Project Report

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BC Hydro

Wind Project Cost Review for BC Update from 2015

Distribution
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1. Introduction

BC Hydro maintains an Integrated Resource Plan (IRP), which is a long-term strategic plan that is part of the Clean Energy Plan, to meet the province's energy needs. BC Hydro diligently works to keep its inventory of resource options that are considered in the IRP up to date and does so with technical expertise from industry.

Hatch was mandated by BC Hydro in 2015 to perform a review of costs associated with the development and construction of wind power projects in the province of British Columbia. The results were provided in the Hatch report titled *BCHydro Wind Project Cost Review* and dated May 19, 2015. BC Hydro used the results in the analysis of their updated long-term demand forecast and supply in 2016.

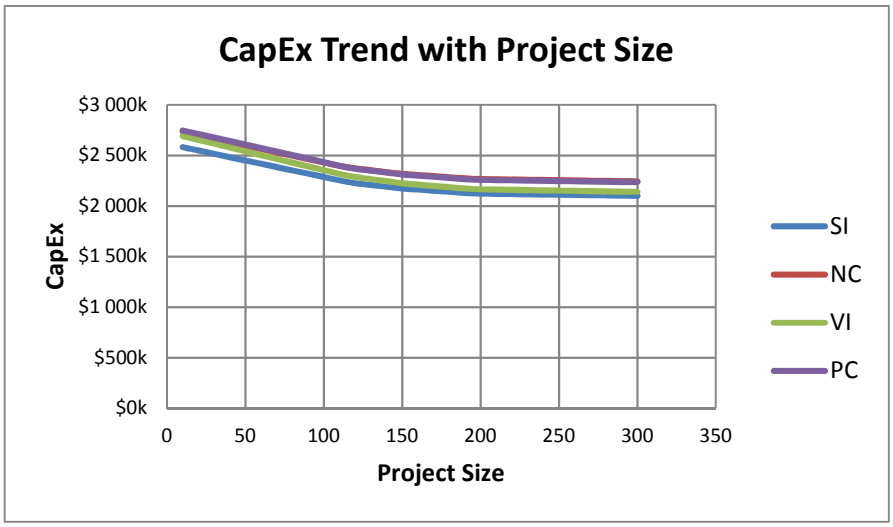
BC Hydro has requested Hatch to update its Wind Project Cost Review Report done in 2015. The objective of this update is to discuss the evolution seen by the wind industry in Canada over the last few years, and particularly how these changes may affect the cost review analysis provided in our 2015 report. Comments are offered for each of the costs breakdown for CAPEX, OPEX and BoP, as was the case in 2015.

2. Summary of 2015 Wind Cost Review

In our 2015 study, Hatch looked at the cost of wind projects in 4 separate regions of the province of BC in order to evaluate how much wind project costs could potentially differ in four areas of the province. The four regions considered include the Southern Interior (SI), the Peace Region (PC), the North Coast (NC) and Vancouver Island (VI). Costs were also evaluated using various project sizes in an attempt to account for economies of scale.

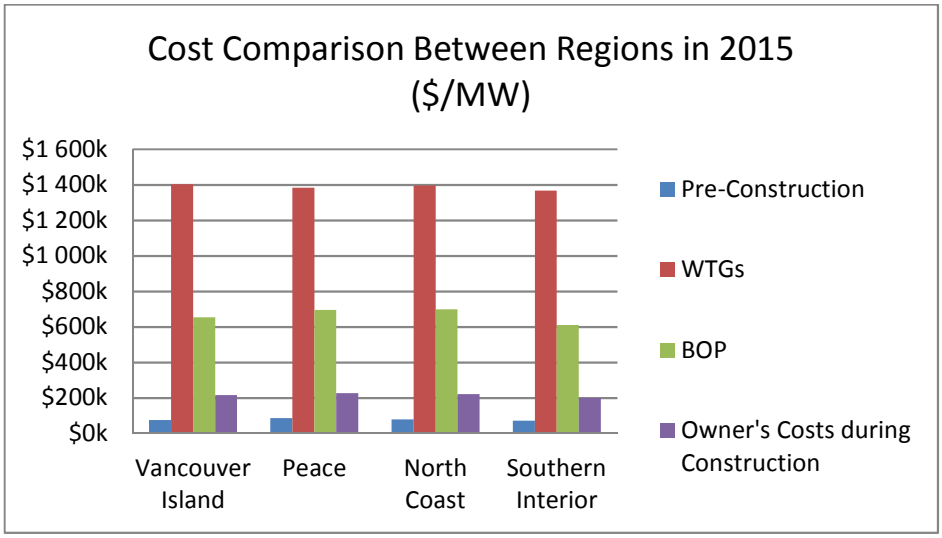
A 'base case' project was the list of project information in the resource option database (RODAT) provided by BC Hydro which includes 121 projects while considering various wind project aspects such a transmission line connectivity, project size, constructability, access, etc. Project costs were broken down into main components including Development (pre-construction) costs, turbine costs, BoP costs, owner's costs during construction and O&M.

