Resource Options Update Technical Engagement

Summary Report 2019-2020

OVERVIEW

This report summarizes the resource options update engagement process that was used for the 2021 integrated resource planning process. It includes feedback received in 2019 and 2020 and how it was considered. The resource options update process was focused on gathering technical information about the characteristics of resource options and did not collect opinions nor make decisions with respect to selection or preference of these options.

BC Hydro and FortisBC collaborated on the resource option update dataset to inform their respective integrated resource plans. As both utilities draw upon an inventory of resource options for their respective planning processes, a common dataset improves efficiencies and provides consistency during reviews.

All engagement materials, including meeting presentations and summary notes are available on BC Hydro’s public electricity supply options website.

The objectives of engagement

The objectives for the technical engagement with industry experts was to:

- build mutual understanding of the resource characterization, and
- gather input and feedback to validate updated technical information such as capital costs and technology.

Our approach

The resource options update occurred in three stages:

1. Notification of the update process and establishing workstreams.
2. Update the resource option information.
3. Gather feedback on the draft results and finalize the update.

STAGE ONE: NOTIFICATION OF THE UPDATES PROCESS & ESTABLISHING WORKSTREAMS

Given rapid changes in technological advancements and some resource options pricing, the process grouped resource options into three categories (evolving, existing, and emerging) to indicate the level of effort required for the update among resources.

- Evolving category included technologies that had seen rapid technological advancements and/or cost declines in recent years, including solar, battery storage, and wind resources. The update considered small-distributed scale sizing of these resources along with utility-scale sizing.
- Existing category included longer standing resources already in the resource options database – the update for these resources built upon existing resource knowledge.
- Emerging category included resources in a qualitative manner, allowing for their tracking and monitoring as they mature.

In September 2019, a scope and approach meeting occurred with representatives of the Clean Energy Association of BC (CEBC), associated First Nations representatives, the BC Sustainable Energy Association, FortisBC, staff representatives of the Ministry of Energy, Mines & Petroleum Resources and the BC Utilities Commission. The purpose of this meeting was to provide an overview of the scope and approach of the technical resource options update workplan, focusing on technology and pricing, and to gather feedback to inform the resource options update workplan.

In October 2019, an email was distributed to 185 people or organizations providing notification of the resource options update workplan. An invitation was distributed to industry experts that had participated in previous ROU processes, contacts provided by BC Hydro technical staff, and the Clean Energy Association of BC for further distribution to their membership[1]. People were invited to sign up for three workstreams within the category of resources that had seen the most changes in recent years: solar, battery storage, and wind. The existing resources were updated through a technical literature review.

STAGE TWO: UPDATED THE RESOURCE OPTIONS INFORMATION

BC Hydro staff updated the inventory through literature reviews and working sessions with developers and technical experts for those resources with established workstreams. Workstream meetings occurred to update the solar, battery storage, and wind resource options.

In December 2019, a technical session occurred to provide an overview of the update approach, updates to the workstream information, and a description of specific updates planned for existing resources, including the approach for demand side management options. Invitations were sent to 26 organizations and individuals, with 12 participants attending the session in person and 11 registering to attend via podcast. Participants were invited to provide written comments following the session, and to contact BC Hydro for further information.

Feedback received during the workstream meetings, and the December technical session helped inform the draft results. Feedback received during the workstream meetings are included in the respective summary notes for each meeting. The feedback received based on the December 2019 session, and BC Hydro's consideration of that feedback is provided in Appendix 1 of this document. Presentation materials and summary notes for all meetings are available on BC Hydro's public electricity supply options website.

[1] BC Hydro was notified by Clean Energy Association that they were pausing participation in the resource options update while the B.C. Government's Comprehensive Review of BC Hydro (Phase Two) was underway

A table listing of the sessions is presented here.

Description	Date	Document
Resource Options Update Session	December 12, 2019	Session Presentation Session Summary Notes
Resource Options Update Scope & Approach Session	September 16, 2019	Session Presentation Session Summary Notes
Technical Workstream: Solar Workshop	November 12, 2019	Workshop Presentation Workshop Summary Notes
Technical Workstream: Solar Workshop	November 20, 2019	Workshop Presentation Workshop Summary Notes
Technical Workstream: Energy Storage Workshop	February 4, 2020	Workshop Presentation Workshop Summary Notes
Technical Workstream: Wind Onshore Workshop	March 5 & April 3, 2020	Workshop Presentation Workshop Summary Notes

STAGE THREE: GATHER FEEDBACK ON DRAFT RESULTS AND FINALIZE UPDATE

BC Hydro completed the draft results of the resource options update in the spring of 2020. On June 11, 2020, BC Hydro sent a notification to 49 recipients announcing that the draft results for the supply side resource options were available on the public webpage and was inviting comments up to June 25, 2020. The notification was sent to people who had participated in the workstreams and sessions, and additional contacts gathered through the process.

Draft results for the demand side management options were reviewed with the BC Hydro's IRP Technical Advisory Committee during the June 2020 Meeting #3, and results of the generation supply options were presented during the July 2020 Meeting #5. For more information, refer to the IRP Technical Advisory Committee meeting presentation and notes.

