Clean Power 2040

Powering the future

Additional information package

The following information sheets provide additional context about our future demand supply outlook and options to meet future power system needs.

1. Charting an uncertain electricity future: our electricity supply and demand outlook
2. Tools we can use to meet our electricity needs: improving energy efficiency and reducing peak demand
3. Looking at potential resource options: expiring Electricity Purchase Agreements with Independent Power Producers
4. Small BC Hydro hydroelectric plants at, or reaching, end of life
5. Generation resource options: new electricity supply choices

BC Hydro
Power smart

Clean Power 2040
Powering the future

Charting an uncertain electricity future

Our electricity supply and demand outlook

Clean Power 2040 is about making choices on how to best meet our customers' future need for electricity. Through this process, we'll look at the scenarios for how much electricity we might need in the future, and then make choices to prepare future electricity supply options that we should advance to meet any gaps.

This is called our supply-demand outlook or our load resource balance (LRB), and it is the foundation for our planning. It estimates how much new supply may be needed and when. It provides an overview of our LRB, options we have to address gaps, if any, and how we are addressing uncertainties inherent in trying to project into the future.

The difference between energy and capacity

We have two aspects of electricity supply to consider – **energy** and **capacity**. You learned about the difference between energy and capacity in the Consultation Workbook. To understand the concepts of energy and capacity and the role they play in BC Hydro's future planning, it's helpful to think of B.C.'s electricity system as a 10-lane freeway. The number of lanes on the freeway determines how much space is available for cars at any time - this is capacity. The number of cars on the highway at a specific time is demand. While not all lanes are needed all the time, they are needed during the morning and evening rush hour. Like that 10-lane freeway, the capacity of B.C.'s electricity system is limited by the amount of power BC Hydro's facilities can generate at one time. Even as it meets predicted day-to-day electricity demand, we also need to ensure our system has enough capacity to meet the province's demand for power during peak periods. BC Hydro's infrastructure - generating stations, substations and power lines - must be able to support that additional demand. As demand for energy grows, the systems' capacity must grow with it.

Another important consideration when thinking about capacity is the ability to deliver electricity in a given moment from where it is generated to where it is needed. This is the purpose of our transmission and distribution systems. While both systems are important, the long distance nature of the transmission system – our fast highway for electricity - can be a limiting factor on a peak day. That's why meeting capacity needs are considered from both province-wide and regional perspectives - so we can make sure each region has enough local generation or transmission system capacity to meet electricity demand at peak times.

We have more than one forecast

To start the process, we look at how much electricity customers will need on an expected date. This is our **reference** outlook. Several factors are important when forecasting future demand for electricity, from population and economic growth, through the evolution of technologies and on to government policy. The reference case includes announced policies to reduce GHG emissions in response to climate change. For example, the reference case includes the provincial government's zero emission vehicle regulation which requires 25 per cent of all new vehicle sales to be electric by 2025.

Above and below the reference case for electricity demand, we have a high and low case to show uncertainties. For example, we know that the demand for power can change if population and economic growth is higher or lower than expected. We also know that new technologies like electric vehicles and new policies aimed at reducing British Columbians' greenhouse gas emissions can have an impact. We update our forecast regularly with a new one planned for the end of 2020. This is why is it unusually high, especially in the first few years, when compared to the reference and the low case, which were updated in the early weeks of the pandemic to adjust for the potential impact from COVID-19.

