Resource Options Update
Technical Engagement Summary 2014–2015

1.0 Overview of the Engagement Process

A key input into BC Hydro's long-term planning process is our inventory of electricity generation options (resource options) that could be developed to meet future electricity demand over the next 20 to 30 years. As part of the Clean Energy Strategy in the November 2013 Integrated Resource Plan, engagement occurred through 2014 and 2015 with Independent Power Producers (IPPs) and industry experts to update BC Hydro's database of resource options pricing, technical capabilities and resource potential within the context of B.C.

For this update, BC Hydro and FortisBC collaborated on a shared dataset from which each utility can produce separate integrated resource plans. As both utilities draw upon an inventory of resource options for their respective planning processes, a common dataset will improve efficiencies as well as consistency during review processes.

BC Hydro's inventory of resource options characterizes supply-side resource options in a manner that is consistent with the objectives of B.C.'s 2010 *Clean Energy Act*, B.C. Government policies, and related legislative initiatives.

This report provides a high level summary of:

- the engagement process that was used to gather feedback for each resource type,
- feedback received, and how it was considered

Materials generated, including consultant reports, in-person meeting summaries and presentations are publicly available on our public website.

1.1 Technical Focus of the Resource Options Update Engagement Process

This update process consisted of working with people who have technical expertise to gather and review high-level technical information on supply-side resource options in B.C. No decisions are made, or opinions collected, during resource option engagement processes on resource option preferences for integrated resource planning purposes.

1.2 Resource Options Update Approach

The resource options update occurred in two steps:

1. The scoping of technical issues was carried out with independent power producer (IPP) industry associations to inform the work plan
2. A tailored plan was implemented for each resource option to collect new information that was available, and present updated data for feedback. Consultants were retained as needed to update the resource characterization information.

The supply-side resource types considered in this update included: municipal solid waste, wood-based biomass, geothermal, run-of-river, solar, natural gas-fired generation, tidal, wave, and onshore wind.

1.3 Scoping Technical Issues with Industry Associations

From May to July of 2014, technical issue scoping meetings occurred with the Clean Energy Association of BC (CEBC), the Canadian Wind Energy Association (CanWEA), and Canadian Geothermal Energy Association (CanGEA). The purpose of these meetings was to understand issues arising from the previous resource options inventory in order to better inform the current work plan. Examples of feedback considered in the scope of work are listed below. Feedback was also received on procurement, policy and analysis issues that fall outside the scope of this update.

- *Wood-based biomass* – consider machinery efficiency improvements and different technologies
- *Wind* - update unit energy costs, project life estimates, and interconnection costs. Additional costs including balance of plant costs and soft cost adders also need revisiting (these additional costs were considered across all resource options)
- *Geothermal* – remove the term 'non-viable' from the planning analysis; recognize resource potential in the northeast part of the province
- *Natural gas-fired generation* – recognize higher efficiency and faster ramp rates
- *Run- of-River Hydro* – focus on lower cost sites from KWL survey; consider small storage hydro option
- *Tidal* – consider how turbine technology has matured
- *Other (Solar, battery storage)* – recognize that technologies are evolving rapidly, which is lowering costs

2.0 Resource Option Update Engagement by Resource Type

For each resource type, this section provides a high level summary of the scope of update, consultants retained to update the information, the engagement process, and feedback received and its consideration. The engagement process varied by resource type and depended on the update scope, and so the written summaries also vary accordingly.

People with industry expertise were notified of the engagement using three primary sources: participant lists from previous resource options updates, planning staff contacts since the last engagement, FortisBC contacts, and contacts provided through the industry associations. Written invitations were also distributed through the following CEBC committees: First Nations, Wind, Hydro, Thermal, and Solar. Ministry of Energy and Mines staff, along with staff from FortisBC and Columbia Power Corporation also participated in meetings and received materials through the process.

2.1 Municipal Solid Waste (MSW)

Scope of Update	Confirm methodology of estimating resource potential; update cost information
Engagement Method	Conference call meeting on April 23, 2015 with Metro Vancouver staff

For this update, BC Hydro solicited the expertise from Metro Vancouver to review the methodology for estimating resource potential and costs. Metro Vancouver staff involved with solid waste management, recycling and MSW participated in a conference call. The purpose of the call was to review the methodology used to estimate the MSW resource potential in the 2010 and 2013 Resource Options Updates and to update the cost information. Feedback from the participants confirmed that the approach to estimate the MSW resource potential is sound. Metro Vancouver provided updated capital and O&M cost information through the report Economic Analysis of New Waste-to-Energy Facility in Metro Vancouver (ICF International, October 2014).