APPENDIX 2 summarizes the feedback and questions on the draft results gathered during the June comment period, as well as BC Hydro's consideration of this feedback.

Appendix 1

CONSIDERATION OF FEEDBACK FROM THE "RESOURCE OPTION UPDATE" TECHNICAL SESSION, DECEMBER 12, 2019

Following the session, feedback was received from the following organizations:

- Avro Wind Energy
- BC Sustainable Energy Association
- Bridge Power
- Commercial Energy Consumers
- FortisBC
- Steve Davis and Associates
- Sunfield Energy
- University of Victoria
- Zen Clean Energy Solutions

Additional Generation supply option types

Feedback	Consideration of Feedback
BC Hydro should ensure that virtual net metering for solar generation is captured in the resource analysis, possibly as an optional attribute of community-scale and/or customer-scale solar generation.	In response, BC Hydro will include virtual net metering as a form of emerging solar.
In light of BC's energy policy objectives, include gas-fired peaker plants that use renewable natural gas or biodiesel instead of regular natural gas.	In response, BC Hydro is including in the database RNG-fueled gas-fired turbines.
Suggestion to consider a qualitative exposition about Tidal and Wave energies, including capacity factors and installation and generation costs.	Tidal and wave resources are included in the database.

Additional technical considerations

GENERAL	
Feedback	**Consideration of Feedback**
Unit energy costs have not been released, and no mention of financing costs. Historically, BC Hydro assumes a high cost of financing. Financing is one of the key drivers for lower power purchase agreements.	Financing is a key driver of costs. Financing costs for generic projects are updated as required.

WIND	
Feedback	**Consideration of Feedback**
Regarding wind cost trends, it would be helpful to have a graph showing the actual costs for just completed projects as opposed to mixing completed and non-completed.	BC Hydro is not able to provide this information because the information is not available to us.
BC's lowest cost utility-scale wind projects located on the NE South Peace River plains and Montney gas field have long-term wind data demonstrating a similar commercial resource to the best of recently developed Alberta wind projects. Due to the easy build terrains of the NE sites, BC Hydro should expect to receive similar low-price bids as experienced by Alberta when these shovel-ready projects and their globally celebrated developers are provided an opportunity to bid clean electricity supply.	Thanks for bringing this to our attention, and we'll endeavour to capture the wind resource potential on the plains in our next Resource Options Update. Our provincial inventory looks at planning level generic costs for a bulk quantity of resources, so specific projects on the lowest end may not be captured in the inventory. We are aware of the bid prices of Alberta, and some factors underlying those prices suggest it is not a simple transfer to BC.
The assumption that multi nationals are entering markets at a loss is incorrect. They have cheaper costs of capital, can take low returns on balance sheet financed projects, but are not taking negative returns. The price people are willing to sell electricity at is the key metric in planning, and unfortunately, you will not get that from capital costs and O&M models.	The comment regarding the position of multinationals when entering the market was noted. BC Hydro's methodology is based on the levelized cost of energy which incorporates factors such as capital costs, O&M costs and an assumed discount rate as the best available data.
The offshore wind generation is already a reality in some countries, so I believe that a roadmap for this technology is something that needs to be started, as there is a lot of available information and the province's offshore generation capacity factor is relevant, based on the "The Atlas of Canada - Clean Energy Resources and Projects" (https://atlas.gc.ca/cerp-rpep/en/). As this technology is new to the province's system, maybe it is good to look deeper into the negative environmental impacts, this way it will be possible to define the regulation frames to enable the development of this resource, minimizing it's impacts in the future.	Offshore wind is included in our database and we continue to monitor developments. There are no plans for a roadmap for this technology from BC Hydro; however members of the sector may have looked into this.

SOLAR	
Feedback	**Consideration of Feedback**
With respect to distributed solar, suggest BC Hydro include solar on rooftops of rental single-family dwellings be captured in the analysis because rental is not so much a technical limitation, as a legal circumstance which could in principle be overcome with the appropriate policies.	BC Hydro will consider this for future resource options update work.
Solar slide shows within 25 km of transmission. Northeast BC has no transmission but is good for solar. Don't forget to add that into the options as transmission will be built for the gas industry.	BC Hydro acknowledges this issue and will consider including for future resource options update work.

