


BC Hydro Wind Project Cost Review Final Report

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Disclaimer

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List of Abbreviations and Acronyms

BC	British Columbia
BoP	Balance of Plant
CAD	Canadian dollar
CAPEX	Capital Expenditures
COD	Commercial Operation Date
EA	Environmental Assessment
EPA	Electricity Purchase Agreement
EPC	Engineering, Procurement and Construction
EPCM	Engineering, Procurement, and Construction Management
ESA	Electrical Safety Authority
GALOO	General Area – Licence of Occupation
Hatch	Hatch Ltd.
IL	Investigative Licence
IRP	Integrated Resource Plan
MFLNRO	Ministry of Forests, Lands and Natural Resource Operations
MW	Megawatt
NPV	Net Present Value
NRCan	Natural Resources Canada
NREL	National Renewable Energy Laboratory
O & M	Operation and Maintenance
OE	Owner's Engineer
OEM	Original equipment manufacture
OPEX	Operating Expenditures
PPA	Power Purchase Agreement
RODAT	BC HYDRO Resource option data base
RFP	Request for Proposals
ROW	Right-of-Way
SIA/S	System Impact Assessment/Study
SOP	Standing Offer Program
TSA	Turbine Supply Agreement
WTG	Wind Turbine Generator

1. Introduction

BC Hydro maintains an Integrated Resource Plan (IRP), which is a long-term strategic plan to meet the province's need in electricity over the next 20 years. BC Hydro is in the process of updating its inventory of resource options that are considered in the IRP and has sought out technical expertise from industry.

Hatch has been mandated by BC Hydro to perform a review of costs associated with the development and construction of wind power projects in the province of British Columbia. These estimated capital and construction costs will be used by BC Hydro to evaluate the levelized costs of energy in the province.

This Report provides the results of a high level cost review for wind project development, construction and operation and maintenance (O&M) in BC. Section 2 provides a description of the scope of work. Section 3 presents the four regions of BC that have been considered and defines a base case project for each region. Section 4 describes the project components that have been considered and provides more details about assumptions made and related considerations. The cost estimates are provided afterwards in Section 5.



2. Scope of Work

The scope of work for this assignment is focused on estimating capital and construction costs as well as ongoing operating costs for wind projects in BC. Hatch's overall methodology is presented below and the sections thereafter provide comments on the various factors that have been considered and how they may influence these costs.

Hatch has endeavoured to gather updated information from various sources including turbine vendors, EPC contractors and developers as well as leveraging in-house knowledge and experience for the purposes of the study under the commitment to strict confidentiality. Individual source data has not been provided to BC Hydro to honour our confidentiality commitments and obligations.

Hatch has relied on its experience and knowledge of the BC wind market to estimate specific costs (in 2015 \$CAD) for major capital cost components for delivery in 2016. These specific components were agreed upon with BC Hydro in conversations throughout this mandate.

Cost estimates for wind projects in BC, elsewhere in Canada and the USA have been previously evaluated and some are publicly available. Hatch has used some of this information and has also gathered up-to-date information through interviews with various wind energy stakeholders. Hatch has received updated price information from various vendors and has validated these costs based on experience and knowledge of turbine supply agreements (TSA), balance of plant (BOP) costs estimates, geography, topography, logistic challenges, local market labour costs, regional considerations and local requirements.

Hatch has divided the cost components into 4 sections. The pre-development phase considers all aspects of the wind project prior to bringing it to the stage of financial close. The wind turbine generator (WTG) section considers elements related to supply, transportation, commissioning and other components of the TSA. The BoP section considers all activities related to the construction of the wind farm including turbine installation but excluding offsite roads and electrical infrastructure upstream of the project substation. The operations and maintenance (O&M) section considers all related costs required after the Commercial Operation Date (COD) to operate and maintain the wind farm for 20 years. Detailed comments about each of these factors that may affect costs are provided throughout this report.



3. Defining a 'Base Case' Wind Project per Region

As there exists no standard project which can be considered an 'average' or template Wind Project to establish average costs for an entire province, Hatch has defined a base case project for each of the 4 regions in BC that are being reviewed. These regions have been specifically identified by BC Hydro and each base case wind project was established in consultation with BC Hydro. The base case for each region was defined using 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 as a transmission line connectivity, project size, constructability, access, etc. The details considered for each region's base case will be described in the respective sections below.

As there exists many differences and options from one project to the next, and considering no two projects will be the same, Hatch needed to make some assumptions in order to establish a base case project. Some assumptions were different from one region to another while other assumptions were applied to all regions. The following assumptions were considered as common to all regions:

- 3MW turbine model
- On-shore projects
- Project lifetime of 20 years
- Crown Land only
- Costs in 2015\$ (CAD) assuming delivery in 2016
- Project development timelines can vary and the costs for pre construction of the template project will be based on 5 years of pre development work until reception of electricity purchase agreement (EPA) and beginning of construction
- When considering the developer's internal costs, Hatch has assumed a development model where all pre-development costs are absorbed by the same stakeholder that is involved in the later stages of the project, including development, procurement, construction, BOP, O&M, etc. This model was chosen over a model where, for example, a project has undergone some level of pre-development and then the project rights and assets are sold to a new stakeholder prior to construction or operation. Such transaction costs cannot be easily or simply quantified and so Hatch considered a simplified model for the purposes of this mandate. Costs associated with procuring assets from another developer are not evaluated.
- The developer is assumed to be experienced, working in a competitive market and to be medium or average in size (i.e. not a public utility and not a private, small scale independent developer with limited experience)



- Geotechnical conditions vary within each region and even within the same project and will impact BOP costs especially with regards to road and foundations costs. The road and foundations costs were based on soil conditions that can accommodate in-situ construction works with no considerable importation or exportation of material required. The soils are expected to provide adequate soil bearing capacity to support a gravity-based spread footing foundation of an industry-standard size but do not include costs provisions for blasting.
- In all cases (each region), the base case project did not include or require a base camp to be constructed/operated during construction. As well, the base case in all regions is considered to have good access via existing public roads and be located within reasonable proximity to services in a small community.

3.1 Vancouver Island

Vancouver Island is well-exposed to the weather coming from the Pacific Ocean. The potential wind project sites are typically located on plateaus, knolls or very wide ridges, which are covered with a combination of productive forest and bogs. The elevations range from 50 m to 500 m for coastal sites and up to 1200 m for two sites located on the mountain ridges. The productive forest consists of old growth forest and re-growth forest resulting from forestry activities. Vegetation is typically taller and denser as compared to sites located on the mainland. The majority of the potential sites are accessible via a network of logging roads; however, access to the transmission network is generally quite limited.