2.2 Wood-Based Biomass

Scope of Update	Update the estimated fiber potential for all 13 regions Review technologies for biomass electricity generation Update cost information and associated unit energy costs
Consultant Retained	Industrial Forestry Service Ltd. AMEC Foster Wheeler
Engagement	Biomass engagement group meetings and conference calls Meeting #1 – March 31, 2015 Meeting #2 – July 2, 2015 Email correspondence Follow up phone conversations and meetings

BC Hydro engaged two consultants, Industrial Forestry Service Ltd. (IFS) and AMEC Foster Wheeler (AMEC FW) to update the fiber potential estimate, review different technologies and update cost information. Similar to the approach in the 2013 ROR, IFS used the proprietary BC Fiber Model with latest industry knowledge to estimate fiber potential for all 13 regions in the Province. The Annual Allowable Cut (key input assumption to the model) was vetted with the Ministry of Forests, Land and Natural Resource Operations. New in this 2015 update is AMEC FW's review of technologies that range from conventional steam boiler types to organic rankine cycle to gasification. Cost information was updated based on input from IFS, AMEC FW, industry stakeholders and project information available to BC Hydro.

Two meetings of the engagement group were held which involved over a dozen representatives from industry, consultants, and ministry staff. Those in attendance included: B.C. Government (Forests, Lands and Natural Resource Operations, Energy and Mines, Climate Action Secretariat), Bastion Power, BC Bioenergy Network, Canfor, Catalyst Paper, Clean Energy Association of BC, CLEAResult, Columbia Power Corporation, FortisBC, Metro Vancouver, and Mirastar Energy. Follow up discussions were done via email, phone or individual meetings (such as with Metro Vancouver, Bioenergy Network).

At the March 31 2015 meeting, draft results were reviewed for the following feedback: estimated fiber potential by region; costs in terms of project development and fiber delivery; and technology advancements. Summary of key changes since the previous update was presented.

At the July 2 2015 meeting, draft results of the update were presented, and changes made to the update since the March meeting, and based on feedback received to date were presented.

The following table describes the general feedback received and how this feedback was considered in the update.

Feedback Received	Consideration of Feedback
Fiber from construction/demolition has increased over the years, and may be comparable to hog fuel.	BC Hydro and Metro Vancouver assessed the amount of additional fiber that could be sourced from landfills and recycled facilities. The estimated potential and associated uncertainties were reported out in the July engagement meeting.
The delivered fiber costs for some regions may be light, for example: • The cycle time in the Coast and Prince Rupert should be longer than consultant's estimate • Delivered fiber costs for new plant should be higher than consultant's estimate which was based on current prices due to greater competition for fiber.	As a result of this feedback, delivered fiber costs including delivery distance and market price for fiber were reviewed and revised where appropriate and reported out in the July engagement meeting.
Proposed lead time for bioenergy plant should be a bit longer – a minimum of 4 years, but the major spending happens in the last 27 months.	The project lead time was changed from 2 years to 4 years, and spending profile used for project development was modified to reflect some spending early on.
The proposed project life of 15 years is short, should be a bit longer – more like 25 years. Projects are designed for 30-year engineering life. EPAs generally have liquidated damage provisions – may serve to keep the project life a bit shorter. Project or contract life would also depend on the fuel risk the developers are willing to take on.	The project life was revised to 20 years. While engineering life could be longer, 20 years was assumed considering the fuel risk the developers are willing to take on as well as the maximum term that the B.C. Ministry of Forests, Lands and Natural Resource Operations is willing to award a forest licence to produce bioenergy under Sections 13.1 and 14 of the British Columbia Forest Act. It is necessary to consider the sustainability of fiber supply in conjunction with project life. Given the fiber potential in most regions is substantially reduced in the long run (by around 2025) and development lead time is 4 years, it may be uneconomical for a new project to utilize near-term elevated fibre supply. Therefore, the fibre potential included in the inventory is based on the long term fiber estimate.
Conversion factor (cubic meters per oven dry tonne) should be 2.2 instead of 2.45	IFS reviewed information provided by participant together with information from other sources including information from existing bioenergy projects, and recommended to stay with the 2.45 assumption.