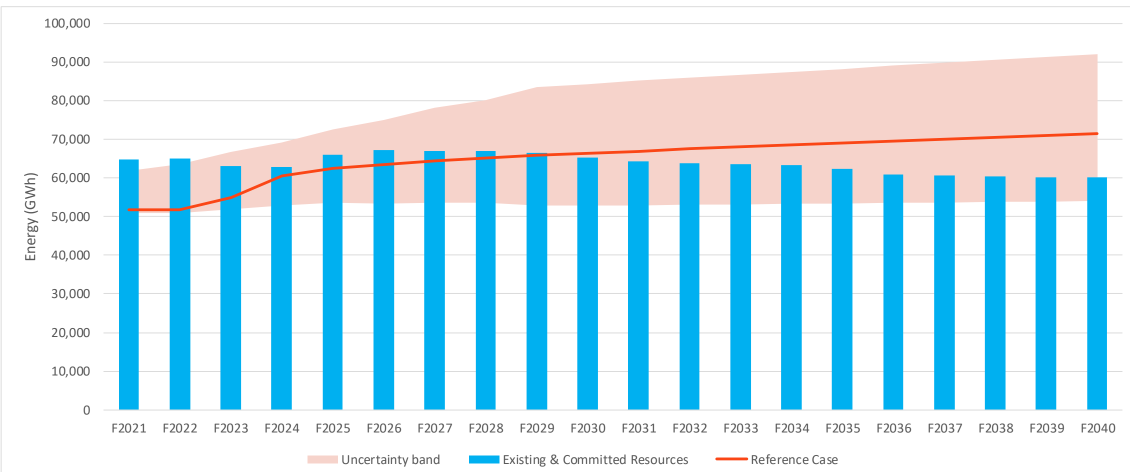
When will we need new supply?

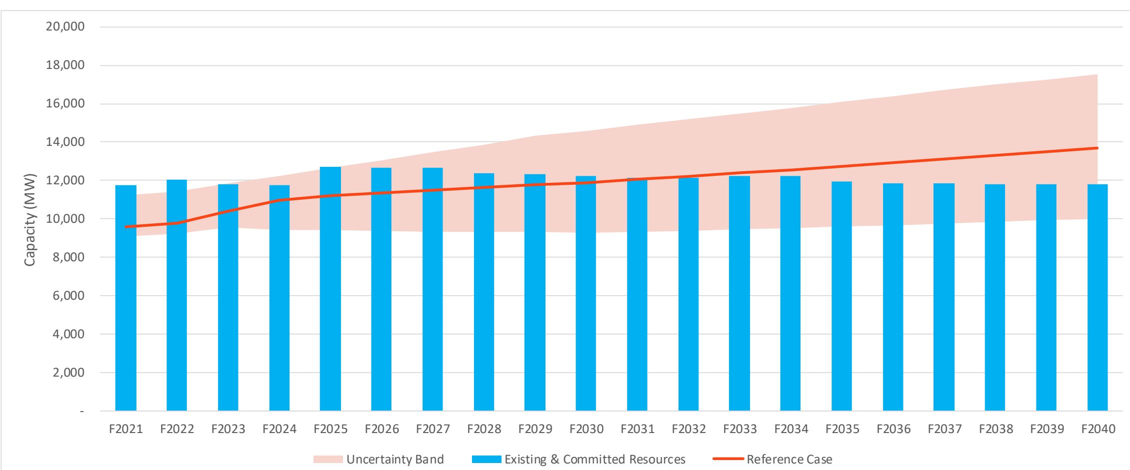
Energy

Placing our reference case up against our current supply resources and projects we have committed to, we see a need for new energy supply starting around 2030. The energy from existing and committed resources decreases over the years. This is due to some of our existing Electricity Purchase Agreements expiring, where no decision has yet been made about renewing them. If demand is lower than expected, we may not need new energy supply until later, or, if at all, in a less optimistic scenario. However, if demand is higher than expected, we could need new energy supply earlier than shown.

Capacity

Performing a similar comparison between supply and demand for capacity under the reference case, we foresee a need for additional capacity starting in about 2032. Like energy resources, the capacity from existing and committed resources decreases over the years, in part, due to the expiration of some of our existing Electricity Purchase Agreements. In addition, there is a decrease from about 2028 to 2032, reflecting our undertaking upgrades to some of our existing hydroelectric facilities.

