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

Final Report

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Prepared by

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The Competitive Cost of Wind Power in North American Markets

1. Introduction

Hydro-Quebec Distribution has asked Merrimack Energy Group, Inc. ("Merrimack Energy") to update its benchmark analysis of the competitive price of wind-generated electricity in North American power markets to reflect most recent cost information for wind generated electricity. Although the pricing of wind-generated electricity will vary based on location (i.e. impact of the local wind regime on the capacity factor of a wind project as well as the cost differentials to construct a wind project in a specific region), Merrimack Energy will provide a perspective on recent market costs and prices for wind-generated electricity based on experience in various power markets, trends expected in market pricing, projects built or contracted and recent market studies which provide information on project costs and contract prices.

As previously noted, 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 in Quebec and benchmark resources very challenging.[1]

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. The methodology undertaken by Merrimack Energy is based on assessing the nominal and real levelized cost of wind generated electricity based on recent market information for wind-generated electricity costs. In this analysis, Merrimack Energy will rely on 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 electric 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.

[1] 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.

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.

A study by Bloomberg New Energy Finance, entitled "Sustainable Energy in America 2013 Factbook" published in January 2013, provides some interesting information on recent trends in the wind industry. For example, the study reports that global turbine prices have declined by roughly 40% over the 2009-12 timeframe. The study finds that keeping all other cost components equal, a 40% decline in turbine prices equates to a roughly 22% decline in the levelized cost of electricity for wind. Turbine performance has also improved, particularly for those proposed for low wind speeds. A 5% improvement in capacity factor, from an average of 30% to an average of 35%, drives down the levelized cost of wind by roughly 13%. The combined effect of a 40% decline in turbine prices and a 5% improvement in capacity factor yields more than a 30% decline in the average levelized cost of wind energy.

In the 2013 Benchmark Report prepared by Merrimack Energy, we also presented a summary of the key findings from a major study by Lawrence Berkeley National Laboratory entitled "2011 Wind Technology Market Report" on wind energy costs and trends in a report for the U.S. Department of Energy in 2012. The major findings applicable to Merrimack Energy's analysis are summarized below.

- Wind turbine prices in the US have continued to decline in 2012 and into 2013 with an average cost of approximately $1,200/kW in $2012;
- The average installed cost for wind projects was approximately $1,940/kW in 2012 down from the previous year, although the data presented illustrates that there were a number of projects in the $2,000/kW to $3,000/kW range;
- Regional differences in average wind power project costs are apparent. For the Northeast US for example the results illustrate that there were a number of projects with installed costs from $1,500/kW to $2,000/kW. On the other hand, it

appears there were more projects that came on line with costs in the range of $2,000/kW up to $3,500/kW. While the number of projects in each group is not presented by actual numbers, it does appear that more projects exceeded $2,000/kW based in interpretation of the graph contained in the report.

Updated information on wind energy costs since early 2013 appears to illustrate that installed cost declines have either continued or remained stable. For this analysis, Merrimack Energy's objective has been to assess how costs and prices have changed in the wind industry (particularly in the Northeast) and utilize such information as the basis for updating this Benchmark report on wind project costs.

3. Current Market Costs and Pricing

Since Merrimack Energy completed its previous Benchmark Report on wind generated electricity costs in June 2013 some additional publicly available information on wind project costs has been released. In addition, Merrimack Energy is also incorporating information illustrated in recent project solicitations to include revisions of previous analyses. Benchmark costs for wind projects defined in this assessment will be supported by the following sources of information:

1. Recent reports and studies in the US and Canada which focus on trends in wind-generated electricity costs;
2. Information reported by utilities for wind projects in other Request for Proposals or Call for Tender processes;
3. Prices for wind projects bid into recent Request For Proposal processes;[2]
4. Studies which provide estimated installed costs or levelized costs for wind projects;[3]
5. Prices for projects built or under construction if reported in publicly available sources.[4]

A. Recent Reports and Studies

The number of recent reports completed within the past year or so on the cost of electric generation options appears limited. While some reports provided estimated capital and O&M costs for wind projects, real or nominal levelized cost information was generally very limited. Nevertheless, Merrimack Energy's approach is to utilize the information available to either directly provide real or nominal levelized cost information or use high level capital and O&M costs to generate real and nominal levelized cost using standard methodologies. A few of the major studies which meet this criterion are summarized below.

[2] The specific projects and exact references are confidential.
[3] Generally, the results of the studies are not differentiated by project size.
[4] Merrimack Energy identified a number of wind projects either contracted and/or under development in Canada and conducted internet research on these projects but was not able to find recent cost information on any of the projects reviewed.

1. US Department of Energy Energy Information Administration Levelized Cost and Levelized Avoided Cost of New Generation Resources in the Annual Energy Outlook 2014

This report presents average values of levelized costs for generating technologies that are brought online in 2019. Levelized costs are presented in 2012 dollars. The study presents cost estimates for a broad range of generation technologies. According to the study approach, levelized cost of energy ("LCOE") represents the per-kilowatthour cost (in real dollars)[5] of building and operating a generating plant over an assumed financial life and duty cycle. Key inputs for calculating LCOE include capital costs, fuel costs (if applicable), fixed and variable O&M costs, financing costs, and assumed utilization rate for each plant type.