Feedback Received	Consideration of Feedback
On OMA costs, information published by U.S. Energy Information Administration and International Renewable Energy Agency could be used for comparison.	AMEC FW further reviewed OMA costs post July meeting and revised its estimate. It notes that there is great uncertainty in the estimate as there is great variability in the different reports. Within the US, there is also significant regional variability. Transferring the data to Canada has to take account of currency and the labour climate differences. For labour rates, there is also regional variation within B.C.
There is massive investment in bioenergy technologies and BC Hydro should think about other technologies like liquid fuels, next generation pellets. At a follow up meeting with Bioenergy network, it was concluded that technological advancements can have positive or negative impact on bioenergy. Some can lead to more competition for fibre while some could lead to more efficient bioenergy production.	Resource options inventory is updated regularly and technologies can be revisited and incorporated as it becomes proven. BC Hydro can provide commentary, noting the uncertainty of bioenergy potential and cost, particularly due to technological advancements.

2.3 Geothermal

Scope of Update	Targeted update of existing public database of a subset of geothermal projects with a more detailed cost assessment; included two projects from the Northeast of B.C.
Consultant Retained	GeothermEx Kerr Wood Leidal
Engagement Method	Engagement session July 17 2015

This targeted update drew upon the work undertaken with GeoscienceBC which involved retaining the consultants GeothermEx and Kerr Wood Leidal to provide an updated assessment of the current set of geothermal projects already existing in the inventory of resource options. Two new projects from the Northeast were added in response to stakeholder feedback to include representative projects in that area of the province. An engagement session occurred on July 17 2015 to review the results of the study.

Eleven people attended the geothermal resource option update session in July 2015, and included representatives from Alterra Power Corp, B.C. Government (Ministry of Energy and Mines), Borealis Geo Power, GeoscienceBC, CanGEA, FortisBC, NBK Mining Institute (UBC), and independents. The meeting focused on the presentation of findings from consultant's work, "An Assessment of the Economic Viability of Selected Geothermal Resources in British Columbia." The consultant's work represents an analysis of all publicly available data related to 19 known geothermal prospects with a purpose of screening the 19 candidate sites based on broad viability criteria, and developing a transparent assessment of the quality of the geothermal resource and the development costs of the most viable sites. This report will inform future resource options updates, though it is recognized that this report provides detailed information only

for the geothermal resources deemed 'most viable' and does not represent a complete inventory of all potential geothermal resources in the province.

Attendees were invited to provide written feedback to BC Hydro over a three week comment period. The following table describes the general feedback received and BC Hydro's consideration of this feedback.

Feedback Received	Consideration of Feedback
A range of feedback was received on the validity of the economic model – the Geothermal Electricity Technology Evaluation Model, or "GETEM" – used in the consultant's report. Among the comments received was some support for the high-level economic model and transparency to the assumptions used to form the assessment, as well as some fundamental challenges to the appropriateness of GETEM for project-specific assessments and detailed critique of the assumptions used.	BC Hydro emphasized that the economic model used in the study incorporates learnings from several decades of experience with on-the-ground geothermal developments in the U.S. and is publicly available (i.e. non-proprietary). Where appropriate, the 2015 model runs incorporate cost assessments based on B.C. experience, though limited. The model runs were made available with the consultant's report, ensuring transparency of assumptions used. BC Hydro recognizes that the consultant's report offers only a high-level cost estimate, which BC Hydro maintains is appropriate for this type of planning study scale. BC Hydro regularly updates its inventory of resource options, and will consider this feedback going forward.
All reviewers emphasized that the report examined only 18 sites, which represent only a fraction of the likely geothermal potential in the province. Further, one reviewer noted that only two Hot Sedimentary Aquifer (HSA) sites were included in the study, which represents only a fraction of the theoretical geothermal potential of the large HSA geological setting in B.C.	BC Hydro acknowledges that the ~400 MW cited in the consultant's report does not reflect the total geothermal potential in the Province, rather it is meant to reflect the generation potential at the most favourable sites based on currently available data.
A detailed review of the assumptions input to the economic model by one of the reviewers generated these challenges: • Vastly overestimated well costs • Failure to recognize lower-costs of drilling for HSA projects • Very high discount rates / cost of capital for early stages of project development • High Contingency costs • Illogical Transmissions costs • Conservative costs associated with exploration phases • Inappropriate application of Canadian/US currency exchange rate • Inappropriate build-out periods	The detailed examination of the economic model conducted by the reviewers showed an important inconsistency in the way the economic analysis for one of the sites was conducted, as it concerned project life. This inconsistency has been corrected and a new version of the final consultant report has been prepared. The critique of the economic assumptions is an important element in furthering an understanding of the costs of geothermal projects in the absence of real costs ground-truthed in B.C. experience. BC Hydro will continue to look at how to improve cost assumptions going forward.