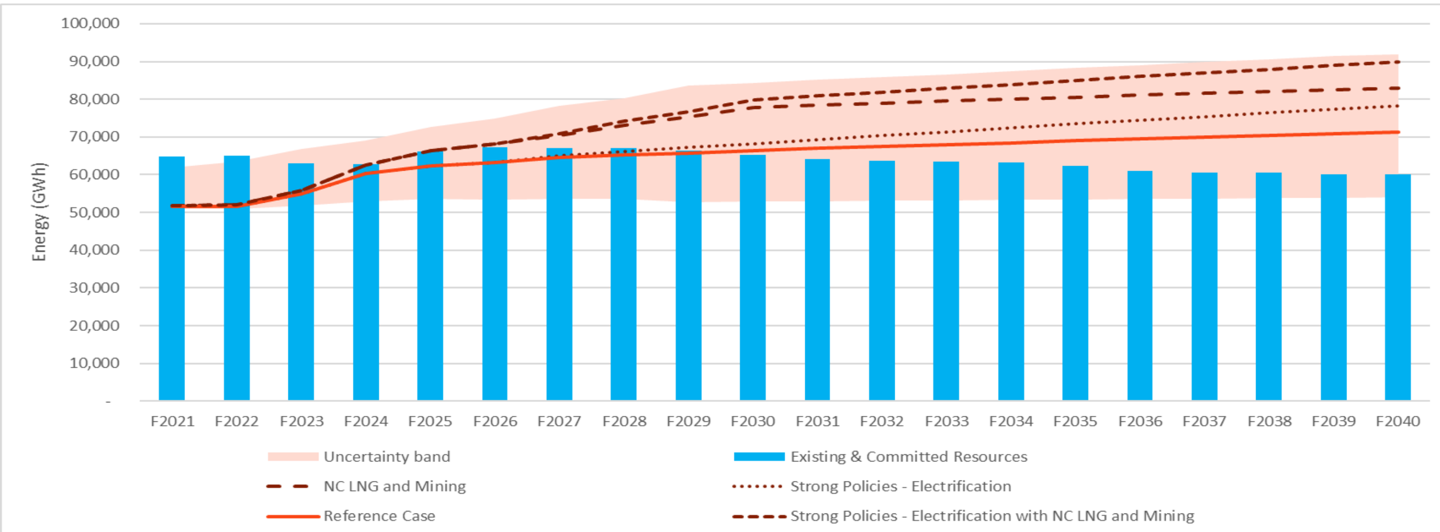




A look at the scenarios we're testing

The graph below shows the broad range of scenarios we are considering. This range of scenarios allows us to test different options against a range of outcomes. It also provides the opportunity to consider whether to advance options that provide benefits across a greater range of potential future states.

The graph below includes our reference outlook, as well as our bookend low and high forecast bands (denoted as the highest line and the lowest line). Above the reference case we also have three 'electrification' scenarios.



Electrification and BC Hydro's role

BC Hydro has a broad and important role to play in the electrification of British Columbia's economy and the reduction of greenhouse gas (GHG) emissions.

The term 'electrification' is used to refer to switching from using fossil fuels to using clean and renewable energy to power activities. This reduces GHG emissions that are associated with fossil fuel burning and the negative impacts of climate change.

CleanBC is the Government of British Columbia's plan to meet the challenge of climate change. It sets out a strategy to reduce GHG emissions by shifting away from fossil fuels and towards clean and renewable energy – like clean electricity from BC Hydro. The focus of CleanPower 2040 is to ensure clean electricity is available along with the infrastructure to get that electricity to customers when and where they need it.

The electrification scenarios are a way to explore what our electricity demand could look like. While these scenarios set out potential levels of electrification, they do not specify the particular roles of BC Hydro, the Government of B.C. or any other parties in achieving those levels:

- **General electrification scenario**: which sees stronger policies increasing electricity demand in the transportation sector, building electrification and the oil and gas industry in the northeast. The increase in demand under this scenario is primarily in the second half of the planning horizon.
- **A Liquified Natural Gas (LNG) and mining scenario**: which sees increased electricity demand as LNG facilities and mining operations request electricity service in the Northwest. This scenario would result in new power needs in the first half of the planning horizon, and
- **A combination of general electrification and LNG and mining scenarios**.

Where and when could demand from electrification occur

The map highlights the three areas where we may see additional demand if electrification increases and the potential drivers of increased load.

We have regional capacity supply needs to think about

We are focused on the potential capacity needs of four regions or sub-regions where we may see transmission constraints develop over our planning horizon:

- **Lower Mainland – Vancouver Island region**
- **Vancouver Island sub-region**
- **North Coast region**
- **Northeast region**

Vancouver Island is examined on its own and as part of the Lower Mainland because it is subject to two constraints: transmission capacity into the Lower Mainland from the rest of the province, and then the capacity on transmission paths in-between the Lower Mainland and Vancouver Island itself.