BATTERY STORAGE (AND OTHER ENERGY STORAGE OPTIONS)	
Feedback	**Consideration of Feedback**
Distributed batteries instead of grid upgrades. Personal experience as a load customer in Pemberton was that the substation is near maximum, so another big customer required a $60 million substation to cover a 2 hour 10 day a year scenario, whereas $2 million in batteries would do the same job.	BC Hydro acknowledges that distributed batteries may be used to relieve regional capacity constraints and defer infrastructure investments. Distributed battery storage is an option being characterized in the database.
As the province continues with renewable resources, utility battery storage will be one of the most important supply-side options to be developed. So, choosing the best locations, based on the wind generation profiles, on the existing river-run facilities and on the transmission lines is the first aspect to be planned.	BC Hydro is characterizing utility scale battery storage options in our database.
When looking at long duration utility scale energy storage, hydrogen should be considered as well (electrolysis pathway). Conversion back to electricity can either be through hydrogen turbines or distributed generation fuel cells (>1 MW). Injection of hydrogen into the natural gas network is another way to store the energy, but if the goal is to convert back to electricity need to use a natural gas generator running a blend. Australia has some good recent studies looking at large scale H2 energy storage costs. This isn't even emerging anymore, its being done in other part of the world now for energy storage.	Hydrogen electrolysis will be included in the database among our emerging resource types.
Regional capacity resource options to avoid substation upgrades. What about batteries on the other side of the substation to shift load to off peak times? If you have a 2	BC Hydro is considering various battery storage options in the database, including distribution and customer scale batteries.

hour a day 10 days a year issue, charging batteries off peak removes the need for capacity.	
EXISTING RESOURCES	
Feedback	**Consideration of Feedback**
Consider pumped hydro storage using a shared reservoir. It means that if the existing reservoir can receive more water, another energy resource's generation can be used to pump the water back to the reservoir. This way, the environmental impacts are reduced (because a new reservoir doesn't need to be constructed), and the uncontrollable energy generation can be used to storage energy in the form of water.	BC Hydro is considering various pumped hydro storage resources.
Summary of existing resources slide Representative sizes seem odd. Run of river at 5MW but if with storage 50MW. Pumped storage at 1,000 MW is a massive project - looks like it is targeted at recycling BC Hydro dams rather than new resources. Geothermal – I only know two projects, but both are 500 MW.	The notes below provide some further context of the representative resource options: Run of river inventory includes many small projects and only a few large ones, so the simple average project size is small (5MW). Small hydro storage is a small group of relatively large run of river resources (minimum of 20 MW of dependable capacity) that have been identified as having the appropriate characteristics to permit impoundment structures. The average project size of the group of projects is 50 MW. The inventory of pumped hydro storage resource options consists of 163 potential sites, and only one of these options is located at an existing BC Hydro facility. Construction of pumped hydro storage facilities have significant economies of scale, and many of the least cost facilities in our database are 1,000 MW, though our database also includes facilities as small as 500 MW. Geothermal estimates in the database are based on a p90 confidence assessment of geothermal resource, so may be lower than other announced figures. In the database, there are two large ~100 MW sites near Pemberton, and a small number of relatively small geothermal resources that are based largely on coarse provincial-level resource assessments.

DEMAND-SIDE MANAGEMENT & RATE OPTIONS	
Feedback	**Consideration of Feedback**
DSM - Additional options	
Suggest the next DSM step is to encourage customers to use smart grid equipment with machine learning. Domestic electric appliances will spend electricity when the prices are lower or when there isn't a demand peak. It makes the system be able to be balanced during the day, and the house will spend more electricity when there is more uncontrolled renewable generation for example.	BC Hydro is considering capacity-focused DSM options, including options to support associated time-varying rates.
DSM - Additional technical considerations	
If it is not already doing so, BC Hydro should factor in geographic considerations, particularly whether geographically targeted DSM has the potential to defer capital spending on system upgrades or extensions in specific regions.	BC Hydro will be considering location when undertaking the IRP analysis and developing DSM options.
Completing a Conservation Potential Review. How to integrate this message with fuel switching from natural gas to electricity for GHG reductions under CleanBC.	This resource options update exercise is focused on characterizing energy efficiency options and demand response options. The topic of fuel switching is not part of this exercise.
Regional capacity resource options to avoid substation upgrades. What about batteries on the other side of the substation to shift load to off peak times? If you have a 2 hours a day 10 days a year issue, charging batteries off peak removes the need for capacity.	BC Hydro is considering various battery storage options in the database, including distribution and customer-scale batteries.
Capacity focused rate options: As presented, the first thing to be done to give the customers the right market signals and incentivize more efficient energy usage is to transmit real time generation prices. A good start is to transfer to the customers the generation costs during the peak hours. In some countries, like in Brazil, the costumers choose the type of rates that they will be charged. And it is based on their consumption profiles. So, some customers are already being charged with a different rate that varies accordingly to the hours of the day and to the peak demand times. So, if a costumer doesn't have a consumption profile as the average consumers, they can have smaller monthly energy costs. This initiative can encourage some costumers that have a more flexible life to change their consumption profiles.	BC Hydro is including time- varying rate options for consideration.

GRID MANAGEMENT SYSTEM	
Feedback	**Consideration of Feedback**
If we bring in time of use pricing there is a potential incentive for customer storage, which means an opportunity for load shifting and distributed resources. This should be considered in more detail - basically the interactions between each of the presentations today rather than thinking of each in silos.	BC Hydro acknowledges the opportunities to integrate the supply and demand at the distribution level through intelligent grid management systems.