Feedback Received	Consideration of Feedback
One reviewer highlighted that the high-level economic model does not account for other grid system benefits (e.g., voltage support), positive externalities (e.g., local economic development or displacement of diesel fuel) or alternative revenue streams (e.g., secondary heat sales to local industries or district heating systems) that would improve the LCOE for relevant projects	BC Hydro recognizes that geothermal projects may offer social or non-energy potential benefits, though the incorporation of these project-specific benefit streams is beyond the scope of the current exercise
One reviewer questioned the consultant's approach to grouping some projects together, while failing to group together other projects that would most likely be developed as a cluster to share transmission infrastructure	BC Hydro recognizes that this report is meant to provide only indicative costs and does not include sufficient project development details to offer more precise cost assessments.
There were conflicting views on the degree of conservativeness in the consultant's volumetric assessment. One reviewer opined that the inputs for the volumetric assessment are all conservative and taken together represented a very conservative overall assessment at each site. Another reviewer offered the view that the Monte-Carlo based volumetric assessment is inherently optimistic and fails to account for the zero or near-zero recovery factors that may be found in the real world	BC Hydro recognizes that there is insufficient data available to accurately define geothermal reservoirs in the province, but in general this report's output is a conservative measure of the resource.

2.4 Run-of-River Hydro

Scope of Update	Resource assessment report updated by consultant with up to date costs and technical data.
Consultant Retained	Kerr Wood Leidal
Engagement Method	Engagement Meetings on March 2, 2015 and July 6, 2015 Email correspondence

Given the maturity of run-of-river technology, a targeted work plan was designed to update the resource assessment report from the last inventory, including updating applicable costs and technical data.

An engagement meeting was held on March 2, 2015 with eighteen people attending. Attendees included representatives from the B.C. Government (Ministry of Energy and Mines), Alterra Power Corp. BluEarth Renewables, Clean Energy Association of BC, Clean Energy Consulting Inc., FortisBC, Innergex Renewable Energy Inc., Elemental Energy, Sigma Engineering Ltd., Sorgent.e Hydro Canada Corp., Summit Power Corp., and an independent. Representatives from Kerr Wood Leidal, the consulting firm undertaking the run-of-river resource option update work, were also in attendance. BC Hydro's technical lead gave an overview of previous methodologies and described the scope of updating the run-of-river resource option. Highlights of the meeting included:

- Concern was expressed that salmon bearing streams are not included in the analysis, thereby under representing the resource potential in B.C. It was explained that this practice has been in place since the first study by KWL in 2007 and it would be a BC Hydro and FortisBC decision to change the assumption.
- It was noted that at-gate capital costs were updated. Additionally, construction camp cost was updated to include a camp operating allowance. Environmental and social permitting costs were changed to a tiered approach. All other costs were escalated by 2% per year.
- There was a comment that an O&M cost assumption of 2% of capital is too high and that number would be more appropriate if it included water rental rates and property taxes (which it currently does not).

A follow-up meeting was held on July 6, 2015 to review the final results from the run-of-river study by Kerr Wood Leidal and respond to issues raised during the March engagement meeting. A representative from Kerr Wood Leidal was present to comment on specific technical questions. Key discussion points included:

- The issue of screening out possible sites due to salmon presence was raised. It was wondered if those streams could be included with some sort of penalty/constraint included, such as a minimum in-stream flow of 50% mean annual discharge. BC Hydro will recognize the issue with a comment in the report, but at this point in time these streams will continue to be excluded from the analysis as significant re-work would be required to include them, along with other considerations. The inclusion of these sites will be considered in the next update.
- BC Hydro discussed the plan to look at storage potential for small hydro projects, with a focus first on the North Coast. This requires new methodology and a study will be undertaken in the fall/winter to address this.

- It was mentioned that in the absence of actual costs from projects, 2% of capital cost would continue to be used for O&M estimates. BC Hydro is open to changing this assumption if data can be provided to support it.
- To address previous concerns regarding public presentation of results, UECs above $200/MWh will not be shown in publically available summary material.