The line in each graph shows the expected outlook while the shaded area shows the uncertainty range.

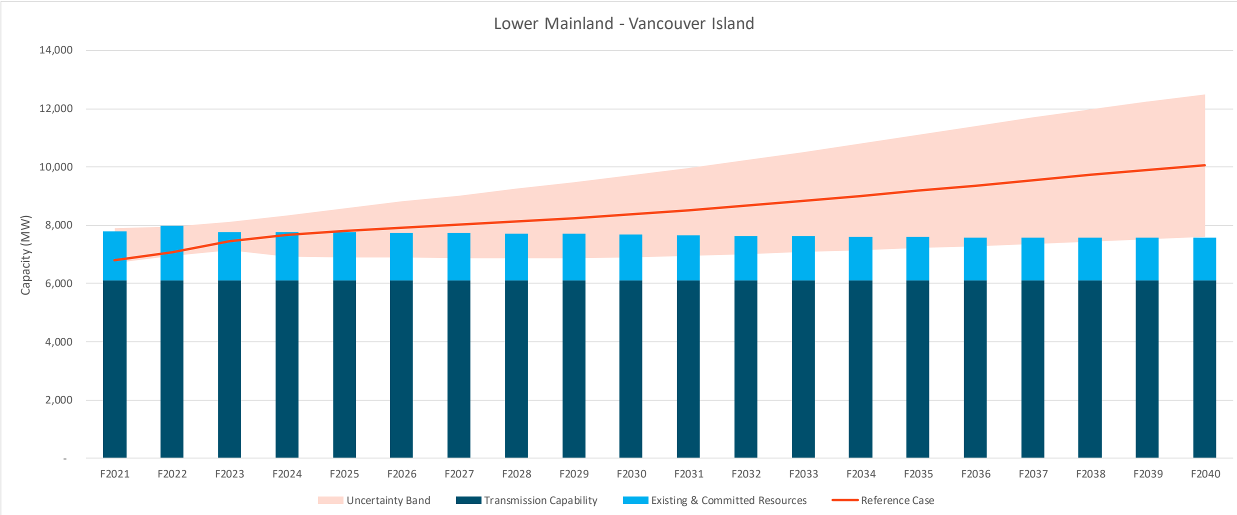
For the Lower Mainland and Vancouver Island, we are showing capacity needs under our reference case, and these regions also show increased demand under our electrification scenarios. The North Coast and Northeast regions see transmission constraints under our electrification scenarios.

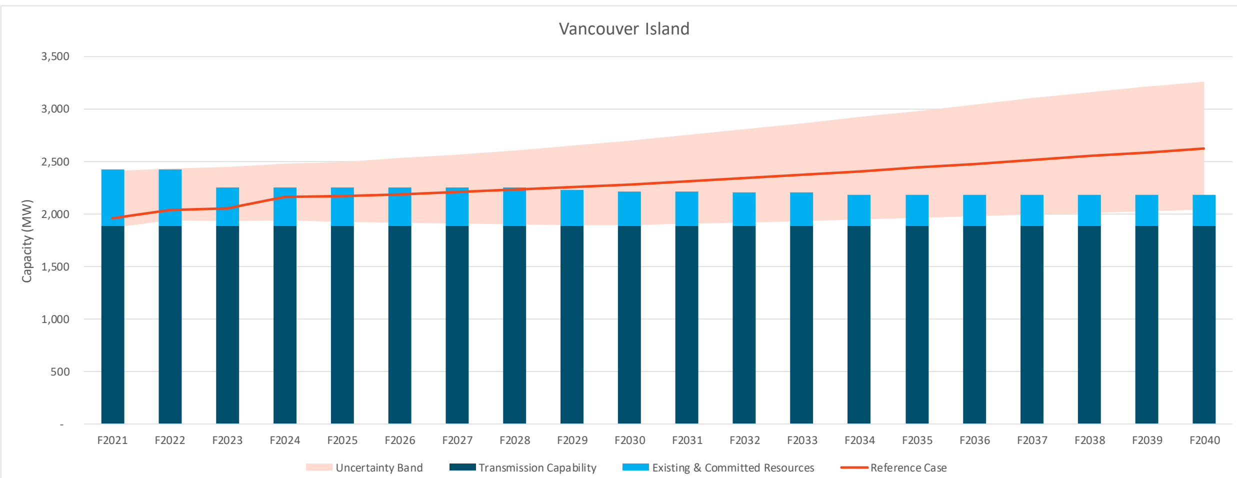
Lower Mainland / Vancouver Island and Vancouver Island