Answers to questions raised

GENERAL
Q. To what extent do we see countervailing trends, that is, while costs are decreasing over time, location matters, and over time the best locations will be taken up, pushing costs up for the remaining resources? A. BC Hydro has not considered this specific trend to date; however, we'll consider it as we move forward to see if it is appropriate to include in our analysis. In general, resource quality at different sites is accounted for in our analysis. Regular updates of this inventory help keep up to date on both location availability and resource quality.
WIND
Q. What would be the cost of adding batteries to existing wind farms to create capacity? All of the required infrastructure already exists. A. The cost of battery systems that are co-located with renewables will be included in battery assessment.
SOLAR
Q. Installed and unit energy costs of community-scale solar power will be significantly higher than utility-scale solar. Why is solar viewed as suitable for community-scale despite its higher cost? Why is BC Hydro not studying community-scale hydro, or community-scale wind power? A. BC Hydro has included community-scale solar within our database as it has changed economics. Community-scale hydro is in our database. Community-scale wind at this point is not included, however, BC Hydro continues to monitor developments and will include in the next options update, as needed.
BATTERY STORAGE (AND OTHER ENERGY STORAGE OPTIONS)
Q. With regards to home battery systems, has BC Hydro looked at any software management systems for this? And would time of day pricing impact the uptake in batteries? A. BC Hydro has not looked in detail at the battery management systems. The structure of customer tariffs impacts the economics of behind-the-meter storage investments and would influence the uptake of customer side batteries.

Appendix 2

CONSIDERATION OF FEEDBACK ON DRAFT RESOURCE OPTIONS UPDATE RESULTS

Ten sets of written comments were received on the draft results from the following entities:

- Clean Energy Association of BC
- BC Sustainable Energy Association
- Capital Power
- HES PV
- Ecosmart
- Sunfield Energy Inc
- Steve Davis and Associates Consulting Ltd
- University of Victoria
- Ministry of Energy, Mines and Petroleum Resources

Comments or questions in the information below that refer to a page number are referring to the draft results document.

GENERAL	
Feedback	**Consideration of Feedback**
Interconnection costs could be lower if a line voltage private sector contractor did this work.	The resource options update does not distinguish who undertakes the interconnection work. BC Hydro acknowledges that contractor costs may be different depending on how the interconnection work is undertaken. BC Hydro considers the cost is reasonable for planning purposes.
Wind, solar, and some run-of-river sites command renewable energy credits and environmental attributes that BC Hydro sells through Powerex – benefits that are overlooked when applying a cost 'penalty' for non-firm or variable power from IPPs.	The purpose of this resource options work is to update the technical and financial characteristics of the resource. Additional benefits may be considered in analysis using the data.
BC Hydro considers renewables as stand-alone projects, excluding aggregation in diversity of supply or geographical separation of wind farms, which would produce a much higher dependable capacity than BC Hydro is currently recognizing.	The resource options work characterizes the individual resources' technical and financial characteristics, rather than evaluating aggregate characteristics of portfolios of resources. Portfolio-level benefits from diversity of resource types and locations are incorporated as part of the portfolio evaluations.
Wind and solar projects can be retooled at a declining cost, which equates to a much longer amortization period for	BC Hydro acknowledges that wind and solar projects at the end of life may be able to be refurbished at a cost

financial analysis and much lower unit energy cost. Wind should be assessed at 25 – 30 years (and if retooled, 40-45 years) and solar at 35 years.	advantage over a similar greenfield project. However, the decision to retool, and/or extend any given project is not part of the resource options database. Instead, lifetime is based on an assessment of the lifetime of core infrastructure assets.
Wind and solar capital costs should be within 10-20% of Alberta's Renewable Electricity Program (3 Rounds in 2017-2018). Round 1: Average cost: $37/MWh, Round 2: Average cost: $38/MWh, Round 3: Average cost: $40/MWh.	Our analysis for solar and wind took a bottom-up approach based on best available information. BC Hydro considers the results are reasonable estimates for planning purposes.
APPROACH	
Feedback	**Consideration of Feedback**
Ensure technology trends (continued cost out, technology cost decline) are acknowledged and captured. This can be referencing the most recent Lazard report or BNEF.	Capturing technology trends has been part of this update to our resource options approach. We chose the National Renewable Energy Laboratory (NREL) Annual Technology Baseline for our source of information on future cost reduction trends in order to be consistent across resource types.
SOLAR	
Feedback	**Consideration of Feedback**
Depending on the transmission costs that is incurred by the IPP, a more appropriate range that we have seen from successful projects is $1,400/kW as a minimum and up to $1,850/kW capital cost for solar. This range includes a good-sized premium for potential additional charges associated with a built in B.C.	BC Hydro's assessment of solar capital costs at gate range from $1,910 – 2,132 / kW (AC) delivered in 2020 – slightly beyond the high range of costs cited. The difference in cost estimates may stem from different input assumptions (e.g. inverter overbuild ratio, Canadian-US currency conversion rate etc.). BC Hydro's input assumptions have been reviewed by technical stakeholders and are considered reasonable for planning purposes.
The at-gate unit energy cost ($/MWh) is shown to range from $81/MWh to $112/MWh. It is not clear whether this is in USD or CAD. The Economist (May 23rd, 2020) estimates that were the resource is strong at solar prices range from USD $50/MWh or CAD $67/MWh. Hydro Review (June 9th, 2020) also estimates utility scale solar at USD $68/MWh.	Costs are shown as Canadian dollars (CAD). The costs presented align with our numbers. The $67/MWh and $68/MWh US is comparable to $81/MWh CAD.
Projects in Alberta are moving forward on the distribution side between $45 and $70/MWh all-in. Although there are many differences between Alberta and British Columbia, it is relevant to take that information into consideration. When normalizing for the resource and interconnect, all solar sections in this report are still overstated by approximately 20%.	BC Hydro acknowledges that lower cost projects may exist, particularly on a small scale, as there are limitations in our high-level resource scan. However, our estimate for the broader resources is considered reasonable for planning purposes.