Feedback received, and the approach to addressing the issues, is shown in the table below.

Feedback Received	Consideration of Feedback
Salmon bearing streams should be considered as potential.	Commentary to be included in current update addressing this and methodology reconsidered for next update.
Small storage hydro projects should be considered.	Requires new methodology and will be included in next update. A Request for Proposals for a small storage hydro study, likely focusing on the North Coast region, will be distributed outside of the scope (and timing) of this update.
The project O&M cost assumption of 2% of capital is too high. It would be more appropriate if it also included water rental rates and property taxes.	Insufficient material has been received to support a change to the O&M assumptions; however, BC Hydro welcomes data and will consider all received for next update.
Cancelled EPA's should be considered as options in Resource Options Update.	These will be considered as potential resources and will be added back in a future update.
Take into account that some large IPPs are able to finance at a rate comparable to a Crown agency.	The discount rate used for resource options unit cost calculation does not reflect individual financing but rather is indicative of BC Hydro's long-term view; however, 5% and 7% rates are both included in results.
Apply maximum cut-offs to UEC data presented to aid readability and prevent misunderstandings.	BC Hydro will consider using a $200/MWh cut off when reporting UECs in publically available summary material; particularly when it is presented in an illustrated format.

2.5 Solar

Scope of update	Technology, potential and costs
Consultant Retained	Compass Renewable Energy Consulting Inc.
Engagement Method	Meetings on March 25 and June 29 Email correspondence

Twenty people attended the solar resource technical engagement on March 25, and expressed interest in participating in a working group to update the solar resource option data. Participants included representatives from B.C. Government (Ministry of Energy and Mines), Clean Energy Association of BC, Columbia Power Corporation, EcoSmart Foundation, Finavera Wind Energy, FortisBC, HES PV, Elemental Energy, and SkyFire Energy. Compass Renewable Energy Consulting presented their approach and their view on the forecast of capital cost. Participants expressed interest in meeting to discuss the preliminary results of the solar resource option update.

An invitation to meet was sent to interested parties on June 19, 2015, with a proposal to meet on June 29, 2015, to review the preliminary results. Eleven responses were received. In this second session, the BC Hydro technical lead sought feedback on the methodology used and the assumption on UEC by sites.

After reviewing the feedback received in the latest meeting, a revised presentation on the solar resource option update was sent on July 8.

Feedback Received	Consideration of Feedback
Utility planners should be considering now the long-term effects of the use of rooftop solar by customers as rates start to increase	While outside of the scope of this review, this is an area BC Hydro will consider investigating.
The amount of land area needed estimated at 5.5 acres/MW may be a little low for the B.C. experience.	It is acknowledged that the consultants drew upon the US studies; although that number is presumably based on fixed-axis. We will consider this feedback going forward in future updates.
The solar intensity dataset uses NRCan monitoring information from the airports, and it was mentioned by EcoSmart that the SunMine project showed higher numbers than the NRCan data.	NRCan provides a guideline of PV potential based on fixed axis. It is recognized that solar potential varies depending on different elevation and tracking capabilities, and we can consider various assumptions in future updates.
The solar potential numbers should be represented as a range of probabilities with error factors rather than focusing on one number.	Recently, NRCAN provided an uncertainty in the annual PV potential values by displaying the data as a value +/- twice the estimated standard error. For a normal distribution, 2 s.d. corresponds to a confidence interval of about 95% around the central value. This range can be incorporated into future updates.

Feedback Received	Consideration of Feedback
General feedback on the draft UECs was that the capital costs were good, O&M was underestimated, and the capacity factor looked lower than expected.	Based on this feedback, an exercise was done where we used several fixed OMA targets (i.e. $20/MWh and $25/MWh) to come up with a range of UEC. Regarding capacity factor, we revisited those numbers presented in the first meeting (which was based on fixed-axis) and adjust them to those with single-axis tracker capability. Result shows new capacity factor is between 17-20%, pending on the location.
Revisit why Osoyoos has high POI UEC.	As a result, and after discussion with our consultant, numbers were revised.
Revisit why Vanderhoof has no incremental cost for transmission.	As a result, and after discussion with our consultant, numbers were revised.