Under our expected forecast with only existing resources and committed resources, we currently see a need for new capacity supply in the Lower Mainland – Vancouver Island region starting in about 2025. There is upside risk for the load in this region that is primarily driven by potential passenger electric vehicle uptake.

In the Lower Mainland and Vancouver Island, under our electrification scenarios we could see additional demand from the electrification of space and water heating in buildings and from heavy duty electric vehicles. The amount of demand in these areas depends primarily on government policy.

For the Vancouver Island sub-region, under the current expected outlook, the need for additional capacity supply is expected to start around 2029. Like the Lower Mainland, under our electrification scenarios we could see additional demand from the electrification of space and water heating in buildings and or from heavy duty electric vehicles.





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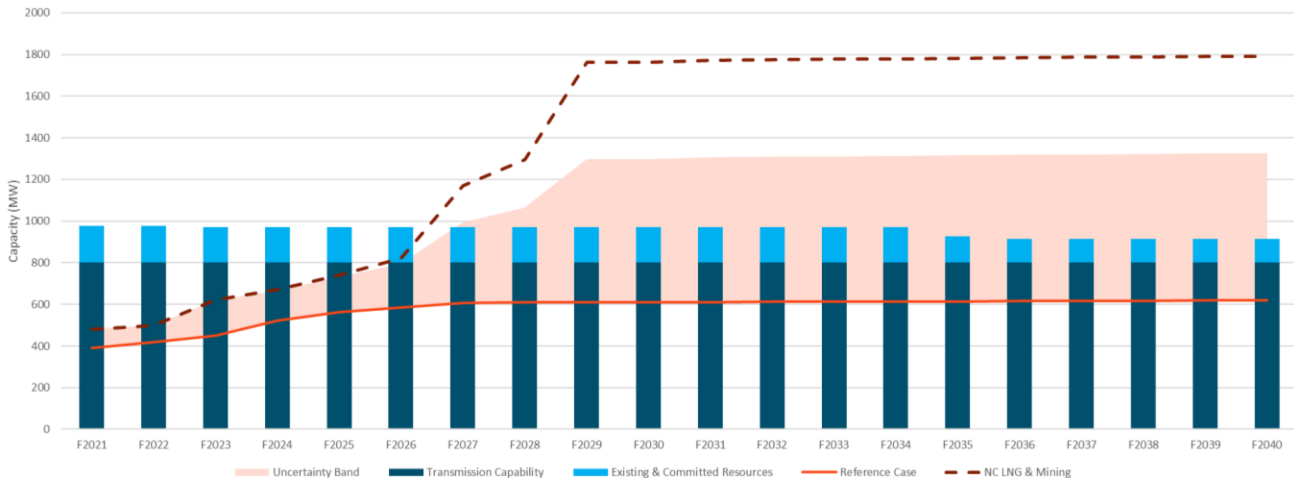
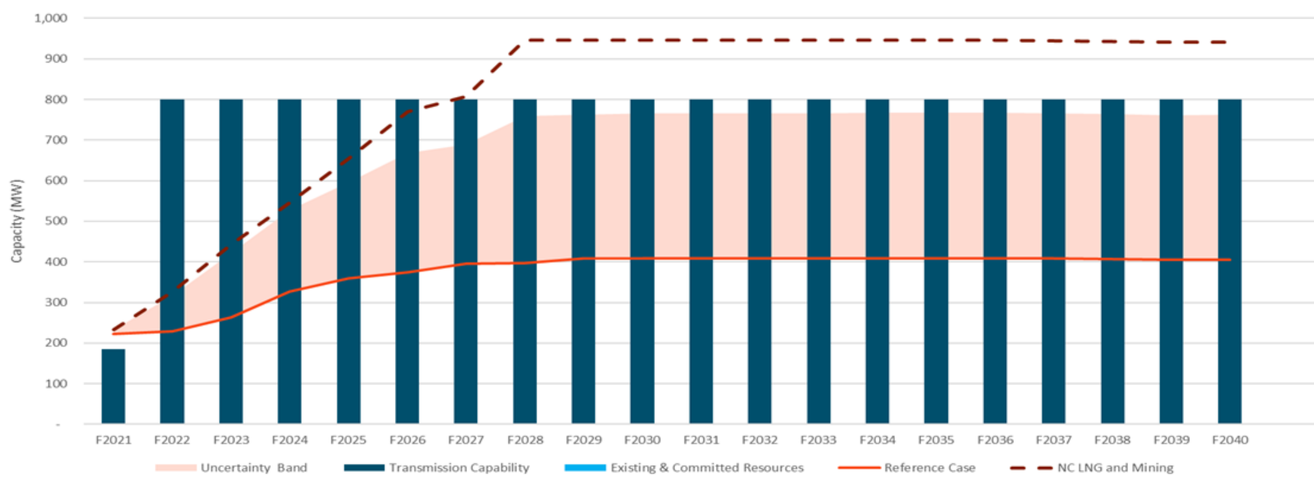
North Coast and Northeast regions