The overall conclusions of the report showed that CapEx tends to decrease with increasing project size as shown in the following figure.



Note that this trend should not be used to complete a detailed cost review but can be used with caution to consider the overall impact of project size on wind project capital costs in BC.

The estimated costs per region are summarized in the following figure. Note that many assumptions were made in the evaluation of these costs and more detailed comments for each of the components considered are provided in Hatch's 2015 report.



This current study focusses more generally on how changes in the industry may influence the province as a whole, rather than per region. Comments are provided on a qualitative basis per major cost component rather than recalculating the breakdown of individual costs.

3. Cost Components

3.1 Development (Pre-construction) Costs

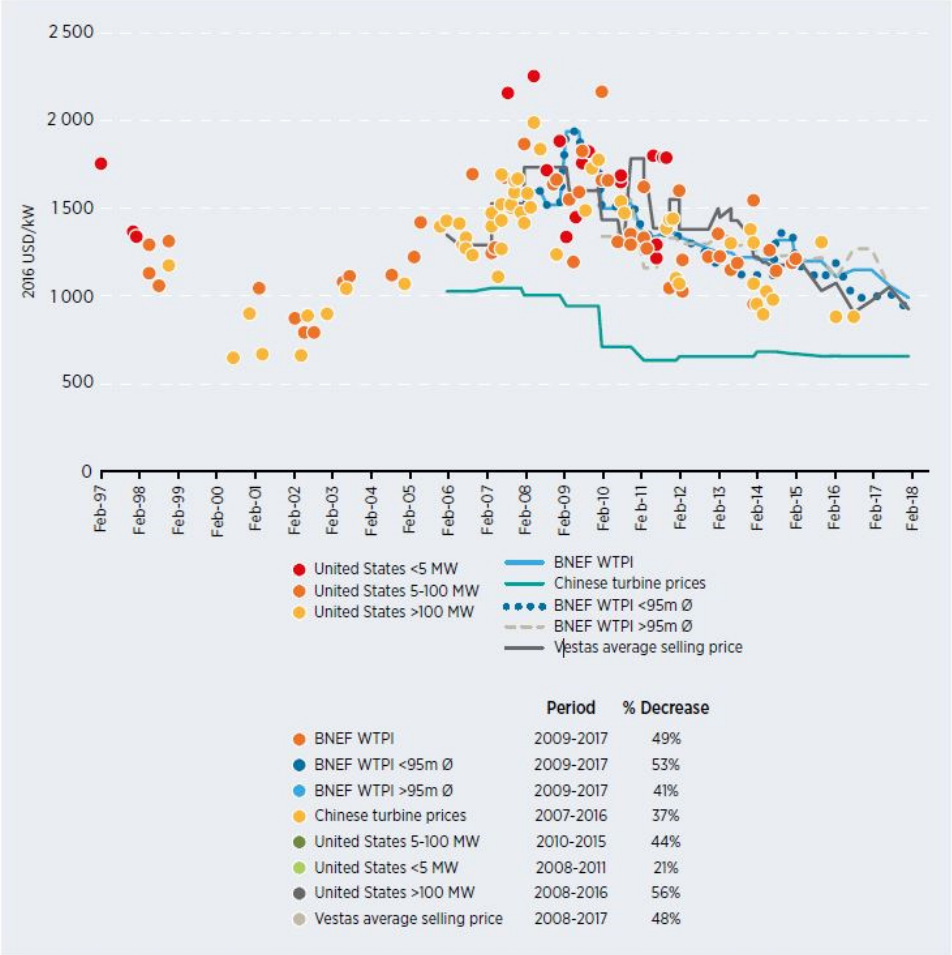
Pre-development costs are expected to have remained relatively stable since the same pre-construction work is still required and still implies a certain level of man hours. Feasibility studies, wind resource analysis, permitting, First Nations and community consultations, etc. are all still required and associated costs are not expected to have significantly changed.