According to the study, the LCOE values shown are US national averages. However, there is significant regional variation in LCOE values based on local labor markets and the cost and availability of fuel or energy resources such as the availability of windy sites. For example, the study calculates the LCOE for incremental wind capacity coming on line in 2019 ranging from $71.30/MWh in the region with the best available resources in 2019 to $90.30/MWh in regions where LCOE values are highest due to lower quality wind resources and/or higher capital costs for the best sites that can accommodate additional wind capacity. Based on market information available, it is expected that prices in the average to high end of the price range are applicable for projects in the Northeast US.[6]

The study calculates an average real LCOE value for wind of $80.30/MWh in 2012 $/MWh, which is comprised of levelized capital cost of $64.10/MWh for capital cost, $13.00/MWh for Fixed O&M costs, and $3.20/MWh for transmission investment. The capacity factor of the wind project is assumed to be 35%.

The EIA study does not exactly correspond to the analysis prepared by Hydro-Quebec Distribution. For example, the EIA study is based on costs defined in 2012 dollars and a project entering service in 2019, while Hydro-Quebec's analysis is based on costs in 2014 dollars for projects going into service between December 2016 and December 2017. However, in Merrimack Energy's view the use of the EIA study results should provide a reasonable benchmark comparison analysis.[7] The use of the median real levelized cost of

[5] The levelized costs presented in the study are real levelized costs which are consistent with the real levelized costs calculated by Hydro-Quebec Distribution.

[6] The Department of Energy's 2012 Wind Technology Market Report prepared by Lawrence Berkley Labs concluded that lowest wind prices are in the Plains states and higher than average prices are in the West, Northeast, Great Lakes, and Southeast states.

[7] It would appear that the differences between the presentation of costs in the EIA study and Hydro-Quebec's analysis would tend to cancel out. For example, the real levelized cost calculated by the EIA of $80.30/MWh in 2012 dollars would be equivalent to $84.36/MWh in 2014 dollars. However, it is expected that the capital costs on which the real levelized costs are based would be higher for the EIA study since the projects are expected to enter service over two years after the projects offered into Hydro-Quebec's Call for Tenders, which should reflect higher installed costs.

energy of $80.30/MWh in US dollars in 2014 would seem to be a reasonable value for comparative purposes.

2. California Energy Commission Draft Staff Report – Estimated Cost of New Renewable And Fossil Generation in California – May, 2014

The California Energy Commission (CEC) issued a draft report in May of 2014 that includes capital and O&M costs for a range of generating technologies, including wind. Capital costs are presented for Class 3 and Class 4[8] one-hundred MW wind projects based on Low Cost, Mid-Cost and High Cost cases. The costs are reported in 2013 nominal dollars.

Table 1 provides a summary of the installed costs ($/kW), Fixed O&M costs ($/kW-year) and Variable O&M costs ($/MWh) for the three cases, all in 2013 dollars.

Table 1: Wind Project Cost Information – California Energy Commission Study

Resource	Installed Cost ($/kW)	Fixed O&M ($/kW)	Variable O&M ($/MWh)
High-Cost Case			
Wind – Class 3 – 100 MW	$3,744	$31.72	$10.57
Wind – Class 4 – 100 MW	$3,352	$31.72	$10.57
Mid-Cost Case			
Wind – Class 3 – 100 MW	$2,458	$31.72	$8.46
Wind – Class 4 – 100 MW	$2,208	$31.72	$8.46
Low-Cost Case			
Wind – Class 3 – 100 MW	$1,779	$31.72	$6.34
Wind – Class 4 – 100 MW	$1,563	$31.72	$6.34

3. Synapse Energy Economics – The Net Benefits of Increased Wind Power in PJM – May 9, 2013

Synapse Energy Economics was retained by PJM to prepare a report on the net benefits of increased wind power in the PJM region. The study examined the effects of roughly

[8] Wind resources are classified by the average wind speeds available on site. Class 4 wind resources have higher average wind speeds than Class 3. Both Class 3 and Class 4 wind resources are typical mid-range on-shore wind resources.

doubling the level of currently projected wind power in PJM by 2026. In conducting the study, one of the major inputs used by Synapse was the estimated capital cost of wind projects in PJM. In the report, Synapse provided a capital cost for onshore wind projects of $1,999/kW in 2012 dollars.

The data from the three studies shows a wide range of installed cost for wind projects, consistent with the actual historical range of costs as presented in the DOE report prepared by Lawrence Berkley Labs. These capital costs along with other capital cost assessments will be used as the basis for calculating the nominal and real levelized cost of energy in a separate section of this report.