For the North Coast and Northeast regions, we expect there will be enough capacity supply under the reference case. However, if demand is higher as with our electrification scenarios, we could see a need for additional capacity supply.



The North Coast region is served by one long single transmission line and there are limited local generation sources. Potential new LNG facilities could significantly increase the demand for electricity in this region, if they proceed and if they decide to use clean electricity to power all or part of their operations. If this happens, new transmission infrastructure (upgrades to the existing line or a new power line), could be required and new generation sources would need to be developed.



In the Northeast region – specifically, the Dawson-Groundbirch and North Montney areas – demand for electricity is growing faster than in any other part of British Columbia. This is largely due to natural gas exploration and development in the Montney area. BC Hydro has already added the Dawson Creek / Chetwynd Area Transmission Project, which doubled electricity capacity to the area and allowed natural gas activities to be powered by clean electricity, avoiding significant GHG emissions. We're currently advancing the Peace Region Electricity Supply Project to further increase capacity, which is the step change you are seeing in the first year of the Dawson-Groundbirch chart.

Meeting British Columbia's GHG emission reduction targets could require even more capacity in the Northeast area so that if additional natural gas activities are undertaken, they could be powered by clean electricity.

Other regions: In the Southeast region, a key question is whether and when to proceed with the installation of a new 6thturbine at Revelstoke Generation facility (Revelstoke 6). Unlike other regions being addressed in this IRP, there is no foreseeable capacity constraints limiting the supply of electricity to customers in the Southeast as the region produces more than enough electricity for its own needs. However, capacity constraints may need to be addressed in the future if new generation from the Southeast or North is used to supply the Lower Mainland where the electricity is expected to be needed (for example, upgrades to or a potential new transmission line from the interior to the Lower Mainland).

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Tools we can use to meet our electricity needs

Improving energy efficiency and reducing peak demand

Clean Power 2040 is looking to how you and the rest of British Columbia will use electricity 10 or 20 years from now. We are asking what will be needed and how will it be supplied. One way to meet the need for new electricity is to avoid consuming it in the first place or to shift our consumption so that we consume less during peak times. This is called Demand-Side Management (DSM). Energy efficiency programs, demand response programs and time-varying rates are all examples of DSM and can help to postpone the need for new resources.

Energy efficiency programs

What is energy efficiency?

In general terms, **energy efficiency** is when the energy consumption of equipment is improved by replacing it with something more efficient (For example, replacing an old light bulb with an LED) or using the equipment more efficiently (For example, turning off the lights when not in use). Energy efficiency provides both energy and capacity savings (For example, when you install an LED light, you lower the wattage and get both energy and capacity savings).

Energy efficiency program options

We are considering two different energy efficiency program options to help reduce energy consumption, with add-ons to create additional savings, if needed.

