exchange rate for the two week period prior to the June 15, 2004 closing date for the Wind-Generated Electricity Call for Tenders. Since it can be expected that bidders likely refined their pricing up to the time bids were submitted, the use of the exchange rates during the two week period prior to bid submission is a reasonable representative of the rates in effect. This allows for a consistent evaluation using the same set of market assumptions. However, it is important to note that the capacity factors of various bids may differ which could influence the cost comparison.

To allow for a consistent evaluation, the cost of US projects that are dependent on receipt of the recently extended Production Tax Credit (PTC) for wind generation is adjusted by adding back the PTC for the first 10 years of the project life. Section 3 of this assessment provides a more detailed discussion of the impacts of the PTC on project costs. In addition, all projects are compared without inclusion of transmission-related costs. Transmission costs are included in assessing the cost of power delivered to Quebec.

## **3. Levelized Cost of Wind Power**

To conduct the competitive cost analysis (comparison of the projects selected in Hydro Quebec Distribution's Wind-Generated Electricity Call for Tenders with other market indicators), several adjustments had to be made to compare the costs on an equivalent basis. The primary adjustment is to include the impacts of the US production tax credit and any state incentives into the project price for US projects since the projects selected by Hydro-Quebec Distribution did not include comparables subsidies. The Production Tax Credit (PTC) is a US federal subsidy, currently \$18/MWh (\$US), guaranteed over the first 10 years of production. The tax credit was originally \$15/MWh, but escalates by inflation annually, which results in the current rate of \$18/MWh. The PTC applies to each kWh of electricity produced from wind energy and sold to unrelated parties during the first ten years after the facility is placed into service. The PTC, therefore, has the effect of reducing the cost of wind energy by almost \$20/MWh during the first 10 years of operation. Without the PTC, wind energy would have had to be priced higher to justify project development in most cases.

Another subsidy available to developers of wind projects in the US with income to shelter is the 5-year double declining balance accelerated depreciation available for facilities using wind to produce electricity. Wind farm owners can recover their capital investment in 5 to 6 years with over 50% recovered in the first two years or less. Canada also offers similar accelerated depreciation for wind facilities.

The first analysis summarized in Table 1, provides a comparison of the cost of wind power based on several studies and reports. Based on the results of these studies and reports, a cost for wind power in the \$45-\$60/MWh range (without the PTC) appears reasonable. This is equivalent to \$61-\$81/MWh in Canadian dollars. The Platts estimates appear low because the analysis is based on an annual capacity factor of 40%, which is quite high on average for wind projects. Thus, for comparative purposes, a market price in the \$60 to \$80/MWh range (CAD) appears reasonable for general comparative purposes, although several studies report an upper range higher than the \$80/MWh level identified above. A brief description and reference for the articles, studies, and reports used to generate Table 1 is included in Appendix A.

**Table 1**

**Cost Comparison – Wind Power Economics**

<b>Study/Report</b>	<b>Average Cost \$/MWh US</b>	<b>Average Cost \$/MWh CAD</b>
<b>AWEA</b>	\$48.00	\$65.20
<b>Platts</b>		
With PTC	\$35.00	\$47.56
Without PTC	\$46.00	\$62.50
<b>State of Maine</b>		
With PTC	\$40-\$50	\$54-\$68
Without PTC	\$60-\$70	\$81-\$95
<b>Canadian Wind Energy Association</b>	\$44-\$88	\$60-\$120

Table 2 provides a summary of the real levelized costs (in 2007 \$) for the bids selected by Hydro-Quebec Distribution relative to the real levelized cost of a sample of projects selected from the market. As this analysis illustrates, the real levelized cost of the two samples are fairly close, within 2%.

**Table 2**

**Real Levelized Cost Comparison  
(\$/MWh – CAD)  
in 2007 \$**

	<b>Average Cost</b>
Hydro-Quebec Distribution	\$65.00
Sample Projects	\$63.80

Furthermore, the average cost of the bids selected by Hydro-Quebec Distribution as illustrated in Table 2 are at the lower end of the range of costs identified in reports, studies, and articles regarding the generally accepted cost of wind power.