B. Utility Cost Information

Another important source of information on wind project costs can be found in utility filings including Integrated Resource Plans ("IRP"). IRP's provide a detailed assessment of supply-side and demand-side options reasonably available to meet the resource requirements of the utility over a longer-term planning horizon (i.e. 20 years). An important aspect of this analysis is an identification of the costs and attributes of a range of different resource options. Merrimack Energy has reviewed a few recent resource plans prepared by utilities with a number of wind contracts in their resource mix as an indicator of the expected cost of new wind generation.

For this analysis, Merrimack Energy has relied upon recent Integrated Resource Plan filings of PacifiCorp and Puget Sound Energy. These utilities were chosen because they have very sophisticated resource planning processes with significant review of the process and are located in regions that have wind resource characteristics and project costs that are generally similar to the Northeast. Table 2 presents the estimated capital cost and O&M cost assumptions for wind projects included in the IRP for each utility.

Table 2: Capital and Operating Costs for Wind Project – Utility IRP Assessment

Wind Cost Information - $2012	PacifiCorp	Puget Sound Energy
Capital Cost ($/kW)	$2,138 - $2,365	$2,437
Fixed O&M ($/kW-year)	$33.11/kW-year	$29.20/kW-year

As another recent example of project specific capital costs for a wind project, First Wind reported that its 148 MW Oakfield Wind Project in Aroostock, Maine closed financing in May 2014 at a total construction cost of $369 million or $2,493/kW.

C. Solicitations for Power Supply

Merrimack Energy has participated in several power procurement solicitation processes in western regions of the US over the past year. Pricing that we have seen in these solicitations have generally averaged around $70/MWh nominal levelized. In one recent solicitation, we have seen bids closely bunched around $70/MWh, while for another solicitation the prices ranged from a low of around $60/MWh levelized to a high of approximately $85/MWh, with an average of approximately $71/MWh.

Another source of information is related to high level reports regarding the cost of wind generated electricity from a recent RFP issued jointly by Massachusetts utilities[9] in April 2013 to meet Massachusetts Green Communities Act targets. The April 2013 RFP targeted the purchase of 1.8% of the utilities' total annual distribution load under PPAs for renewable energy, renewable credits, or both, corresponding to approximately 850,000 MWh per year (equivalent to approximately 300 MW). The duration of the PPAs sought was from 10 to 20 years.

In a November 2013 report of the US Department of Energy Wind and Water Program – WINDExchange it was reported that Massachusetts regulators and the investor-owned utilities announced that they had received 40 proposals and have negotiated power purchase agreements (PPAs) for 565 MW of electricity capacity from existing and proposed wind farms in New Hampshire and Maine that would provide electricity at wholesale rates of approximately $80/MWh.[10] The $80/MWh does not reflect the cost of transmission upgrades necessary to integrate these projects into New England's electricity grid. The projects selected and the size of the projects is listed in Table 3.

Table 3: Projects Contracted by Massachusetts Utilities - 2013

Developer	Project Name	Net MW	Term	Location
Exergy	Peskotmuhkati Wind Farm	20	20	Columbia Falls, Maine
Exergy	Passamaquoddy Wind Farm	38.2	15	Columbia Falls, Maine
Iberdrola	Wild Meadows Wind	75.9	15	Grafton County, NH
Iberdrola	Fletcher Mountain Wind	97.1	15	Somerset County, Maine
First Wind	Oakfield Wind	147.6	15	Oakfield, Maine
First Wind	Bingham Wind	186	15	Mayfield Township, Maine

[9] The utilities who were involved in the RFP included Unitil, National Grid, NSTAR Electric, and Massachusetts Electric Company.

[10] Contract pricing is not publicly available. Merrimack Energy is assuming that the reported average price is levelized in nominal dollars.

The same DOE report also noted that Connecticut Power and Light and United Illuminating also completed a solicitation process in 2013 that resulted in selection of a 250 MW wind farm called the Number 9 Wind Farm developed by EDP Renewables in Aroostook County, Maine. No pricing was identified.

D. Methodology for Estimating Wind Generation Costs

In previous Merrimack Energy Reports on the Competitive Cost of Wind-Generated Electricity, 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 recent market information from other studies and reports as well as our own information gathered through regular involvement in the market. To calculate the levelized cost of wind power we have relied upon the following formula for calculating the levelized cost of wind power: Cost of Energy = ((Capital Cost x Capital Cost Recovery Factor) + Operating Costs))/Energy Production), with the Capital Cost Recovery Factor set at 10% which generally represents the annualized capital cost recovered for the return on and of investment.

Given the range of capital costs for wind projects as presented in various studies and publications, Merrimack Energy view is that conducting such analysis using a range of capital cost values based on a 10% capital cost recovery factor will provide a reasonable range of levelized costs for wind projects in areas similar in cost structure to the Northeast.

Based on recent information, Merrimack Energy has dropped the lowered end of the range for capital costs of wind power slightly from our June 2013 report from $2,000/kW in the June 2013 report to $1,950/kW in this report. In addition, based on improvements in technology and the use of larger blades, we are seeing slight improvements in the capacity factor for wind projects. The assumptions utilized are summarized below.