3.1.1 Vancouver Island 'Base Case' Wind Project

- Wind Farm Capacity of 48 MW - Based on median project size. Mean project size tends to skew the standard project to a size that is not supported by the majority of investigative use permits (IUP) or the majority of viable interconnection options.
- Number of turbines: 16
- IEC Class III- All but one project identified by BC Hydro are Class III
- Interconnection voltage of 138 kV - Most accessible interconnection voltage in proximity of majority of projects
- Terrain type is considered a plateau, based on input provided by BC Hydro. (Plateau being the most common type of project under development on Vancouver Island)
- Approximate area – we have considered that a General Area – Licence of Occupation (GALOO) of 200 hectares would be suitable for a 48 MW project
- Length of collector system: 16.6 km
- Length of new site roads: 17.5 km
- Length of existing roads likely subject to upgrade: minimal



3.2 Peace Region

The Peace Region is located in the northeast of BC. Proposed wind farm sites in Peace can be divided in two categories according to their geographical location. The first group contains sites located on the eastern mountain range in the northeast section of the Rocky Mountains. These sites are found on narrow ridges at elevations from 1400 to 2100 m. They are typically covered with low lying alpine vegetation or no vegetation at all. The access to roads and transmission for these sites is challenging. The second group of sites is located on the northeast foothills, east of the Rocky Mountains. Sites on the northeast foothills are typically located on wide rolling hills or plateaus covered with productive forest at elevations ranging from 800 to 1300 m. The majority of the potential sites in this group are easier to access and are in close proximity to transmission where the terrain is less challenging and there is a presence of other industries such as oil and gas.

3.2.1 Peace 'Base Case' Wind Project

- Wind Farm Capacity of 117 MW - Based on median project size.
- Number of turbines: 39
- IEC Class I - This is the most common wind class from the entire set as well as a smaller, screened set.
- Interconnection voltage of 230kV - Most accessible interconnection voltage in proximity of majority of projects
- Terrain type considered for the base case is on ridges (Ridges being the most common type of project under development in the region based on input provided by BC Hydro)
- Approximate area – we have used the assumption of 4 ha per MW for the wind project GALOO. In this case, we consider 468 ha.
- Length of Collector System: 38.3 km
- Length of new site roads: 37.1 km
- Length of existing roads likely subject to upgrade: 6 km

The base case site in this region is considered remote in terms of logistics but with good road access since sites are typically sharing lands with oil and gas operations or logging operations. A construction camp was not considered for the base case.

The density of oil and gas development and operations on available lands is likely to affect BOP costs as well as availability of ideal turbine positions which is likely to have an impact on overall economics but this cannot be estimated in generic terms. Similarly, BOP land requirements and costs are likely to be increased to some extent since ideal routing for BOP infrastructure is also likely to be affected by existing infrastructure.



3.3 Southern Interior

The Southern Interior region is bordered by the Rocky Mountains to the east and the Coastal Mountains to the west. The region extends south all the way to the United States border and to the north past Kamloops. The majority of the sites are located on high elevation plateaus or rolling hills that have wide ridges. The elevation ranges from 1400 to 2100 m and the majority of the potential sites are located at elevations between 1500 and 1700 m. These potential sites are typically covered with a combination of productive forest and clear cut areas that resulted from recent efforts by the Province to combat the pine beetle infestation. Logging roads provide access to the majority of the sites; however, transmission is more limited to the major transportation corridors, typically located along the highways and close to urban centers.

3.3.1 Southern Interior 'Base Case' Wind Project

- Wind Farm Capacity of 117 MW - Based on median project size.
- Number of turbines: 39
- IEC Class III
- Interconnection voltage of 138 kV - Most accessible interconnection voltage in proximity of majority of projects
- Terrain type considered for the base case is on a plateau
- Approximate area – we have used the assumption of 4 ha per MW for the wind project GALOO. In this case, we consider 468 ha.
- Length of Collector System: 23.8 km
- Length of new site roads: 32.3 km
- Length of existing roads likely subject to upgrade: 5 km



3.4 North Coast

The North Coast region is bordered by the Rocky Mountains to the east and the Pacific Ocean to the west. The region stretches past Prince George to the south. The potential sites can be divided into two types: coastal and inland sites. Coastal sites tend to be covered by stunted trees and bog vegetation, as they sit on low lying plateaus (at elevations up to 200 m) and are well exposed to the weather from the Pacific. The inland sites are found on the mountain ridges at elevations from 1300 to 1600 m. The ridges are typically covered with productive forest that has been cut as a result of forest activity. The inland sites are in general accessible via a network of forest roads, while the coastal sites are hard to access. The majority of the proposed sites in this region, especially the coastal sites, have very limited access to the transmission network.

3.4.1 North Coast 'Base Case' Wind Project

- Wind Farm Capacity of 195 MW - Based on median project size.
- Number of turbines: 65
- IEC Class III
- Interconnection voltage of 230 kV - Most accessible interconnection voltage in proximity of majority of projects
- Terrain type considered for the base case is on ridges
- Approximate area – we have used the assumption of 4 ha per MW for the wind project GALOO. In this case, we consider 780 ha.
- Length of Collector System: 55 km
- Length of new site roads: 68.6 km
- Length of existing roads likely subject to upgrade: 10.3 km



4. Cost Components

The following sections provide a summary of cost considerations used to evaluate the cost estimates for each of the region's base case project.

4.1 Development (Pre-Construction) Costs

4.1.1 Preliminary studies

Preliminary engineering studies could include geotechnical evaluations, preliminary civil and electrical diagrams, scheduling, equipment review and any other study included up to the specific design stage.

The wind resource assessment (WRA) would typically be included in this phase. These would include preliminary site selection, site visits, tower acquisition and installation, assuming an 80 m tubular tower with standard sensors and maintenance every 2 years. This can vary depending on number of years of the measurement campaign, options selected and number of turbines being considered. Costs could also vary if developers do some of this assessment work in house. Even though these costs have tended to increase with the increase in hub height, the WRA costs are small in comparison with other pre construction costs.

Costs here will also include studies for BC Hydro including owner's engineer model preparation, feasibility studies, system impact studies (SIS), facilities study and the consulting fees associated with these.

Environmental assessments, visual and noise impact studies are likely to vary a little depending on the size of the project, the amount of land use, the proximity to occupied private land and possibly the presence of sensitive ecosystems. The cost estimates below assume a base amount of \$350,000 plus an incremental amount for increasing size of the project.

4.1.2 Community Consultation and First Nation Engagement

The importance of early engagement of community and First Nations has been generally adopted by all developers as this early engagement can often reduce the risks of potential public opposition and improve the project's viability. Early engagement may increase the pre-development costs but it is expected to also decrease the risk of any major opposition to the project by engaging the local stakeholders and creating involvement in the project at the onset of pre-development. Many developers have experienced that 'engagement costs' could significantly increase as soon as there is any sort of opposition. Hatch has assumed that there is minimal opposition if community and First Nations are consulted and engaged from the very start.