The ranges stated on page 19 for utility solar at point of interconnection, $94-$233/MWh is reasonable.	This comment was noted.
It is appropriate to use NREL data, although sometimes the application to Canadian context is inaccurate.	This comment was noted.
Agree with using PERC; however, the horizontal single-axis trackers widely used in the US are much less efficient in northern latitudes because they are horizontal at mid-day and the angle of incidence is too pronounced here.	The technical stakeholder group stated that, despite the lower performance of horizontal single-axis trackers in higher latitudes, there was a clear global trend towards single axis trackers. The tradeoff between cost and productivity in the selection of mounting infrastructure will be at the discretion of individual developers, and we will continue to monitor developments in the Canadian context.
Slide 45. Consider adjusting the bottom of future solar cost decline “Uncertainty Band” downwards to accommodate solar technology in British Columbia at larger utility-scale project sizes – recommend ~$60 MWh solar by 2025/26. Project life is not exposed, but please note that most solar projects are designed today for 30-year life, and future projects to 35 years.	We’ll continue to monitor developments of solar cost declines and incorporate into updates in our database.
Please break out the ~ 6 GW figure by residential and commercial installations.	Generally, about 2/3rds residential and about 1/3 commercial. The combined number is suitable for the analysis.

WIND	
Feedback	**Consideration of Feedback**
Wind ROU in slide 3 states that BC Hydro is continuing to use 2009 BC Hydro Wind Data Study. This is not advisable because better turbine efficiencies and lower capital costs have effectively changed the economics of wind sites in BC, resulting in lower capital cost and economically viable sites that were not possible before higher efficiencies and lower cost turbines came into effect. To properly inform the IRP 2021, a new wind study is required.	While wind turbine technology has changed over the decade, we believe the sites selected based on the 2009 BC Hydro Wind Data Study are still a reasonable representation of the most viable wind resources. Class 3 wind resources with wind speeds above 6 m/s were included among the sites studied. Among the 122 potential sites included in the 2009 Resource Options Report, 91 are Class 3 resources. Modern wind turbines that can take advantage of Class 3 wind speeds found on relatively flat terrain and close to existing transmission may indeed have made such sites more economical than more remote Class 1 and Class 2 wind resources. Our 2020 database includes all three types of wind resources, and resources located on rough terrain are assigned a cost premium for development. As technologies continue to change, we will update our work to account for the changing costs of development in different terrain types.
There is a risk that caribou protections are not fully captured in the onshore model. This is further compounded because of the timeframe of when these resources may be required.	For the screening of this resource in our database we only eliminated legislatively protected areas from consideration.
Please confirm that “each project” in Slide 27 refers to the 122 “resource options” in Slide 28	Confirmed.

BATTERIES	
Feedback	**Consideration of Feedback**
Most financial analysis overlooks their benefits and do not value batteries appropriately. Other benefits that are often not included in financial analysis include, but are not limited to, ancillary services to the grid like voltage-ampere reactive regulation.	Additional value streams and value stacking of battery depend on the operation of the battery system and the grid context.
Lithium ion is currently more cost competitive. However, lithium ion has a usable life (measured in cycles) of less than half of that of flow batteries. Therefore, the longer lasting flow batteries should have a lower cost due to their greater life span. Include further data sources regarding	Our review with the battery workstream indicated the lithium ion resources were preferable to other battery types such as flow batteries and so our analysis focused on lithium ion. This will be reviewed in updates to the database.

cost and performance estimate sensitivities to the assumption of lithium versus flow types.	
Slide 38 – It would be worth mentioning that these prices are on a very rapid decline. These already seem very high. By the time you publish, this will have changed significantly. Or add a graph of project costs like you have for wind and solar.	Cost reductions of batteries are included in our analysis and in updates to the database.
EXISTING	
Feedback	**Consideration of Feedback**
A minor point, I am not sure that the assumption that all biogas will go to renewable natural gas (RNG) production, leaving none for electricity production is a fair one. The costs of producing RNG are high.	This comment was noted.
Suggest Simple Cycle Capital Cost range be increased to $1,100-2,200/kW to better reflect BC specific cost factors, higher BC permitting and development risk and to incorporate both frame and aeroderivative technologies.	This comment was noted.
Slide 43 states "After accounting for interconnection costs, only natural gas combined cycle turbines offer energy at a UEC less than $90/MWh." This is misleading, because the slide excludes the other types of resource options.	This slide showed the existing resources results. Slide 44 shows the full list.
EMERGING	
Feedback	**Consideration of Feedback**
Consider active monitoring and participation in wave and tidal marine energy generation exploration.	This comment was noted.