Exhibit 4: Input Assumptions and Cost Parameters for Wind Projects

Parameter	Assumption
Capital Cost (2014)	$1,950/kW to $2,500/kW installed[11]
Fixed O&M Cost (2014)	$33.00/kW-year escalating at inflation
Capacity Factor	30% - 35%
Project Size	100 MW
Capital Cost Recovery Factor	10%
Inflation rate	2.0%/year

The fixed O&M cost of $33.00/kW-year escalating by inflation previously used by Merrimack Energy appears to be very consistent with the O&M costs reported in other studies.

[11] The median value within this range is $2,225/kW.

Table 5 provides the nominal and real levelized cost of energy calculated under a range of capital cost assumptions identified above. Each capital cost case is evaluated based on a 10% capital cost recovery factor. All cases assume the Fixed O&M cost is the same as is included in Table 4. The capacity factor assumed for all cases is 35% which may be high for projects in the Northeast.

Table 5: Nominal and Real Levelized Costs for Wind Generated Electricity

Capital Cost	Capital Cost Recovery Factor	Nominal Levelized Cost of Energy ($/MWh)	Real Levelized Cost of Energy ($/MWh)
Low Case			
$1,950/kW	10%	$76.20	$63.30
Mid Case			
$2,225/kW	10%	$85.17	$70.90
High Case			
$2,500/kW	10%	$94.14	$78.20
Massachusetts Utilities		$80.00	$66.15

The range of capital costs included in the above analysis is generally consistent with the recent studies and projects reviewed and evaluated. The capital costs of all projects and studies evaluated fall within the above range with the exception of the California Energy Commission low case.

E. Comparison of Market Prices to the Results from the Call for Tenders

Hydro-Quebec Distribution selected three projects from the Wind-Generated Electricity Call for Tenders (A/O 2013-01) for a total of 450 MW of Installed Capacity totaling 446.4 MW at a real levelized cost of $70.64/MWh (Cn$) prior to including transmission upgrade costs and $75.58/MWh (Cn$) including transmission upgrade costs. The comparative metrics compiled by Merrimack Energy don't explicitly include transmission upgrade costs and generally represent costs at the plant site. As a result, we feel the appropriate metric is to compare the real levelized cost from the Call for Tenders without transmission upgrade costs relative to the real levelized costs presented in Table 5 above. In addition, the representative costs in Table 5 are in US dollars. If the real levelized costs in US dollars are converted to Canadian dollars using the exchange rate in effect at the time bids were due on November 5, 2014 (i.e. 1 Cn$ = .8875 US $) would result in the real levelized cost from the portfolio of bids selected to be lower that even the low capital cost case, i.e. $63.30/MWh (US $) for which the real levelized cost would be $71.35/MWh (Cn$).

F. Conclusions

The results of the analysis clearly demonstrate that the real levelized average cost of the wind projects selected from the Wind-Generated Electricity Call for Tenders is competitive with and actually lower than the real leveized cost for wind-generated electricity in other neighboring markets in North America. While Merrimack Energy was able to secure limited cost information on other projects in the Northeast and neighboring markets to Quebec, we feel that the capital costs and fixed O&M costs reflected in the analysis is representative of the range of market price of wind in these markets and supports the assumptions made in the analysis regarding capital and O&M costs. Furthermore, a comparison of the real levelized costs of the portfolio of projects selected by Hydro-Quebec is similar to or lower than benchmark costs of wind energy in other markets, which illustrates the value and benefit of the projects selected.

The Competitive Cost of Wind Power

June, 2013

Prepared by

Merrimack Energy Group, Inc.

The Competitive Cost of Wind Power in North American Markets

1. Introduction

Hydro-Quebec Distribution has asked Merrimack Energy Group, Inc. ("Merrimack Energy") to conduct a benchmark analysis of the competitive price of wind-generated power in North American markets. Although the pricing of wind-generated electricity will vary based on location (i.e. impact of the local wind regime on the capacity factor of a wind project), Merrimack Energy will provide a perspective on recent market costs and prices for wind-generated electricity based on experience in various power markets, trends expected in market pricing, projects built or contracted and recent market studies which provide information on project costs and contract prices. Since Hydro-Quebec Distribution has issued Call for Tenders ("CFT") for wind power on three occasions dating back to 2005, the report will also provide a perspective on the trends in wind project costs as a basis for assessing expected current market prices.[1]

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 in Quebec and benchmark resources very challenging.[2]

Compounding the locational issues associated with wind energy economics, several states in the US and Canadian Provinces rely heavily on Feed-in Tariffs as the preferred means to procure renewable energy. A consistent problem with Feed-in Tariffs is that prices are generally established based on estimates at a point in time and therefore do not effectively adjust to actual market conditions. A good example is Ontario where Feed-in Tariff prices for wind power have generally remained very high even as turbine costs, capital costs for wind projects and the cost to produce energy from these projects have declined in the past few years.