It is not expected that community consultation and First Nation engagement will vary significantly per region if it is properly initiated in the very early stages of the project.



4.1.3 Land Costs and Permits

When reviewing the various regions and locations of potential projects in BC, the majority of wind projects are and will most likely be developed on Crown Land only and the costs related to the land lease and necessary permits are detailed in the document titled ‘*Crown Land Use Operational Policy : Wind Power Projects*’ issued by BC’s Ministry of Forests, Lands and Natural Resource Operations (FLNRO).

Land costs include permit fees during the wind measuring phase of the project as well as initial land leases during the operational phase. Ongoing land lease costs also apply and are discussed in the O&M section further in this report in Section 4.5

The estimated pre-construction land costs consider entitlement for 5 years.

Applications for approval from Transport Canada and NavCanada, the investigative licence (IL), the investigative permit and meteorological (met) tower licence of occupation are all fixed prices that are the same for all regions of BC and are considered minimal. Costs associated with the GALOO will vary per region based on the zone land value attributed to that region.

$$\text{GALOO Annual rental rate} = 7.5\% \times \text{zone land value} \times \text{land area}$$

The zone land values are outlined in the document titled ‘*Crown Land Use Operational Policy: Utilities*’ and are presented in the table below.

Table 1: BC Zone Land Values

Zone	Rate per hectare (Effective June 1, 2011)	Rate Used for Cost Estimate
A – Kootenay	\$1506	
B – Thompson/Okanagan	\$1557	\$1557 – Southern Interior
C – E. Island/Lower Mainland	\$3260	
D – Cariboo/Central Coast	\$1498	\$1498 – Vancouver Island
E – Omineca	\$799	\$799 - North Coast
F – Northern BC	\$680	\$774 – Peace Region
FA – Peace Block	\$867	



4.1.4 Owner's Costs Pre-Construction

These costs can vary significantly depending on the size, topography, soil, access and quality of the project, owners prioritization of one project versus other projects, whether the developer acquires the project from a third party, whether some of the activities are done in house or subcontracted, length of pre development and many other factors. The costs as identified in the costs table are based on a project being moderately challenging. We have included the salary for 2 people over 5 years plus various expenses, including legal, financial and sub contracts.

4.2 Turbine Costs

The turbine cost estimates are based on the most common contracting model and the most typical turbine scope of supply as provided by the turbine equipment manufacturers. The contracting model is based on a TSA providing for the supply and delivery of the turbine equipment, along with technical support and commissioning services. Separate complementary agreements exist for the BOP as well as the operations and warranty provisions of the turbines and wind farm.

No specific turbine model(s) was selected but a generic 3 MW turbine was used for the cost estimates for the base case for each region. For each region the base case project included review of the anticipated projects (based on the RODAT) as well as the likely turbine range to be provided. Concurrent with this review, Hatch conducted interviews with developers and turbine suppliers to determine the likely range of turbine models and key design parameters. Key parameters included primarily design class, generator capacity, rotor diameter and tower height.

4.2.1 Turbine Supply Agreement

The costs for the turbine scope of supply is largely based on a single TSA. The scope includes all the basic and necessary scope of supply. The costs of each turbine in the estimates below is based on a project life of 20 years.

As power purchase agreements for 25 years have become an option often considered by developers and utilities, this may impact the costs of the turbine and these costs would need to be reviewed on a site by site basis. Based on input received from original equipment manufacturer (OEM), the impact of project extension from 20 to 25 years could be minimal and involve limited costs. On the other hand, in projects where the turbine design is already on its design limits for the site, there may be requirement for design assessment and the costs to increase to 25 years could involve a 3 to 4 % increase in the costs of the turbine.

4.2.2 Delivery and Transportation

As most turbine prices are provided as “delivered”, it was necessary to break out the cost fraction due to delivery as this was identified as a highly variable factor in the cost of turbines in BC between each of the 4 regions. Costs then are denoted as having a separate delivery component, estimated and in addition to the base turbine equipment supply cost. The 4



regions in BC under study would all necessitate important transportation costs due to BC's distance from any major OEM facility. Based on information received, transportation of turbines to all 4 BC regions will range from 15 to 20 % of turbine costs or \$ 600,000 to \$700,000 per turbine dependant on region.

4.2.3 *Equipment and options*

The standard scope of supply for wind turbines generally includes only the required equipment in the base scope of supply. In addition to the base scope of supply, it is apparent that many developers are now opting for additional equipment and options that can provide better value in the overall operation. This may include items such as a cold weather package, condition monitoring and others. Hatch made the determination based on the base case as to which optional equipment and services would be likely to be considered as value added and so would likely be procured in the base case. For all regions, the base case included pricing for commissioning, installation, SCADA system and installation, spare parts package for initial delivery, cold weather package, bad weather day allocation, component storage, provision for aviation lights based on existing BC requirements and condition monitoring.

4.2.4 *Exchange rate variations*

Many, if not all, of the major turbine's OEM operate in the USA and in Europe with a few now having limited manufacturing operations in Canada. As the TSAs vary from one OEM to the next and pricing can often times be provided in Canadian or US dollars or a mixture of Canadian, US and Euro, we have established our base costs for all the base case projects on Canadian dollars. As can be seen when investigating exchange rates, fluctuations are now more rapid and extreme and this could have a significant impact on turbine cost from the time an EPA is signed to COD. The US \$ exchange rate with CAD \$ has varied by 23 % in last two years while the Euros and CAD \$ has varied by close to 18% in the same period. It is likely that the exchange rate could have an impact as high as \$100,000 to \$200,000 per MW dependant on the time of the TSA and the terms included in the TSA.

In reading this section, it needs to be noted that other financial and political aspects can also influence 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, commodity prices and other.

Many wind turbine OEM and developers struggle with the rapid and sudden exchange rate variations which can affect the turbine costs significantly and consequently the financial viability of projects.

The turbine cost estimates provided in this report are based on an average exchange rate in the first three months of 2015:

- Average Jan to March 2015: 1.24113435 CAD (0.80571455 USD)
- Average Jan to March 2015: 1.3967 CAD (0.7160 EUR)



Note that it would not be advisable to use a direct relationship of exchange rate to evaluate future costs of turbine as other market factors will also influence turbine costing.

4.2.5 *Qualifying delay due to bad weather day*

The TSA will normally include provisions for bad weather days and standard per diem costs. Even though there exists no standard as such and much will depend on the clauses entered in the TSA, and also depend largely on the construction schedule, we have budgeted 1 bad weather day for every 3 turbines or 9 MW.