3.2 Turbine Costs

As mentioned in Hatch's 2015 report, the cost of the turbines account for roughly 60% of the total wind project costs. Financial and political aspects continue to influence the costs of turbine components such as the strength of the wind market in the USA, supply and demand for components in a particular construction period, interest rates, currency exchange rates, commodity prices, turbines manufactured in China and other. All these factors continue to influence the price of wind turbines in Canada.

Hatch has seen costs decrease by approximately 7-10% in the last 3 years in Canada. This is based on project experience and discussions with developers reporting figures in CAD or USD, despite exchange rate fluctuations. As reported by IRENA (International Renewable Energy Agency), turbine costs have indeed been declining since they peaked between 2008 and 2010 in the United States. It appears that this trend holds during the 2015-2017 period.

The following figure is an excerpt from IRENA's report titled *Renewable Power Generation Costs in 2017*.



Sources: Wiser and Bollinger, 2017; CWEA, 2013; BNEF, 2016; Global Data, 2014 and Vestas Wind Systems, 2005-2017.

Figure: Wind turbine price indices and price trends, 1997 to 2017 (IRENA)

Among other factors, supply chain competition has markedly increased and is working in favour of lower turbine prices. Five to ten years ago, the turbine suppliers were hard to reach to even get a quote. Nowadays, the turbine manufacturers reach out to developers and consultants and want to present their latest products and discuss future opportunities in advance.

3.2.1 Exchange rates

Exchange rate fluctuations will also likely continue to have a significant impact on turbine cost from the time a PPA is signed to COD. These fluctuations can be rapid and extreme and this could continue to have an influence on the turbine costs in Canada given that the major turbine's original equipment manufacturers (OEM) still operate in the USA and in Europe with very little operations in Canada. It is likely that exchange rate fluctuations could have an impact as high as $150,000 to $250,000 per MW depending on the time of the TSA and the terms included in the TSA. These variations can significantly affect the turbine costs and consequently the financial viability of projects.

3.2.2 Turbine Supply Agreement

In our 2015 analysis, Hatch considered a project lifetime of 20 years and mentioned that OEMs predicted minimal impact and limited cost differences for project extension from 20 to 25 years. Hatch is now starting to hear about OEMs that offer products with a 30-year design life. Higher cost impacts can be expected for this longer lifetime but they can also be offset by more favourable terms being offered in the TSA, given the increase in OEM competition. Advantages that can be seen in the wind project costs could include shorter delivery lead times, more generous initial O&M contracts and perhaps even performance guarantees. However it remains a challenge to specifically quantify how these changes may directly affect turbine costs.

Hatch remains of the opinion that for projects where the turbine design is already on its design limits for the site, there will likely be a requirement for a turbine design assessment and/or upgrade and the costs to increase to 25-30 years lifetime could involve a 5 to 6% increase in the costs of the turbine.

3.3 BoP Costs

BoP costs are expected to have remained relatively stable since the associated civil and electrical works are all still required. The complex terrain in the province of BC remain the same and pose the same construction constraints and challenges. Acquired experience could prove to be valuable as this can potentially accelerate the construction schedule, increase efficiency and minimize potential construction delays.