[1] The first Wind Call for Tenders issued by Hydro-Quebec Distribution for 1000 MW (Wind Generated Electricity for 1,000 MW of Capacity – A/O 2003/02) was issued in 2004. The average commodity price (not including transmission costs) was $75.80/MWh levelized in 2013 dollars. The second Wind Call for Tenders issued in 2007 for 2000 MW (Call for Tenders for the Purchase of Wind-Generated Electricity for a Total of 2,000 MW of Installed Capacity – A/O 2005-03) had an average commodity cost of $99.00/MWh not including transmission costs in 2013 dollars. The Call for Tenders for Wind-Generated Electricity from Aboriginal Projects and Community Projects for 500 MW (A/O 2009-02) issued in 2010 resulted in contracts with an average price of $119.00/MWh not including transmission costs in 2013 dollars. While the pricing increased significantly for the last wind solicitation, it is important to note that the maximum project size under that solicitation was 25 MW. It is expected that there will be no maximum project size associated with this 2013 CFT.

[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.

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. The methodology undertaken by Merrimack Energy is based on assessing the real levelized cost of wind generated electricity based on recent market information for wind-generated electricity costs. In this analysis, Merrimack Energy will rely on 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.

A recent study by Bloomberg New Energy Finance, entitled "Sustainable Energy in America 2013 Factbook" published in January 2013, provides some interesting information on recent trends in the wind industry. While several of the trends will be discussed in a separate section of this report, the information provided on wind energy economics offers valuable insight. For example, the study reports that global turbine prices have declined by roughly 40% over the 2009-12 timeframe. The study finds that keeping all other cost components equal, a 40% decline in turbine prices equates to a roughly 22% decline in the levelized cost of electricity for wind. Turbine performance

has also improved, particularly for those proposed for low wind speeds. A 5% improvement in capacity factor, from an average of 30% to an average of 35%, drives down the levelized cost of wind by roughly 13%. The combined effect of a 40% decline in turbine prices and a 5% improvement in capacity factor yields more than a 30% decline in the average levelized cost of wind energy.

3. Market Conditions at Time of Previous Wind Call for Tenders

Hydro-Quebec has issued three previous Wind Call for Tenders with different contract pricing and offers by the bidders, likely reflecting market conditions and costs for turbines and other capital costs at the time of the solicitation. Exhibit 1 provides a summary of the pricing of proposals selected via the Call for Tenders and the estimated capital cost for wind projects at the time the solicitation was undertaken.

Exhibit 1 – Contract Prices From Previous Hydro-Quebec Distribution Call for Tenders

CFT Timeframe	Contract Pricing ($2013 Cn) – Average price	Capital Cost of Wind Power Projects – US (nominal dollars)
1,000 MW Wind Call for Tenders – A/O 2003/02 - 2004	$73.00/MWh	$1,250
2,000 MW Wind Call for Tenders – A/O 2005-03 - 2007/2008	$99.00/MWh	$2,000
500 MW Wind Call for Tenders – A/O 2009-02 - 2010/2011	$119.00/MWh	$2,200

A major report on the wind industry sponsored by the US Department of Energy[3] entitled "2011 Wind Technologies Market Report" illustrates that at the time the initial 1,000 MW Wind-Generated Electricity Call for Tender was issued and implemented (2004), the capital cost of wind projects was at or near its lowest level over the recent 20 year period. Merrimack Energy's Report for Hydro-Quebec Distribution on the 1,000 MW CFT, entitled "The Competitive Cost of Wind Power" concluded that based on a sample of wind projects in other jurisdictions and the submission of bid responses, that the average

[3] While the Study was sponsored by the US Department of Energy, the primary authors of the study were Ryan Wiser and Mark Bolinger of Lawrence Berkley National Laboratory. As a result, references in this report to Lawrence Berkley National Laboratory and US Department of Energy may be used interchangeably.

capital cost in Quebec and neighboring regions was approximately $1,500/Kw installed, higher than the averages reported in the Study.[4]

At the time the 2,000 MW CFT was undertaken, both the capital cost of the wind projects had increased as well as the price of power secured under the contracts resulting from the CFT.[5] The DOE Study shows that wind project capital costs continued to increase in the 2007-2008 timeframe to around $2,000/kW. As a result, the contract price increased significantly as well. The study completed by Merrimack Energy for the 2,000 MW CFT provided a list of the capital costs for several projects in Canada and New England and while the results showed a wide range of project capital costs, the average would likely be at least $200/kW higher than the average capital cost presented in the DOE Study.

By the 2010-2011 time period at which the 500 MW CFT was undertaken, the capital cost of wind projects peaked at approximately $2,250/kW. The installed costs began to decline starting in 2011. By 2012, capital cost of wind projects had declined to about $1,800 according to the US DOE study.

In conclusion, based on the results from the three Hydro-Quebec Distribution Wind Call for Tenders, it appears that the trends in pricing and installed wind project costs in Quebec generally follow the market trends. However, based on the results of Merrimack Energy's analysis, it appears that the installed costs in neighboring markets to Quebec exceed the US average by at least $200/kW. As a result, we would assume a capital cost for projects bid into the upcoming CFT would be approximately $2000 to $2,100/kW for the most competitive projects, assuming that capital costs continue to experience a downward trend in price.