4.3 **BoP Costs**

Note that a review of the costs associated with off-site access roads and transmission systems upstream of the project substations were **not** within the scope of this mandate, nor was the cost of interconnection to the BC Hydro transmission grid. We expect these costs to be key differentiators in the relative viability of projects.

4.3.1 *Civil Works & Construction Overhead*

Costs considered here as part of civil works include project management, staff overhead, civil engineering, site and forest clearing/logging, mobilization, site facilities, site surveying, geotechnical studies, WTG foundations, new on-site roads and potential road upgrades, etc. The estimated costs presented here, which vary per 50MW, per 48MW or per 28MW, are based on figures obtained from BOP contractors and on Hatch's experience.

Overall engineering costs are assumed to be around \$1.2M plus \$10,000 for every MW over 28MW. Civil and structural engineering costs are expected to be 30% of the overall engineering budget. For our purposes, we have included civil and structural engineering costs associated with the substation within the electrical engineering budget.

Mobilization and site facilities costs can be expected to be in the range of \$600,000 per 50MW and we would expect to see costs in this range for the majority of BC. However, for Vancouver Island, we anticipate the costs to mobilize major equipment to have an associated premium. For Vancouver Island, we would expect mobilization costs to be closer to \$800,000 per 50MW and have accounted for such in the estimate.

In all base cases, it has been assumed that projects do not require a base camp to be constructed/operated during construction. If a construction camp is required, costs for its construction and operation could cost at least \$1.5M (based on 38 man camp for 6 months). This would need to be validated based on location, size of project, construction schedule, distance from major centre, existence and condition of access roads, type of accommodation,



etc. It should be noted that the base camp set up and operation would account for less than 2% of total BOP costs.

The evaluation of cost increments due to location of the project from a major service centre is challenging to estimate for all BoP components without specific project details.

For site surveying and geotechnical investigations, Hatch assumes approximately one borehole per turbine, substation, building and 2 km of road. The study and report with resistivity testing is included. The boreholes are assumed to be sufficient depth to gather data to implement a gravity-based spread footing foundation. Costs for drilling deep bores into rock for the purposes of informing a rock anchor designed have not been accounted for. We expect the costs to be in the order of \$200,000 per 45MW for this scope.

Cost estimates for WTG foundations are based on the provision of gravity-based spread footing foundations suitable to accommodate the typical 3MW machine. Costs estimated are expected to be inclusive of excavation and mechanical 'ripping' of rocks and soils but do not account for any rock hammering or blasting of rock. Hatch does not have any data that would indicate specific regions are more likely to contain shallow rock than others. The cost of the turbine foundations includes \$50,000 for turbine conduit and grounding. We have assumed that soils will have electrical properties that do not necessitate the inclusion of deep-driven ground rods, grounding-enhancing material or local ground grids that extend beyond the immediate proximity of the turbine foundations. An on-site batch plant has been accounted for and it is assumed that a local water source can be permitted to provide for foundation and other construction works.

New roads will be designed and built according to industry-standard turbine vendor transport specifications with grades, bearing capacities and turning radii sufficient to accommodate all typical turbine and construction loads. It is assumed that all roads will need clearing and revegetation to the road shoulder. Only limited importation of material has been accounted for and it is expected that the constructor can make use of on-site borrow pits. It is also assumed that there are varying amounts of existing roads at each project site, having been previously established to service the oil and gas and logging industries. In some cases, the project will be able to make use of the existing road as-is and other portions of existing road will require varying degrees of upgrade, especially to address widening of roads and increasing of turning radii. Hatch assumes at least one significant road upgrade per km of existing road at a cost of \$10,000 per upgrade. However, we have assumed the vast majority of site roads will be new or that the level of upgrade required to bring existing roads to turbine-ready states allows them to essentially be considered new roads.

For turbines pads, crane pads and a laydown area, Hatch assumes \$10,000 of civil work per pad beyond clearing, \$5,000 per crane pad for material import and compaction plus \$50,000 per 50MW for laydown area civil works and setup.

Restoration, revegetating and landscaping is assumed to cost \$2,000 per ha.



Additional items required for the construction site including site services, security, utilities, communications, waste management, road maintenance, etc. is expected to cost in the order of \$200,000 per year of construction per 50MW of installed capacity. It is assumed that the construction operations in these regions will stretch over 2 construction seasons, with the construction season expected to be from May to November. We have assumed that larger projects will mobilize additional resources to accommodate this 2 year target construction timeline.

4.3.2 Mechanical Works

Costs considered here as part of mechanical works include the turbines' erection, mechanical assembly, wiring and all other activities within the turbine required to achieve Mechanical Completion.

4.3.3 Electrical Works

Costs considered here as part of electrical works include balance of plant electrical design for the collection system, substation and grounding systems. Costs for all collection system equipment, including turbine padmount transformers, underground and overhead collection systems including power and grounding/bonding conductors, fibre optic communications cables, overhead pole line structures and equipment and supplementary equipment such as cable terminations and splice kits are included. The collection system is expected to be primarily overhead with some underground runs connecting turbines to the overhead network.

Costs for all substation civil and structural works and substation equipment including an outdoor switchyard, VAr support systems, main step-up transformers, fencing, station service and protection, control and communication facilities contained within a small substation control house.

Electrical facility design costs (including civil and structural engineering associated with collection system and substation) are based on a calculation that says the overall engineering cost is \$1.2M plus \$20,000 for every MW beyond 28MW. Electrical engineering is expected to be 70% of the engineering budget and include the civil and structural engineering scope for the substation and overhead collection system.

Standard collection system grounding is assumed sufficient and is included in the collection system pricing. Assumed collection system grounding includes bare copper conductors in underground trenches and pole grounding for overhead lines, with an accompanying neutral wire carried on the overhead.

The turbine grounding system is assumed to be a typical set of counterpoise bare copper rings and leaders supplemented by four 3m ground rods with no special ground enhancing material and special construction methods required for installation. The costs for turbine grounding are included in the turbine foundation cost numbers.



A standard ground grid occupying the entire footprint of the switchyard and fence is included in the substation cost. No remote ground grids are allowed for in the substation or project in general.

Projects up to 100MW are expected to have just one substation transformer. Projects larger than 100MW and up to 250MW are assumed to require two transformers. The substation cost calculation is as follows: \$4M base cost+ \$2.5M per 50 MW + \$1.25M per substation transformer.

4.3.4 Other Hard Costs

Other hard costs not included in the previous sections would normally include items such as a permanent met tower, an equipped O&M building with utilities, signs, fencing, cattle guards, if required. An allocation for these costs has been included in the tables below. These costs do not vary much between one region to another but will be impacted slightly due to the size of the project.

4.4 Owner's Costs during Construction

This cost review does not include aspects relating to financing activities and financial costs. The costs presented as part of owner's construction costs relate to OE fees, document control and QA, insurance during the construction period, the owner's in-house legal services, and contingency. Owners costs during the construction do not vary much from one region to another and were estimated in the 8% to 9 % of Capital costs.