Answers to questions raised

APPROACH
Q. With BC Hydro's load forecasts claiming a surplus for 15 years why and how is BC Hydro is considering Resource Options in the IRP? A. As part of our long-term planning process, we track trends in resource option technology and pricing. Understanding trends allows us to plan effectively for the future, including contingencies if demand comes sooner than expected. We focused this resource options update on evolving technologies which have seen material developments in recent years and are projected to see continued cost declines over the near- and mid-term.
Q. Will potential effects of COVID-19 on resource costs be reported in the final version of the ROU report? If not, how will this analysis be incorporated in the IRP process? A. While COVID-19 is projected to have a significant impact on near-term deployments of renewable generation technologies, we have deemed it reasonable to assume the long-term costs of the technologies will return to their pre-COVID trajectories. We'll continue to monitor these trends going forward and adjust in updates to the database.
Q. Are adjusted UEC and UCC values within the scope of the ROU? A. Adjusted UEC and UCC values will be developed as part of the portfolio analysis, and not as part of the resource options update.
Q. Why are batteries, pumped hydro storage and SCGT the only capacity options for which data are presented in the ROU? What about the capacity contributions of energy resources? A. Batteries, pumped hydro storage and SCGT are resources deemed to primarily provide capacity, and therefore the relevant metric for cost-effectiveness is UCC. For some other resources that provide primarily energy but also provide capacity (e.g. small storage hydro, geothermal, biomass), their cost effectiveness is characterized in terms of UEC but their capacity contributions are nonetheless captured. Dependable capacity contributions from these types of resources are captured as an adjustment and included in the portfolio analysis.
SOLAR
Q. How are land acquisition costs factored into to generation costs in the three categories of solar? Is land acquisition cost assumed to be zero? Assumed to be an average? A. Land acquisition costs are assumed part of the development costs. Site-specific land costs are beyond the scope of this high-level assessment, so generic land costs were used. The overall costs will be less accurate for sites with particularly low or high cost land.
Q. Please confirm Solar Customer Scale includes that power is provided to the grid and not used to displace customer load directly; or whether it refers to solar generation provided through net metering. A. Customer-scale is a generic resource located on the customer side of the meter (i.e. customer-owned rooftop solar) that looks at the cost and potential of rooftop solar, irrespective of any program or policy.
Q. How sensitive are the cost and performance results to the assumption of single axis tracking and PERC technologies? A. BC Hydro did not undertake a sensitivity test, given the high-level scale of resource options and the assertion from the working group this was the state of the art technology for B.C.

Q. What assumptions or assessments were made regarding installation costs, and how sensitive is the cost analysis to these? A. The resource options included installation costs which were consistent with US average costs. We did not undertake a sensitivity analysis of these costs for purposes of the database.
Q. Does “In general, capital costs are in line with U.S. average capital costs” take into account exchange rates? Why is snow removal not considered a possible extra cost for BC versus the US average for OMA? A. Yes, the costs take into account exchange rates prevalent at the time of analysis. Snow removal costs were not included. It was discussed at a solar work stream session and it was not considered a significant factor.
Q. Does “discrete utility scale options” mean discrete sites where utility scale solar project could be built? A. Yes.
Q. It would be helpful to specify what is included in OMA, and whether this is the same for each supply option. A. Please see the engagement materials for what is included in OMA for the evolving resources.
Q. What causes the variation in UEC values at gate and POI? A. Three main factors cause the variation in unit energy values at gate and point of interconnection: (a) scale (size of facility), (2) solar resource – how much energy is achieved per installed capacity MW, and (3) interconnection costs.
Q. The results include sites where there is a high differential in cost between plant gate and POI. Do the criteria for being an "option" take into account transmission costs? A. Initial screening of viability included only a proxy of transmission costs (e.g. less than 25 kilometers from transmission). Therefore, some facilities are still included which have high interconnection costs.
Q. The range of UEC at POI for Utility Scale Solar is very broad ($94/MWh to $233/MWh). However, the range would be about $94-$100 /MWh for up to 12 MWh/y. Is the broad range included simply because that reflects the sites that were analyzed? In terms of communicating the expected cost of different types of supply resources, has consideration been given to providing a narrower range and quantity over which the range applies? Some readers may interpret $94/MWh to $233/MWh as meaning that the cost is roughly halfway between the ends of the range. A. We are explicit on the range of high and low. We will be showing a range of solar in the results. The transmission factor is addressed above. These comments were noted.
Q. Please give more detail on the screening parameters for “available land in urban areas.” What is meant by “urban” areas? Does it include areas within the boundaries of small communities? A. Available land in urban areas follows the definitions as described by NREL’s “The Renewable Energy Potential Model: A Geospatial Platform for Technical Potential and Supply Curve Modelling”. In general, this refers to any urban land (including within the boundaries of small communities) that has a limited existing density of infrastructure build-up. Landmarks, parks and some other designated land uses are also excluded.
Q. Please confirm that the “resource options” 59 refers to sites. 59 seems like a small number of feasible sites. Please give some detail on their locations and characteristics. E.g. are they on public land? Mostly in large urban areas? A. Confirmed. The distributed scale solar included a relatively limited number of sites to small amount of land available and the need to be close to distribution line with sufficient capacity to host additional solar resource.