4. Current Market Costs and Pricing

Benchmark costs for wind projects defined in his assessment will be supported by the following sources of information:

1. Recent reports and studies which focus on trends in wind-generated electricity costs;
2. Information reported by utilities for wind projects in other Request for Proposals or Call for Tender processes;
3. Prices for wind projects bid in Request For Proposal processes;[6]
4. Studies which provide estimated costs (levelized costs) for wind projects;[7]

[4] This Report provides much more information from the Department of Energy study later in the Report.
[5] According to the US Department of Energy Study, "After hitting a low of roughly $700/kW from 2000 to 2002, average wind turbine prices increased by approximately $800/kW through 2008, rising to an average of more than $1,500/kW." The report also concluded that the installed cost of wind projects in the US lagged the cost of turbines by about two years. As a result, the installed costs of wind turbines likely peaked during the time between the second and third Wind CFTs.
[6] The specific projects and exact references are confidential.
[7] Generally, the results of the studies are not differentiated by project size.

5. Prices for projects built or under construction if reported in publicly available sources.[8]

A. Recent Reports and Studies

US Department of Energy 2011 Wind Technologies Market Report – August 2012

As noted, Lawrence Berkley National Laboratory prepared a major report for the U.S. Department of Energy in 2012 entitled "2011 Wind Technologies Market Report". The Report and associated presentation summarize trends in the U.S. wind power market, including information on wind installations, industry developments, project costs, O&M costs, performance, power sales prices, and market trends. The report included data from a number of sources including power purchase agreements in a number of regions of the US.[9] Provided below are the key summary points included in the report:

1. After hitting a low of roughly $700/kW from 2000 to 2002, average wind turbine prices increased by approximately $800/kW (>100%) through 2008, rising to an average of more than $1,500/kW. The increase in turbine prices over this period was caused by several factors, including: a decline in the value of the U.S. dollar relative to the Euro; increased materials, energy and labor input prices; a general increase in turbine manufacturing profitability due in part to strong demand growth and turbine and component supply shortages; increased costs for turbine warranty provisions; and an up-scaling of turbine size. Since 2008, wind turbine prices have declined substantially, reflecting a reversal of some of the previously mentioned underlying trends that had earlier pushed prices higher, as well as increased competition among manufacturers and a shift to a buyer's market. A number of turbine transactions announced in 2011 had pricing in the $1,150 to $1,350/kW range, while typical turbine prices in the US in the first half of 2012 were reported by Bloomberg New Energy Finance to be in the range of $900 to $1,270/kW depending on the technology. These figures suggest price declines of as much as 33% or more since late 2008, with an average decline closer to 20% for orders announced in 2011;

2. The average installed costs of wind power projects have declined dramatically. Whereas turbine prices peaked in 2008/2009, however, installed costs only started

[8] Merrimack Energy identified a number of wind projects either contracted and/or under development in Canada and conducted internet research on these projects but was not able to find recent cost information on any of the projects reviewed.

[9] For the study, Berkley Lab gathered price data for 96 US wind turbine transactions totaling 26,600 MW announced from 1997 through 2011, including 12 transactions summing to 2,630 MW announced in 2011. Sources of wind turbine price data vary, but many derive from press releases and news reports. Berkley Labs also compiled data on the installed cost of wind power projects in the United States, including data on 90 projects completed in 2011 totaling 6,402 MW, or 94% of the wind power capacity installed in that year. In aggregate, the dataset (through 2011) includes 564 completed wind power projects in the US totaling 40,022 MW, and equaling roughly 85% of all wind power capacity installed in the US at the end of 2011. The study also supplements data for 2011 and 2012 with wind turbine price quotes as reported by Bloomberg New Energy Finance.

to turn the corner in 2011, suggesting 2009/2010 as a likely peak. Average installed project costs lag average turbine prices and reflect the normal passage of time between when a turbine supply agreement is signed and when turbines are actually installed and commissioned. In 2011, the capacity-weighted average installed project cost stood at nearly $2,100, down about $100/kW from the reported average cost in both 2009 and 2010;

3. Falling wind turbine prices have begun to push installed costs lower;

4. Lower wind turbine prices and installed project costs, along with improved capacity factors, are enabling aggressive wind power pricing;

5. There is a substantial over-capacity of U.S. nacelle assembly capability in 2011, with even greater over-capacity possible after 2012;

6. Average installed wind power project costs exhibit weak economies of scale, at least at the low end of the project size range. Among the sample of projects installed from 2009 through 2011 there is a steady drop in per-kW average installed costs when moving from projects of 5 MW or less to projects in the 20-50 MW range. As project size increases beyond 50 MW, however, these data do not show strong evidence of continued economies of scale;

7. Installed wind project costs vary by region of the US, with installed costs generally higher in the East, California and New England. New England had the highest capacity weighted average installed costs over the 2009-2011 timeframe at nearly $2,400/kW (in 2011 dollars), more than $200/kW higher than the national average;