4.4.1 Contingency

We have included contingency in the project estimate numbers even though the contingency required will be highly variable and is very much a function of the quality of executed contracts, the gaps between the respective contracts, the quality of the project team, the expertise of the development team, the variability of sub-surface conditions and the specific weather conditions throughout the duration of construction. Hatch does not anticipate that any particular region is more or less susceptible to unforeseen costs. Contingency values will also be heavily influenced by the requirements of the project lenders. For the benefit of BC Hydro, we have budgeted a contingency equal to 10 % of BOP costs and 5 % of Turbine costs. One would normally expect contingencies to typically be in the 5-10% range of capital costs.

4.5 O&M Costs

Cost of operations and maintenance were estimated for the base case in each region. The estimates generally include all costs to operate the wind farm excluding financing and any particular system costs, such as grid loss factors and tariffs. No provisions have been made for inflation or the actual value of the O & M costs for the life of the project. This would normally be done as part of the developer financial model.



4.5.1 **Planned WTG Maintenance**

Operations costs include the turbine maintenance costs including planned and unplanned maintenance, as well as major components replacement. These costs were estimated using typical operation agreements as well as estimated repair and equipment costs either included in the service agreements, or in addition to the base maintenance services. Operations and Maintenance costs include a significant cost of the owner for on site management as well as off site owners costs.

Costs that vary from year to year were estimated based on an average year. For example significant maintenance events were averaged over the long term. Costs, such as environmental monitoring which may diminish as the project ages were averaged and a single average value was provided.

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.

No analysis from Hatch exists that would suggest that with higher capacity factor, i.e. more kWh per year produced, the O&M costs go up or down. Therefore, fixed and variable costs are not distinguished.

Several projects have transitioned into their post-warranty period in the recent past. OEMs are offering competitive long term service contracts with similar maintenance packages to their warranty entailed previously. Risk for major component replacements is transferred to the owners but the immediate costs remain comparable to before. These costs would normally go down as more projects are built in BC whereby some economy can be attained on a per MW basis.

4.5.2 **Property Taxes**

The amount of property tax paid by the owner of a wind project is based on a municipal tax rate and a property assessment value calculated by the BC Assessment Office. Alternative energy projects (turbine tower and foundations) are exempt from paying school taxes.

The rate varies depending on the municipality and the valuation of the property by the Assessment Office depends on land value, improvement valuation and depreciation. Rates and assessed value also vary with time and should be considered when developing a financial model for specific projects.

Based on gathered information, annual property taxes were estimated to be approximately \$8333/MW.

4.5.3 **Land Leases and Wind Participation Rent**

Land leases and Wind Participation Rent fees are detailed in the document titled '*Crown Land Use Operational Policy : Wind Power Projects*'. Similar to the pre-construction costs for the



GALOO, the Wind Power Project land lease or licence of occupation are a function of the zone land value and is payable for the lifetime of the electricity purchase agreement (EPA).

After a 10-year grace period which extends 10 years from the COD, the land lease converts to a Wind project Participation Rent. This rent would be calculated as a function of the wind project's annual revenues. The costs associated with the Participation Rent after 10 years of operation have not been considered as part of the O & M costs in the cost tables below and would increase the overall O & M costs of the project after 10 years of operation.

4.5.4 Community Benefits

Community benefits, including those for First Nations, during the operation phase can be challenging to quantify and these have varied from one project to the next. Based on input received that these would normally range between 2 to 3 % of revenues. At the request of BC Hydro, Hatch has not included these costs in this assessment.

4.5.5 Insurance

All projects will need insurance throughout its project life. For budgeting purposes, insurance costs have been estimated to be approximately 0.3% of total capital costs.

4.6 Decommissioning

In BC, no site decommissioning has yet taken place and as such related costs are estimated based on previously-undertaken analyses in other jurisdictions.

A growing trend is to re-power a wind farm with newer, more modern turbine technology, rather than complete decommissioning. If there is new technology available that can improve the energy production of a wind farm and this is economically feasible, even before the pre-set lifetime of the project, it may be of interest to consider re-powering prior to the expected end of term of the project.

The duration of decommissioning will depend on the degree to which the facility needs to be dismantled. Turbines could potentially be removed within weeks if access roads are left in place and depending on the project size, but complete removal of foundations would require substantially larger demolition efforts and could extend over an entire construction season.

We have not accounted in the budget for the actual costs of funds required for decommissioning after the project life. Even though a more detailed study for each specific project would be required, it needs to be understood that actual decommissioning costs in net present value (NPV) could range from \$ 3M for a small project to \$ 10M for larger projects dependant on extent of decommissioning required. Some do create special allowance or reserve fund within the financial models when required. For budgeting purposes, an allowance of \$ 60,000 per MW is deemed appropriate.



4.7 Other Factors Affecting Cost

4.7.1 Labour

In order to evaluate general variations of labour costs in different regions of BC, Hatch reviewed various sources of information (including interviews with industry members, WorkBC and wowjobs.com). Based on our review (which is not to be considered a statistical analysis), we can conclude that average wages in the Peace and North Coast Regions appear to be higher as compared to those in the Southern Interior and on Vancouver Island, which are generally close to the average in BC. This trend also appears to agree with income level per region.

Some specialised labour work such as a 'Power System Electrician', for example, will likely vary less from one region to another, given its requirement for a high level of expertise and that they are likely unionized positions. On the other hand, labour costs can vary from high of 138 % in the Peace area to a low of 96 % in the Okanagan for specific trades or labour. It needs to be emphasised that local labour conditions can vary rapidly dependant on other development projects within the respective area. Labour costs and labour retention were also identified as a key factors by industry staff especially as the construction of a wind project is concentrated on two seasons and in competition with other high paying industry such as oil and gas.

The following table below can provide general indication of labour cost differences by regions in comparison to BC averages.

Table 2: Labour Costs per region

Labour costs difference between region with BC Average				
	Peace	Okanagan	Northern BC	Van Island
High	138%	105%	116%	106%
Low	111%	96%	102%	94%
Average	125%	100%	109%	100%

4.7.2 Topography

Generally, topography will have primary impacts on construction mobilization, road and civil costs, collection system costs and turbine transportation costs. Site roads will need to be constructed to accommodate delivery of components by being designed and built according to turbine manufacturer transportation specifications. In areas of challenging topography, the costs to build and upgrade these site roads will be greater. The average projects defined for each region do not differ substantially from one region to another so no factor has been applied in the cost estimates to account for variations. However, care must be taken in extrapolating base estimate values across the entire RODAT portfolio as some outlier projects have especially challenging topography with high relief approaches to turbine sites. It should be noted that these sites are more likely to be IEC Class I and straight extrapolation



may skew the results to make some outlier projects appear more economical than is practically the case.