Q. What factors make the capital cost higher for distributed scale solar than for utility scale solar? A. Higher installation costs and panel costs per unit of capacity.
Q. Why are the minimum and maximum capital costs the same for both residential and commercial installations? Is this because only one generic installation example was used? A. The capital costs were the same because we assume one cost per megawatt for distributed scale solar. Whether it is 5 MW or 15 MW, they are similar for planning purposes.
Q. The range of UEC at POI from $115 – $545/MWh is misleading on the high end. It looks like the range is from about $110 –$140/MWh for up to 700 GWh/y. A. This high cost at the high end is due to substantial interconnection costs for a small resource.
Q. Why are capital costs for smaller systems determined to be lower than the US average? A. Based on insights and feedback from the solar workstream group who have solar technical expertise.
Q. What OMA costs are assumed for residential installations? For commercial? What is included/excluded? Are the OMA included in the UECs? If not, why not? A. Engagement materials provide additional information on OMA cost assumptions. OMA costs are included in UEC calculations.
Q. Given that “Generation characteristics of customer-scale resources was modelled using NREL’s SAM and a single representative solar resource based on generic residential and commercials rooftops in Victoria,” does this mean that the size of installations (reflected in the Average Installed Capacity) could be quite different if larger (or smaller) installations were desired? A. Yes. For planning purposes, we choose a generic characteristic.
Q. Does average installed capacity refer to a single example installation (for each of residential and commercial)? A. Yes.
Q. Please explain why “number of resource options” is “N/A”. Is this because customer scale solar is treated as a single supply resource option? A. For the purposes of the resource options report it is treated as a single resource. Please note that customer-owned generation is not treated as a supply resource option because the decision to build or acquire the resource is not primarily at the discretion of the utility.
Q. Why is the capital cost for customer commercial solar installations estimated to be lower than for distributed solar? A. This was an error in the presentation of the costs of the solar resources. For utility and distributed scale solar resources, costs are presented in $ / kW AC (i.e. taking into account a presumed 1.3 overbuild ratio). For customer scale solar, costs are presented in $ / kW DC (i.e. assuming there is an overbuild ratio of 1). If customer scale solar were presented in terms of $ / kW AC and an assumed overbuild ratio of 1.3, the costs for customer scale solar is higher than distributed scale solar.
Q. Please comment on why the residential and commercial customer scale solar installations, with capital costs similar to those of distributed solar and ~30% more than utility scale solar, have UEC estimates ~twice those of industrial solar and ~60% more than distributed solar.

A. The main difference is energy production per year. Rooftop solar mounted at a flat angle in urban areas with low to moderate solar resources will yield less energy production and so ultimate costs will be higher. A secondary difference is the inconsistency in the assumed overbuild ratio between customer scale and distributed/utility scale solar which conceals the true cost premium per kW installed for customer scale over distributed or utility scale.
Q. Is the cost of energy shown a total resource cost? I.e. do the costs include costs borne by individual customers as well as costs that would need to be covered by Hydro and its ratepayers? A. Yes, it is a total resource cost.
Q. Is the solar plant capacity in MW DC or MW AC? There is typically a 25% difference between the two. A. The solar plant capacity for this resource options update is in MW AC.
Q. Are the UEC costs LCOE or first year based? A. The UECs are based on a levelized cost of energy calculation.
Q. Why does the UEC at the gate increase with the sum of annual energy? Is it because of forced curtailment? A. The chart is a supply curve so the UEC represents multiple plants and locations.
WIND
Q. How sensitive are the cost and performance estimates to the assumed hub height on 110 m? A. The resource options update did not include a sensitivity analysis on the cost and performance estimates to the assumed hub height.
Q. What factors explain the difference between the minimum and maximum capital costs? A. The complexity of terrain was the significant factor.
Q. What causes the variation in the UEC values at gate? A. The complexity of terrain, quality of wind resource, and size of facility.
Q. Is the variation in the UEC values at POI caused by the cost of transmission, or are other factors involved? A. The cost of transmission as well as complexity of terrain, quality of wind resource, and size of facility.
Q. To confirm, our understanding is that slide 30 indicates that Wind Onshore at POI UEC of $55-$100/MWh for 36,000 GWh/y, with an additional 14,000 GWh/y available at a POI UEC of $100-$300 GWh/y. What determines the cut-off point on the right-hand side of the graph? Is there a uniform criterion applied across resource types? A. The graph represents our full inventory of options. All resources are shown graphically with the full inventory of options identified, with the exception of run of river, which we are only showing resources under 500 $/MWh.
Q. As you explained that the costs for off-shore wind may be over-estimated and appears counter-intuitive to the increased deployment of off-shore wind resources globally. Will an update or further research be possible? A. This can be included in our assessment of further studies for the next update.
Q. Please describe the method for identifying potential projects.