2.6 Natural Gas-Fired Generation

Scope of update	Update cost and technical characteristics for three simple cycle gas turbines and three combined cycle gas turbines
Consultant Retained	AMEC Foster Wheeler
Engagement Method	Email correspondence and written comment period, Phone conversations when requested by industry stakeholders

Ten organizations participated in the engagement process. These included IPPs and Original Equipment manufacturers (OEMs) such as Capital Power, GE Power and Water, TransAlta, and TransCanada. The bulk of the engagement was through email correspondence with phone conversations as necessary. Feedback received included:

- Observations that the cost of the turbines seemed somewhat higher than those seen during recent installations in other parts of Canada.
- Comments that the performance of the turbines will vary due to site conditions such as elevation.

The cost estimates provided by the consultant included a lump sum fixed price risk premium. The consultant had indicated that BC Hydro may wish to eliminate or adjust the premium. The premium was removed recognizing the feedback received as part of the engagement process.

2.7 Tidal

Scope of Update	Review status of tidal energy industry and update to capital cost estimate
Engagement Method	Meeting held on March 26, 2015

A meeting was held with a tidal energy researcher at the University of Victoria on March 26, 2015. The discussion began with the BC Hydro technical lead providing background on the Resource Options Report. They then provided an overview of how tidal energy in B.C. was characterized and costs estimated in the 2010 and 2013 Resource Options Reports. The discussion from there on focused on the current status of the tidal energy industry, the latest available resource assessment data for British Columbia, and current research underway to improve the resource data available. Key items discussed in the meeting include:

- An overview of current tidal energy companies, with a special focus on those operating within Canada
- A discussion on tidal energy test sites (including FORCE in the Bay of Fundy) and results from those sites
- A discussion of tidal turbine technologies currently proposed/in development
- Updated cost estimates were shared (sourced from the World Energy Council/Bloomberg New Energy Finance 2013 report “World Energy Perspective: Cost of Energy Technologies”)

Feedback from the meeting on March 26, 2015, and BC Hydro’s approach to addressing the issues, is shown in the table below. At this time no further data is available to update the resource assessment from previous Resource Options Reports; however, capital cost estimates were updated using the report mentioned above.

Feedback Received	Consideration of Feedback
NRCan study getting underway now that will do detailed hydrodynamic modelling of tidal energy resources in B.C. Dr. Crawford and his research group to look at combining oceanographic modelling with CFD modelling of tidal turbines to better capture total system impacts.	BC Hydro will monitor the ongoing NRCan and UVic research in order to update the tidal energy resource assessment in a future Resource Options Report.

2.8 Wave

Scope of Update	Update wave energy resource assessment and capital cost estimate
Engagement Method	Stakeholder Engagement Meeting held on March 27, 2015 Email correspondence

A meeting was held with several wave energy researchers at the University of Victoria on March 27, 2015. The discussion began with the BC Hydro technical lead providing background on the Resource Options Report. They then provided an overview of how wave energy in B.C. was characterized and costs estimated in the 2010 and 2013 Resource Options Reports. The discussion from there on focused on the current status of the wave energy industry and the latest available resource assessment data for British Columbia. Key items discussed in the meeting include:

- An overview of resource assessment modelling for wave energy in British Columbia that has occurred since the last Resource Options Report, including research done by the West Coast Wave Initiative at the University of Victoria
- A discussion on wave energy test sites and demonstration projects, and results from those activities
- An overview of current wave energy companies, with a special focus on those operating within British Columbia or North America
- A discussion of wave energy converter technologies currently proposed/in development
- Updated cost estimates were shared (sourced from the World Energy Council/Bloomberg New Energy Finance 2013 report “World Energy Perspective: Cost of Energy Technologies”)

Feedback from the meeting on March 27, 2015, and BC Hydro’s approach to addressing the issues, is shown in the table below.

Input Received	BC Hydro Consideration of Input
The wave resource assessment for B.C. should be updated to reflect improved resource modelling completed by West Coast Wave Initiative at University of Victoria.	Wave resource data was updated with results from West Coast Wave Initiative research. The latest research includes near shore wave propagation modelling and energy generation calculation through modelling of a generic wave energy converter.

2.9 Wind – Onshore

Scope of update	Update to technology, cost and wind potential
Consultant Retained	Hatch Consulting
Engagement Method	Engagement meetings held on 12 September 2014, 5 December 2014, 5 May 2015 and 3 June 2015 Email correspondence Meetings with CEBC/CanWEA representatives on 29 September 2014, 11 February 2015 and 13 May 2015

The industry engagement group included twenty-seven members, including representatives of Acciona, Aeolis Wind, Alterra Power, Avro Wind Energy, Bastion Power, B.C. Government (Ministry of Energy and Mines), Clean Energy BC, Canadian Wind Energy Association, Capital Power, Capstone Power Development, Columbia Power Corporation, EDF-EN Canada, EDP Renewables, Elemental Energy, Innergex Renewable Energy Inc., Lil'wat Management Services LP, Seabreeze Power, and Senvion.