#### **4. Delivered Cost Assessment**

To accommodate delivery to the grid in Quebec from the selected wind projects, transmission system upgrades are required because the amount of generation added is quite high relative to the capability of the grid in the preferred area. Hydro-Quebec has estimated that the cost of interconnection and the cost of upgrading the transmission system to deliver the wind power into the grid would equate to \$13/MWh (CAD).

To undertake a comparative assessment of the cost of delivering power from Northeast markets to Quebec requires the calculation of transmission costs from each region to Quebec. Merrimack Energy has relied upon the approach undertaken in previous analyses to estimate the cost of transmission from each market.

For New England, the seller will have to contract for Through or Out Service with ISO New England, as well as contract with an owner of the New England/Hydro-Quebec Interconnection facilities to deliver power to the Quebec border. The combined rate for service is estimated to be \$31.20/kW-year (US\$) for the firm transmission capacity required to deliver the power.

In New York, the rate is a unit-based rate charged on the basis of the amount of Megawatt-hours delivered. The rate includes a basis from Zone A (likely area from which

the generation will emanate) to Zone M, an uplift charge, ancillary services, transmission service charge (TSC), NYISO cost of operation, and other charges included in the tariff. The latest transmission cost is estimated to be \$9.54/MWh (US\$).

The structure of the transmission charge for New Brunswick is similar to the New England transmission rate structure and is charged based on the level of contract requirements. The Ontario charge is similar to New York in that it is a unit charge based on the amount of power delivered.

The results of the comparative pricing analysis for the cost of the wind projects selected by Hydro-Quebec with the price of power from other markets are presented in Table 3. It is important to note that the cost of wind generated electricity from the market is based on a sample of bids from larger projects consistent with the size of the projects selected by Hydro-Quebec Distribution. Wind projects in the Northeast are generally smaller and more expensive due to the local wind regimes. Therefore, the comparative economics may be conservative since the costs reported are likely to understate the true cost for Northeast projects. As a result, a range of cost estimates is provided in Table 3, with the upper end of the range still on the conservative side for comparison purposes.

**Table 3**  
**Real Levelized Delivered Cost Comparison**  
**(\$/MWh – CAD)**  
**in 2007 \$**

<b>Region</b>	<b>Project Cost</b>	<b>Transmission Cost</b>	<b>Total Cost</b>
Quebec	\$65.00	\$13.00	\$78.00
New England	\$63.80-\$68.00	\$16.78	\$80.58-\$84.78
New York	\$63.80-\$68.00	\$14.74	\$78.54-\$82.74
New Brunswick	\$63.80-\$68.00	\$ 9.12	\$72.92-\$77.12
Ontario	\$63.80-\$68.00	\$13.01	\$76.81-\$81.01

## **5. Conclusion**

As illustrated in Table 3, the average cost of the selected bids (including transmission costs) is competitive with the sample of projects adjusted for transmission costs on a real levelized cost basis. However, in comparison with market studies and other reports, the cost of power for the projects selected by Hydro-Quebec Distribution is at the low end of the range compared to the State of Maine and Canadian Wind Energy Association studies and is comparable to the American Wind Energy Association estimates.

## **Appendix A: List of Studies, Articles and Reports on Wind Costs**

1. Maine Public Utilities Commission, Draft Report on the Viability of Wind Power Development in Maine (December 2004). Website reference is ([www.state.me.us/mpuc/](http://www.state.me.us/mpuc/)).
2. American Wind Energy Association Website ([www.awea.org/financing](http://www.awea.org/financing)). The website contains several articles and reports on wind power costs, including a summary of generation costs prepared by Platts
3. Canadian Wind Energy Association Website ([www.canwea.ca/en/faq](http://www.canwea.ca/en/faq))