Why did BC Hydro not re-assess the number of potential projects for the current ROU? A. The primary criteria for identifying potential sites was based on the 2009 BC Hydro Wind Data Study, screening for locations with average wind speeds of at least 6 m/s. Exclusions were applied based on land use and slope and a maximum distance from existing transmission infrastructure. No new wind study or review of the sites based on the 2009 wind data study was conducted because the sites already identified provided a reasonable assessment of the available wind resource options.
Q. Do the 5 MW turbines assumed here have greater capacity than the turbines assumed in BC Hydro's 2009 studies? If so, why are the installed capacities of the projects left unchanged? A. Yes, individual turbines in the 2020 Resource Options Report have a higher capacity than individual turbines in the 2009 study due to the higher towers and greater swept area. However, the greater capacity of individual turbines also comes with a greater need for space between turbines. Within a given footprint for a wind power development, these two factors were presumed to generally offset one another, with the overall capacity for a constant footprint remaining the same. Although the installed capacity of projects in the 2020 Resource Options Study remains unchanged, the greater efficiencies and higher wind speeds at higher hub heights results in greater annual energy production at sites in this 2020 update relative to the 2009 study.
BATTERIES
Q. Specify the source for: "The capital cost of 4-hour lithium ion battery resources range from $1,581 to $1,900/kW." A. BC Hydro's calculation is based on sources listed in our engagement materials.
Q. "Batteries are generically defined as having a four-hour peak duration..." Is that an industry definition or a statement of BCH's needs? A. This is assumed to be a current industry standard, as per input from our technical workstream information.
Q. Does BC Hydro anticipate that co-located batteries could or would be deployed to help with grid capacity issues, or that they would be used entirely on the co-located site to help integrate on-site generation into the grid? If the former, can BC Hydro provide an order-of-magnitude estimate of the potential capacity? A. Co-located battery systems could be deployed for either of the applications noted. BC Hydro cannot provide an order of magnitude as it will depend on future development of new future generation resources.
EXISTING
Q. In the statement, "Due to competition from procurers of Renewable Natural Gas (RNG), it is assumed that all available biogas resources will be used to produce RNG rather than electricity," does "all available biogas resources" include wood fibre and cellulosic digestion used to create biogas? If so, how does this relate to the "Biomass" resource described in the same table? A. No. Biogas resources here are limited to methane from landfill or other municipal organic wastes.
Q. Please confirm that "Number of Resource Options" refers to potential facility sites? A. Confirmed, with the exception of natural gas.

Q. Regarding “Number of Resource Options,” and regarding the supply resource option report more broadly, please discuss whether the scope is limited to yet-to-be- built facilities. What about existing facilities, such as run of river or biomass, that have EPAs with BC Hydro that expire during the planning period? How is the renewal of EPAs dealt with? A. EPA renewals are not included as resource options in our database. These are addressed separately as part of the IRP analysis.
Q. What is the basis (or critical limiting factor) for identifying the “number of resource options” and average installed capacity for the various resources, particularly: biomass; geothermal; MSW; CCGT; SCGT? A. In general, for those options that are not limited by a renewable energy resource (natural gas and battery storage) we recognize there is no obvious critical limiting factor in the number of resource options. For all other resources, the number is based on a combination of resource potential and economic viability.
Q. How is geothermal prospecting risk factored into cost? A. The cost of each geothermal resource option includes a cost for a number of wells that prove unsuitable for use as production wells.
Q. Please explain Municipal Solid Waste in more detail. Are the 3 “resource options” new MSW facilities that have not yet been built? What does the “Capital cost min and max” include – is this limited to the electrical generation equipment or does it include the MSW incineration/gasification? If the Capital Cost includes the incineration equipment, how does this financial information relate to the other supply options? The OMA cost footnote says, “not including revenues associated with tipping fees.” This doesn’t appear to create a meaningfully comparable unit cost. A. In response, we will include more detail in the write up of the resource options report.
Q. For Run of River, do the financial measures show the impact of the seasonal time of delivery during the freshet? A. No, the financial measures do not show the impact of the seasonal time of delivery during the freshet (spring snow melt) period.
Q. Slide 42 is titled “Existing Resources.” Explain what “existing” means. A. Existing resources is how we have described the category of resources in our database that have not, for the most part, seen material changes in cost declines and technology advancement compared with solar, wind, and battery storage.
Q. Why is the cost curve for pumped storage and small storage hydro not shown? A. These are primarily capacity resources and do not have a unit energy cost.
Q. Why is customer scale solar not shown on slide 44? A. Customer-scale solar is on the customer side of the meter and is accordingly not considered a supply resource. It is considered as a demand-side resource.

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