During the first engagement meeting, turbine and loss assumptions were reviewed and input was sought from the industry stakeholders. The primary feedback was that the updated turbine characteristics should be representative of the most recent or slightly forward looking turbine technology. At the request of the engagement members, BC Hydro contacted five major turbine manufacturers and obtained a number of up-to-date power curves for the three IEC turbine classes as well as insights into turbine size and hub height trends. This information was reported back to the stakeholders during the second meeting. The impact of the updated turbine and loss information on the net capacity factors, along with preliminary results of a wind cost analysis completed by Hatch were presented to the stakeholders during the third engagement meeting. During the fourth meeting, preliminary UECs were presented and input was sought on how to how to adjust costs for challenging sites.

The table on the following page provides a summary of the key feedback and how it was considered during the update process of the wind resource option.

Feedback Received	Consideration of Feedback
BC Hydro should look into testing the assumption that Peace Region wind speeds are ~20% higher than the modelling would indicate (i.e. this assumption may unfairly favour the Peace Region over other regions).	BC Hydro reviewed the 2010 BC Hydro Wind Data Study, and found that the justification to adjust the wind speeds in the Peace Region by 20% was sound. A validation had been completed for the study based on 30 observation points, and a persistent negative modelled wind speed bias was found for validation sites in the Peace Region. No persistent bias was found in any other areas of B.C.
BC Hydro should contact AWS Truepower to see if their high resolution wind resource data could be useful.	BC Hydro looked into the applicability of AWS Truepower's high resolution wind resource data for resource planning. It was found that, due to the high computational costs, the underlying mesoscale modelling is based on only 366 days from a 15-year period (i.e. a representative meteorological year). However, BC Hydro has been using a 10-yr time series data set for both resource planning and the wind integration study. Hence, AWS Truepower's high resolution wind resource data does not provide the length of time series that is desired by BC Hydro.
BC Hydro should go back to DNV GL to review losses, and confirm if these numbers represent average losses, or are loss assumptions used by financial institutions. A couple of stakeholders also offered to review the various loss components and to provide feedback on them.	BC Hydro followed up with the stakeholders who offered input, and made adjustments to the loss assumptions based on the input.
BC Hydro should consult original equipment manufacturers (OEMs) to get their views/information on hub height, turbine size, and power curves.	BC Hydro contacted and consulted with 5 major OEMs (GE, Vestas, Siemens, Senvion and Enercon) on near-term trends on hub height and turbine sizing. BC Hydro also requested and received from each OEM the latest power curves for each IEC turbine class.
BC Hydro to go back to OEMs and explore the concept of pushing up the IEC classes, based on the mean wind speed alone.	BC Hydro exchanged multiple emails with OEMs as well as met with several IPPs to discuss a number of concepts with regard to pushing up IEC classes. A methodology was proposed by BC Hydro to the stakeholders. One comment received back from a stakeholder was that pushing turbines in certain wind regimes is on a case by case basis only, and should not be generalized. Hence, the concept of pushing turbines was dropped.
It was suggested that the Resource Options Report should contain a footnote which states that available projects are quite distinct and different in costs.	BC Hydro will consider including a general note to this effect as this could also apply to other resource options.
A stakeholder expressed concerns about the tight timeline to provide feedback on the turbine assumptions.	In response to the concern raised, the timeline was extended by a week.

Feedback Received	Consideration of Feedback
In addition to the 'ridge' and 'plateau' type projects, there should also be a 'plains' category to account for that construction costs for 'plains' type project are much lower.	This suggestion was noted. However, in the current data base of wind projects, there are very few or no wind projects that fall under the 'plains' category, and hence it is believed that including such a category does not make a material difference.
During a separate meeting with CEBC and CanWEA representatives, concerns were expressed about estimating the capital costs on a regional basis. It was mentioned that site specific conditions can easily outweigh regional differences in costs and that it would make more sense to use capital costs averaged over B.C.	BC Hydro agreed to use a B.C. wide average instead of regional capital cost estimations.