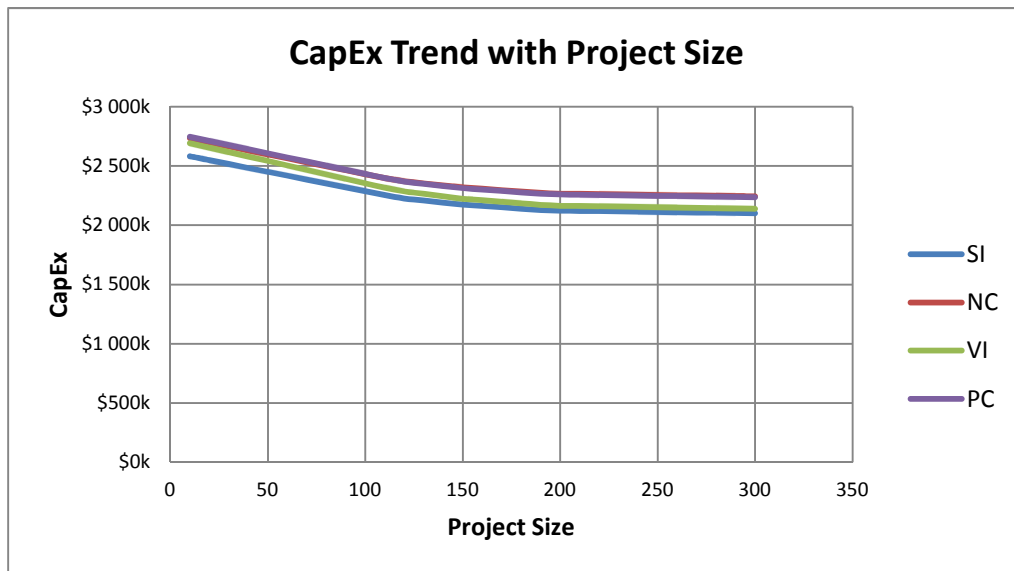
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4.7.3 Project Size

As previously mentioned, many factors influence the wind project construction costs and the number of turbines per project is an important factor. With increasing turbine size, there can be a general reduction in capital expenditures (CapEx) per MW since a lower number of turbines can result in economies for length of roads, collector lines, number of foundations and so on. As shown in the following sections of our report and as confirmed in numerous publications, the average costs per MW can significantly vary from one region to another but also from a large project to a small project.

Even though it is difficult to arrive at general guidelines to estimate costs of wind projects based on project size alone, with a view to assist BCHydro in reducing the uncertainty related to estimating costs of projects in the RODAT, Hatch has completed a review of costs for different project sizes. Our review has shown that the costs per MW for wind projects will have a larger differential for projects smaller than 120 MW and the differential will begin to level off for projects larger than 200MW. Hatch has prepared the following figure (for indicative purposes only) to illustrate how project size may impact capital costs.

Figure 1: CapEx Trend with Project Size



Even though the variations will be different from one project to another dependant on other local factors, it is Hatch’s opinion that the trend shown above will normally be consistent in all regions of BC. 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.



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5. Estimated Costs per Region

Hatch has attempted to provide estimated costs that are most representative for a feasible base case wind project within each region.

These cost estimates are based on a number of assumptions as stated in previous sections and there needs to be caution in interpreting these estimates as this is a high level, desktop cost review of base case projects.

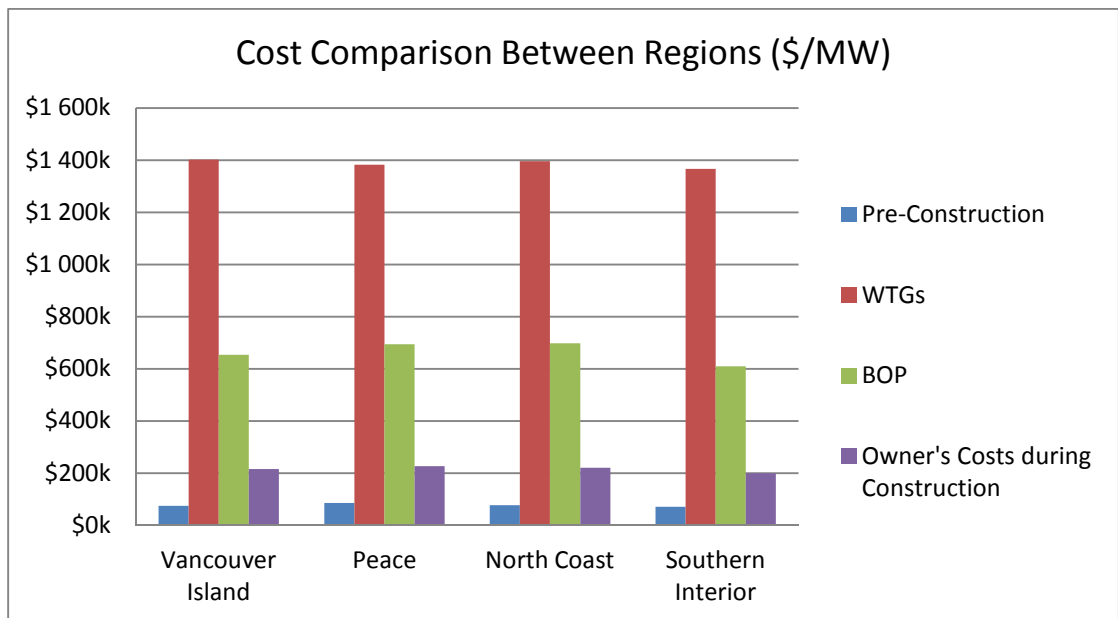
At the request of BC Hydro, the estimated costs per MW were further evaluated by extrapolation for a same project size in each region. A common project size of 102 MW was agreed upon between BC Hydro and Hatch, based on the assumed WTG of 3 MW and a total wind farm capacity in the ballpark of 100 MW.

Even when developers attempt to estimate costs for their own project, with known topography, obstacles, distances, with firm quotations from OEM and BOP contractors, on a project that they have been working on for several years, there remains some uncertainties with costing. Contingencies remain in the 5 to 10 % range.

The following figures and tables present a comparison of costs between regions and the summary of cost estimates of the base cases per region. Comments for each of the components considered are provided in the previous sections.

Note that costs associated with off-site access road improvements and off-site transmission systems are not included in these estimates as it was not part of the scope of this mandate.