8. Newer projects appear to show improvements in operations and maintenance costs as well, with O&M costs for newer projects averaging around $10/MWh (although the authors note that the O&M costs reported do not include all operating costs);

9. Average capacity factors have also improved over time, but leveled off in recent years. The average capacity factor for 2011 was around 32% nationally;

10. Regional performance differences with regard to capacity factors are prevalent. For example, in the East, the average capacity factor in 2011 was approximately 26% compared to about 29% for New England. These regions had the lowest capacity factors;

11. Among a sample of PPAs signed in 2011, the capacity-weighted average levelized price was $35/MWh, down from $59/MWh for PPAs signed in 2010 and $72/Mh for PPAs signed in 2009. The lower PPA prices for 2011 reflect the fact that the vast majority of PPAs included in the study for 2011 were from the wind belt states;

12. For projects built in 2010 and 2011, the average price nationally in the US was approximately $77/MWh.

The DOE sponsored report is recognized in many other studies and articles reviewed for this analysis, indicating the widespread interest in the study's findings.

Bloomberg New Energy Finance Sustainable Energy in America 2013 Factbook – January 2013

As previously noted, the Bloomberg study provides updated information on wind energy costs and trends. Some of the key findings of the study with regard to wind-generated electricity include:

- The major federal subsidy for wind energy in the US was the Production Tax Credit ("PTC"), which was extended on January 1, 2013 for an additional year and with an important adjustment that will allow it to have market impact well into 2014. The incentive provided an income tax credit of roughly $22/MWh (indexed for inflation) for electricity generation for the first 10 years of the project's life;

- The availability of wind manufacturing capacity peaked in 2012. Alstom, Gamesa, GE, Nordex, Siemens, Clipper, Vestas, and Mitsubishi all received tax credits for building manufacturing facilities in the US, resulting in a surge in turbine supply and significant overcapacity, which eventually contributed to declines in turbine prices;

- Bloomberg estimates that wind turbine costs in 2013 will range from $1,050/kW to $1,300/kW;

- Pricing for PPAs has reflected the improving economics for wind. Pricing in Michigan, for example, is reported to have dropped from the mid-nineties in 2011 to the mid-sixties in 2012. In North Dakota, Kansas, and Oklahoma, PPA prices in 2012 were recorded in the low $30/MWh range and at least one contract was priced below $30/MWh, with the prices contingent on the PTC;

- A table in the study shows wind prices in California and the Southwest US ranging from $75 to $95/MWh, while prices in PJM have ranged from $50/MWh to $75/MWh. Other regions in the Midwest and SPP region have prices in the $30 to $50/MWh range;

- Low-priced power purchase agreements in markets with exposure to electricity prices – rather than feed-in tariffs – seem to have put further pressure on turbine contracts.

International Renewable Energy Agency – Renewable Energy Technologies: Cost Analysis Series – Wind Power, June 2012

The International Renewable Agency (IRENA) prepared a working paper on the international wind energy industry in 2012. The Findings of the study are presented below.

- Preliminary data for the US in 2011 suggests that wind turbine costs have peaked and that total costs could have declined to $2,000/kW for the full year (a reduction of $150/kW compared to 2010). Wind turbine costs account for 64% to 84% of total installed costs onshore;

- Operations and maintenance costs can account for between 11% and 30% of an onshore wind projects levelized cost of electricity. O&M costs for onshore wind farms in major wind markets average between $10.00/MWh to $25.00/MWh;

- The levelized cost of electricity from wind varies depending on the wind resource and projects costs. The levelized cost of energy typical of new onshore wind farms in 2010 assuming a cost of capital of 10% was between $60.00/MWh and $140.00/MWh;

- The potential for renewed cost reductions is good, as supply bottlenecks have been removed and increased competition among suppliers will put downward pressure on price in the next few years. Assuming that capital costs onshore decline by 7% to 10% by 2015, and O&M costs trend towards best practice, the levelized cost of energy of onshore wind could decline by 6% to 9%;

- The report provides a table providing a breakdown of costs for a typical onshore wind project. The results are summarized below.

Cost Item	Amount
Capital Investment Costs (US$/kW)	$1,700 to $2,450
Wind Turbine Cost Share (%)	65-84%
Grid Connection Cost Share (%)	9-14%
Construction Cost Share (%)	4-16%
Other Capital Cost Share (%)	4-10%

B. Utility Cost Information

Another important source of information on wind project costs can be found in utility filings including Integrated Resource Plans ("IRP"). IRP's provide a detailed assessment of supply-side and demand-side options reasonably available to meet the resource requirements of the utility over a longer-term planning horizon (i.e. 20 years). An important aspect of this analysis is an identification of the costs and attributes of a range of different resource options. Merrimack Energy has reviewed a few recent resource

plans prepared by utilities with a number of wind contracts in their resource mix as an indicator of the expected cost of new wind generation.