3.4 O&M Costs

As mentioned in our 2015 report, O&M can cover a range of aspects from land rent, insurance, planned and unplanned servicing, spare parts, administration costs, etc. It is expected to see a slight rise in the costs for O&M for existing projects as the fleet of installed turbines continues to age but data with specific project O&M costs is hard to come by. It is also difficult to evaluate these costs against the potential gains from better energy production.

As stated in Hatch's 2015 report, the average total estimated fixed and variable O&M costs amount to about $70 to $ 82 per kW installed per year with slight variations depending on size of project and location, site accessibility, turbine type, project size, service agreement with the turbine vendor, etc. This estimate range is still considered valid for 2018 based on recent discussions with industry professionals.

General observations about the O&M market overall include the following:

- Producers are starting to focus more on condition monitoring and performance assessment in an effort to prevent down time and major component failure and increase energy production. These can lead to significant yearly investments and also potential increases in energy production.
- OEMs are constantly working on technology improvements that may result in less maintenance requirements and more efficient repairs when needed.
- Given the increased level of competition between OEMs, turbine suppliers may be inclined to offer more attractive initial O&M packages to ensure their turbines are used over the competitor.
- There has been an increase in the number of companies providing independent O&M services and these are also lending to a more competitive market to provide such services.
- The global O&M market is trending upwards as the fleet of installed turbines continues to age.

In considering the above points, there may be more ongoing investment for operational performance of a project with the expectation of increasing the energy production. A site specific cost-benefit analysis would be required to quantify the potential benefits.

4. PPAs

Note that a review of financing structures is not part of this scope and nor was it in Hatch's 2015 study. However, general comments are offered to discuss some key factors that can affect the cost of wind projects, including BC.

There are several factors affecting the price of wind projects and some of these include improved financing structures with increasing experience in electricity PPAs, growing investor confidence, increased industry maturity and policy support.

One of the most significant shifts seen in the Canadian wind market in the past 3 years is the price that utilities and generators establish in a PPA. Alberta's most recent auction in Round 1 of the Renewable Electricity Program (REP) has resulted in the lowest weighted average bid price ever seen in Canada for wind at 37$ per MWh. The bids were so attractive that the government is prepared to award contracts for 600 MW rather than the original 400 MW that had been planned. The purpose of the bidding competition is to drive the price of renewable projects down and this was certainly accomplished.

In discussing the results with other industry professionals, questions arise about how profitable such a low bid price can be. The details of the financial model are confidential so we can't really know.

What we do know is that the general market trend appears to be competitive auctions resulting in record breaking lowest bid prices for wind projects. This is what we are seeing in countries around the world including those that are new to renewable power projects, such as Mexico and Argentina. We are seeing the end of Feed-In-Tariff programs that have previously been adopted in places like Ontario and the phasing out of government incentives like the Production Tax Credit (PTC) in the USA. According to IRENA, at least 67 countries adopted renewable energy options by mid-2016 compared to 6 in 2005.

5. Conclusions

This brief report provides comments relating to wind projects costs and how these have changed over the past few years, since Hatch prepared a detailed cost review in 2015. The purpose of this report is to provide general information about how the Canadian wind energy industry is evolving and in particular how this evolution may potentially affect the cost of wind projects in BC.

Turbine prices continue to fall and this can contribute to lower wind project costs but it is not necessarily a linear relationship. There are risks associated with currency exchange rates and political influences affecting commodity prices and international trade tariffs.

Government and utility involvement in the PPA's is trending towards, if not already establishing, a competitive global market with auctions for lowest bid prices for electricity from wind. This is what happened in Alberta, resulting in the lowest prices for wind ever seen in Canada at 37$/MWh and the lowest in the world in Mexico at 17.7$/MWh.

Financing structures play an important role in these prices. For Canada, lenders are more willing to invest in wind now that it is an established market. In Alberta, where there is a very good wind resource and relatively easy accessible sites, the conditions may be more favourable for lower prices compared to BC. Debt versus equity ratios, current exchange rates and lower turbine prices will all factor in.

Terrain complexity remains a reality in BC. The best wind sites tend to be at higher elevation in remote locations and this will continue to contribute to higher wind project costs in BC compared to easier access sites in other regions of Canada.

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