Figure 2: Cost Comparison Between Regions in BC for a 102 MW project



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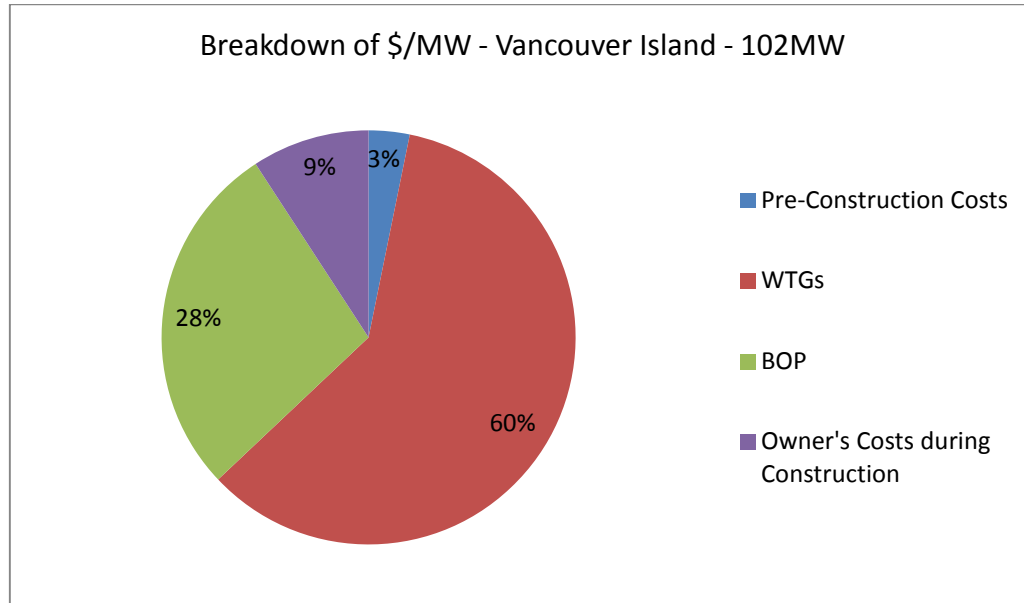
5.1 Vancouver Island

Table 3: Cost Estimate Summary - Vancouver Island

Vancouver Island	Total Costs Base Case (48 MW)		Extrapolated for 102 MW Project (\$/MW)
Project Phase	Total	Total per MW	
Pre-Construction	\$6 572 350	\$136 924	\$74 925
Wind Turbines	\$67 933 667	\$1 415 285	\$1 402 583
BoP	\$36 443 761	\$759 037	\$654 084
Owners Costs During Construction	\$11 418 253	\$237 880	\$215 454
TOTAL Capital Cost	\$122 358 030	\$2 549 126	\$2 347 046
TOTAL Yearly Operating Cost	\$3 574 933	\$74 478	\$71 566

* Base Cost for Wind Turbines does not include actual WTG machines. These are accounted for in the \$/MW incremental addition costs. The Base Cost here includes only Standard TSA Scope of Supply and optional equipment.

Figure 3: Cost Breakdown – Vancouver Island



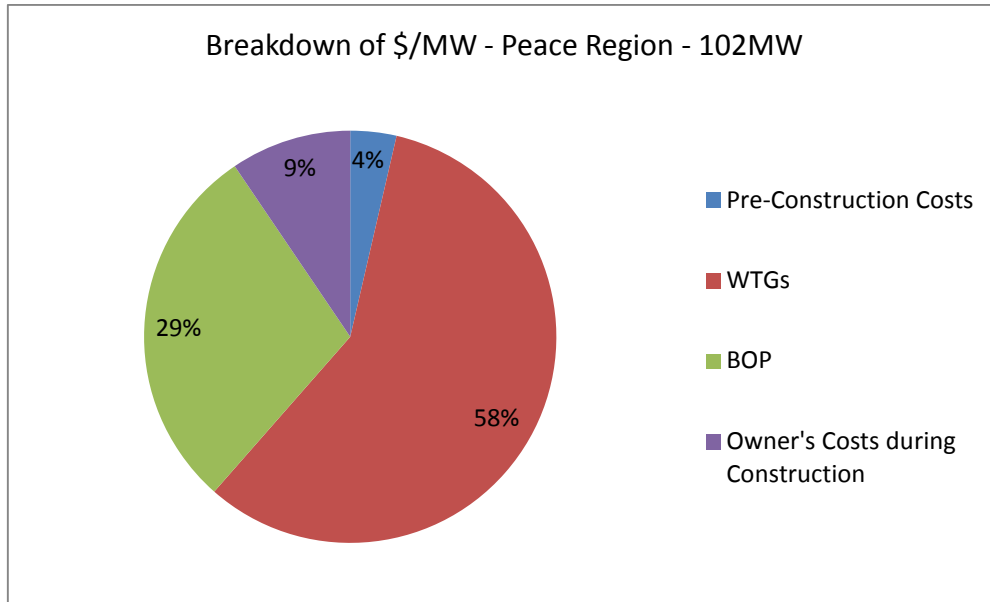
5.2 Peace Region

Table 4: Cost Estimate Summary – Peace Region

Peace	Total Costs Base Case (117 MW)		Extrapolated for 102 MW Project
Project Phase	Total	Total per MW	(\$/MW)
Pre-Construction	\$9 405 837	\$80 392	\$86 136
Wind Turbines	\$161 804 000	\$1 382 940	\$1 383 229
BoP	\$80 266 186	\$686 036	\$694 614
Owners Costs During Construction	\$26 268 479	\$224 517	\$226 638
TOTAL Capital Cost	\$277 744 503	\$2 373 885	\$2 390 617
TOTAL Yearly Operating Cost	\$8 593 290	\$73 447	\$74 236

* Base Cost for Wind Turbines does not include actual WTG machines. These are accounted for in the \$/MW incremental addition costs. The Base Cost here includes only Standard TSA Scope of Supply and optional equipment.