PacifiCorp

PacifiCorp serves seven states in the western US. In addition, PacifiCorp's parent company, Mid-American is a major developer/owner of wind projects. PacifiCorp has executed several contracts for wind-generated electricity with renewable energy project developers. In its 2012 IRP, PacifiCorp provides cost information for utility-scale wind projects in several locations of its service area by capacity factor. PacifiCorp provides capital cost and O&M cost estimates for these locations as well. PacifiCorp reports a base capital cost of approximately $2,200/kW installed and fixed O&M costs of $33.11/kW-year. At a 30% capacity factor PacifiCorp estimates a levelized cost of wind energy to be about $87/MWh while at a 40% capacity factor, the levelized cost drops significantly to $62.15/MWh.

BC Hydro

BC Hydro is in the process of completing its 2012 Integrated Resource Plan. Based on a study by DNV Global Energy Concepts to assess the wind resource potential in B.C., BC Hydro provides estimates of the levelized cost of energy for wind project potential in several transmission regions within British Columbia. BC Hydro provides a supply curve for wind energy in each region, which estimates the amount of wind that could potentially be produced at different price ranges. For the Peace River region, the region with the largest onshore wind potential, levelized costs started at a low of $95/MWh in $2011. The supply curve illustrates that approximately 6,000 MW of wind could be developed at prices between $95/MWh and $110/MWh. In all other regions, the lowest point on the supply curve or the price that could generate the initial MWs of wind power start at between $117 to $127/MWh.

Ontario Power Authority

The Ontario Power Authority (OPA) has relied on a Feed-in Tariff (FIT) program to procure renewable energy resources**.** For wind the Feed-in Tariff price has been $115/MWh with 20% of the rate escalating by the Consumer Price Index (CPI). However, the Ontario Government recently decided to end the province's FIT program for large scale renewable energy projects in favor of a competitive procurement mechanism. It is expected that under a competitive procurement mechanism, the cost of power will decline. According to a recent article, Ontario has renegotiated its original $9.7 billion energy deal with Samsung for wind and solar projects. Under the original deal, Ontario would pay Samsung $135/MWh for wind generated electricity. Under the renegotiation, the price for wind energy under the agreement has been reduced to $105/MWh,

Puget Sound Energy

Puget Sound Energy (PSE) recently filed its 2013 Integrated Resource Plan. For wind projects, PSE estimated a 2011 installed capital cost of $2,437/kW and a Fixed O&M cost of $28.07/kW-year, all in 2010 dollars.

Avista Utilities

Avista Utilities is in the process of developing its 2013 Integrated Resource Plan. Avista estimates the capital cost of wind projects to be $2,140 in 2013 dollars and a levelized cost of $115/MWh.

C. Solicitations for Power Supply

Merrimack Energy has participated in several power procurement solicitation processes in various regions of the US over the past three years. Pricing that we have seen in these solicitations have generally been in the $75/MWh to $95/MWh range on a levelized cost basis in current 2011 dollars. At 2% inflation, this would translate into a range of $78/MWh to about $99/MWh. Actually, the pricing reported by Bloomberg for California, the Pacific Northwest, and the Southwest conform very closely with the pricing for wind projects we have seen in these regions.

Massachusetts utilities were required to procure renewable power under long-term contracts (defined initially as 10 to 15 years) as part of the state's Renewable Portfolio Standard. The utilities issued a solicitation for renewable power in 2010. As we understand, pricing for the best wind projects ranged from a low of approximately $120/MWh to $145/MWh.

D. Methodology for Estimating Wind Generation Costs

In previous Merrimack Energy Reports on the Competitive Cost of Wind-Generated Electricity, 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.

The report by Lawrence Berkley Labs contains recent capital cost and operating cost information for wind projects. These assumptions are summarized below.

Exhibit 3: Cost Parameters for a Higher Cost Wind Project

Parameter	Assumption
Capital Cost (2012)	$2,000/kW to $2,200/kW installed
Fixed O&M Cost (2012)	$33.00/kW-year escalating at inflation
Capacity Factor	33%
Project Size	100 MW
Capital Cost Recovery Factor	10%
Inflation rate	2.5%/year

Based on the above assumptions, assuming a capital cost of $2,000/kW, the real levelized cost of wind power using the above assumptions and Hydro-Quebec Distribution's discount rate would be $68.25/MWh (US$), with a levelized cost of $83.50/MWh (US$). At a capital cost of $2,200/kW, the real levelized price would be $74/MWh while the levelized cost would be $90.41/MWh.

F. Conclusions

The information provided in this report regarding trends in capital costs of wind projects as well as the levelized cost of energy illustrates a wide range in project costs, generally driven by project location, capacity factor of the project, and any specific cost characteristics in the regional market. While it is difficult to define a specific market price, the information presented in fairly consistent with regard to capital cost, cost of turbines, and fixed O&M costs.

The cost evidence based on the capital cost and fixed O&M costs from the studies identified and the methodology implemented would result in a reasonable range of expected levelized costs of $85/MWh to $100/MWh.[10]

[10] Merrimack Energy has seen references to the termination of some tax credits for wind projects in Canada, If that is the case, we would expect a price at the high end of this range to be most applicable. As noted, the US still has a production tax credit that should effectively reduce the price of the project by over $20/MWh.