Figure 4: Cost Breakdown – Peace Region



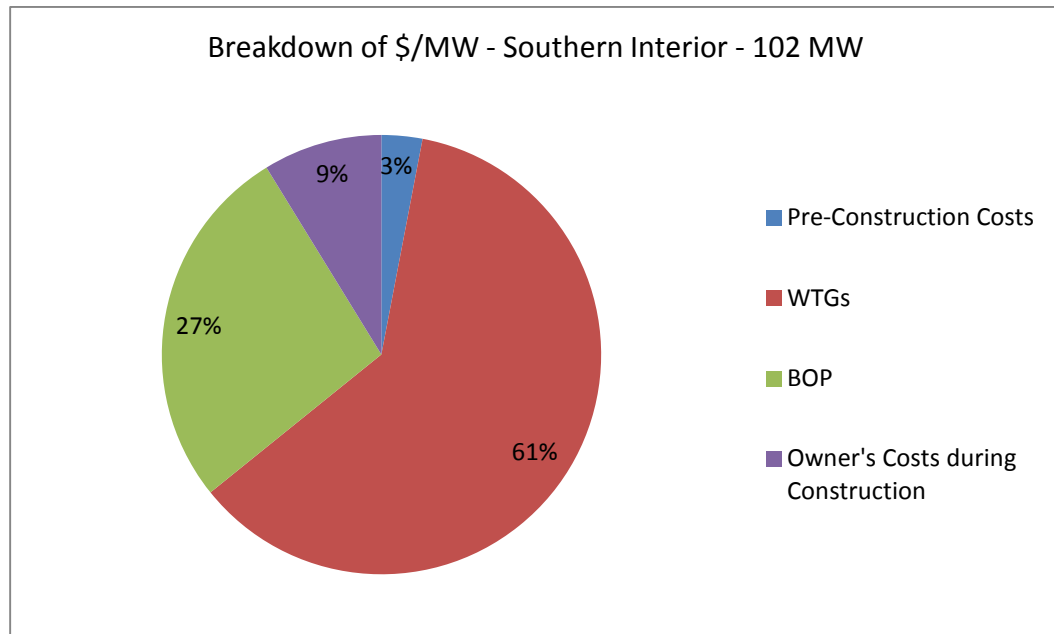
5.3 Southern Interior

Table 5: Cost Estimate Summary – Southern Interior

Southern Interior	Total Costs Base Case (117 MW)		Extrapolated for 102 MW Project (\$/MW)
	Project Phase	Total	
Pre-Construction	\$7 803 254	\$66 694	\$71 370
Wind Turbines	\$159 854 000	\$1 366 274	\$1 366 563
BoP	\$70 510 887	\$602 657	\$609 520
Owners Costs During Construction	\$22 906 797	\$195 785	\$200 309
TOTAL Capital Cost	\$261 074 937	\$2 231 410	\$2 247 762
TOTAL Yearly Operating Cost	\$7 833 732	\$66 955	\$67 646

* Base Cost for Wind Turbines does not include actual WTG machines. These are accounted for in the \$/MW incremental addition costs. The Base Cost here includes only Standard TSA Scope of Supply and optional equipment.

Figure 5: Cost Breakdown – Southern Interior



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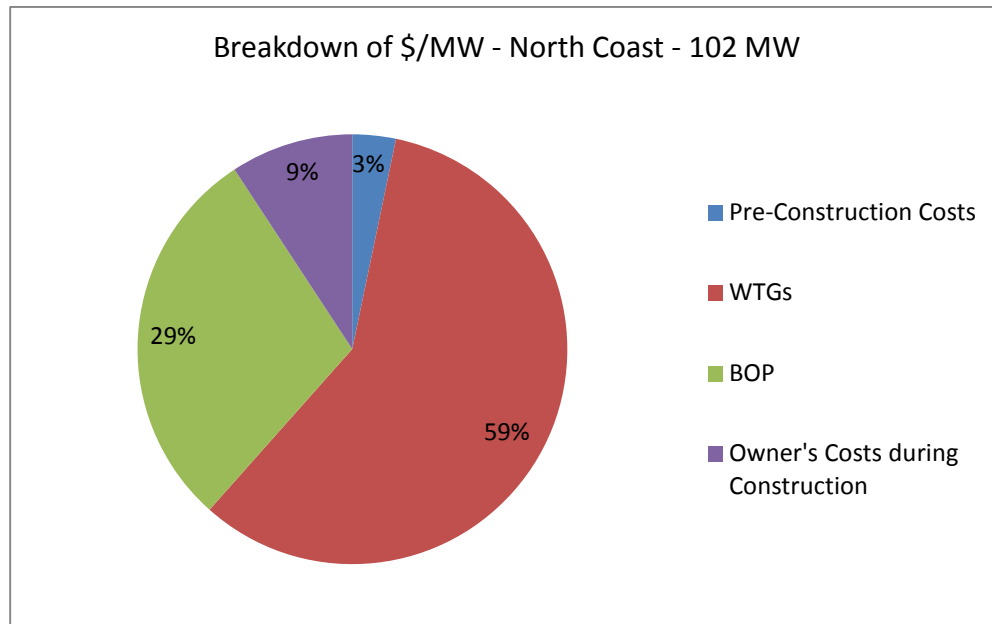
5.4 North Coast

Table 6: Cost Estimate Summary – North Coast

North Coast	Total Costs Base Case (195 MW)		Extrapolated for 102 MW Project (\$/MW)
	Project Phase	Total	
Pre-Construction	\$9 839 708	\$50 460	\$77 806
Wind Turbines	\$269 891 667	\$1 384 060	\$1 396 431
BoP	\$123 836 315	\$635 058	\$698 546
Owners Costs During Construction	\$38 670 125	\$198 308	\$221 008
TOTAL Capital Cost	\$442 237 814	\$2 267 886	\$2 393 791
TOTAL Yearly Operating Cost	\$13 194 072	\$67 662	\$78 966

* Base Cost for Wind Turbines does not include actual WTG machines. These are accounted for in the \$/MW incremental addition costs. The Base Cost here includes only Standard TSA Scope of Supply and optional equipment.

Figure 6: Cost Breakdown – North Coast



6. Conclusion

In completing interviews with different stakeholders, turbine manufacturers, developers and BoP contractors, Hatch has identified the main cost items required to develop, build and operate wind farms in four different regions of BC. This high level desk top costs review considered the majority of the variations between regions.

Costs presented in this report need to be considered as high level estimates and not as detailed costs estimates. The reader should recognize the challenges of defining a wind project that can be representative of each of these provincial regions and in estimating its associated costs. This is especially true since all these BC regions span very large areas and have altitudes ranging from 50 m to over 2000 m.

Assuming a similar project size (102 MW) can be developed in each of the 4 regions, the numbers presented above in Section 5 indicate that the cost estimates can vary by about 6% (or say, a range from 5-10%) between regions. Our review confirms that, based on our noted assumptions, the Capex for a 102 MW project in BC should range between \$2.2 M to \$2.4 M per MW.

Given the various project sizes in BC Hydro's RODAT, from 35 MW to over 500 MW, the Bases Cases evaluated by Hatch in each region provides some insight into how project size may affect costs. The cost estimates presented above in Section 5 can vary by about 11% (or say, a range from 10-15%) for project sizes ranging from 48 MW to 195 MW.

The reader should also appreciate that when developers attempt to estimate costs for their own projects, with known topography, obstacles, distances, with firm quotations from OEM and BOP contractors, on a project that they have been working on for several years, there always remains some uncertainties and contingencies can range from 5-10 %.

All these ranges of variations combined can lead to a 20-35% margin of error for any high level cost estimates made for wind projects and this should be considered when looking at the numbers presented in this high level cost review.

Hatch would like to thank the many wind industry members and all stakeholders in BC who assisted in providing various input in completing this report.