The first program option includes current BC Hydro initiatives and financial incentives for residential, commercial and industrial customers to help enable energy efficiency projects, operational or behaviour savings, or improve energy management.

The second program option includes increasing our incentive levels as well as marketing and awareness efforts to achieve higher levels of savings at a higher cost.

The following add-on could be applied to either of the two program options described above, but would require additional funding: **a construction program** that would provide incentives for new construction projects to build buildings to a higher level of energy efficiency in the residential and commercial sectors, than the building code requires.

Demand response program options

We are considering three voluntary demand response program options.

- **Direct load control (for example, home automation)** is when BC Hydro provides the customer with an incentive, and sometimes the technology, that then allows BC Hydro to control some of their electricity-consuming equipment such as space heating, water heating, or electric vehicle charging. Customers would have the ability to opt out of the event if desired. When the BC Hydro system needs the capacity during a peak event, we turn off or turn down any participating equipment. Oftentimes, the customer would not notice their equipment is being controlled (for example, their hot water tank was filled with enough hot water to last through the peak event).
- **Load curtailment** is when large commercial or industrial customers sign a contract with BC Hydro to reduce their electricity consumption when requested by BC Hydro in exchange for an incentive. BC Hydro would give advanced notice of such a request during a peak event. The customer could perform this reduction in any way they chose, such as reducing lighting or HVAC usage for commercial customers, or shifting process loads for industrial customers.
- **Peak saver** is an option, like load curtailment, but for residential customers. After signing up, participants would be notified the day before a peak event and would be compensated financially if they reduced their consumption during the event. They could reduce their demand by shifting their electricity use in any way, such as using their appliances later in the evening.

While each of these options have costs associated with them, they have the potential to defer or eliminate the need for what may be costlier upgrades to the BC Hydro system.

Time Varying Rates

What is a time-varying rate?

Time-varying rates send price signals to encourage customers to shift electricity use from times of high use to time of lower use period. Like demand response programs, time-varying rates could curtail electricity use at peak times and help utilities to avoid building new infrastructure across the system. An example of a time varying rate is a time-of-use (TOU) rate.

Time-varying rate options

We are considering three voluntary time-varying rates options to shift demand at peak times to non-peak time. All time-varying rate options would require the advance approval of the BC Utilities Commission in follow-on processes to the IRP.

- **Time of use (TOU) rate** is a rate that BC Hydro customers would pay according to the time of day electricity is used. TOU rates fluctuate to reflect the fact that the cost to provide electricity changes throughout the day according to BC Hydro's supply and demand. For example, TOU can put a higher price on electricity during peak times that are more expensive for BC Hydro to serve, such as 4 to 9 p.m. evening, and a lower price at other times, such as overnight.
- **Critical peak pricing (CPP)** would offer a discount on winter electricity rates in exchange for higher prices during CPP event days called by BC Hydro, occurring between 4 and 8 p.m on the critical system peak in coldest winter days. The CPP option we are considering would allow up to 5 CPP events per year.
- **Time of use plus critical peak price** would amplify the price signals by combining both TOU and CPP rates. It will encourage BC Hydro customers to shift their usage from peak hour to non-peak hour not only on daily base but also on five critical system peak days during Winter season.

Looking at potential resource options

Expiring Electricity Purchase Agreements (EPAs) with Independent Power Producers (IPPs)

Clean Power 2040 is about making choices on how to best meet the future need for electricity. Through this process, we'll determine the future supply options that we should advance to meet any gaps between future demand and existing supply. One option is to renew Electricity Purchase Agreements with Independent Power Producers (IPPs).

Who are Independent Power Producers

We've been acquiring power from IPPs since the mid 1980s to help meet B.C.'s electricity needs. These IPPs develop and operate generation facilities, many of them clean and renewable, to provide energy to BC Hydro under Electricity Purchase Agreements or EPAs. Typically, the term of an EPA ranges between 20-40 years. Many of these existing EPAs will be expiring over the IRP's 20-year time horizon. At expiry, BC Hydro has no further obligation to purchase electricity from the IPP, nor does the IPP have any further obligation to sell electricity to BC Hydro. Each expiring EPA provides an opportunity for BC Hydro to renew the contract at lower prices and/or more beneficial terms to BC Hydro and our customers.

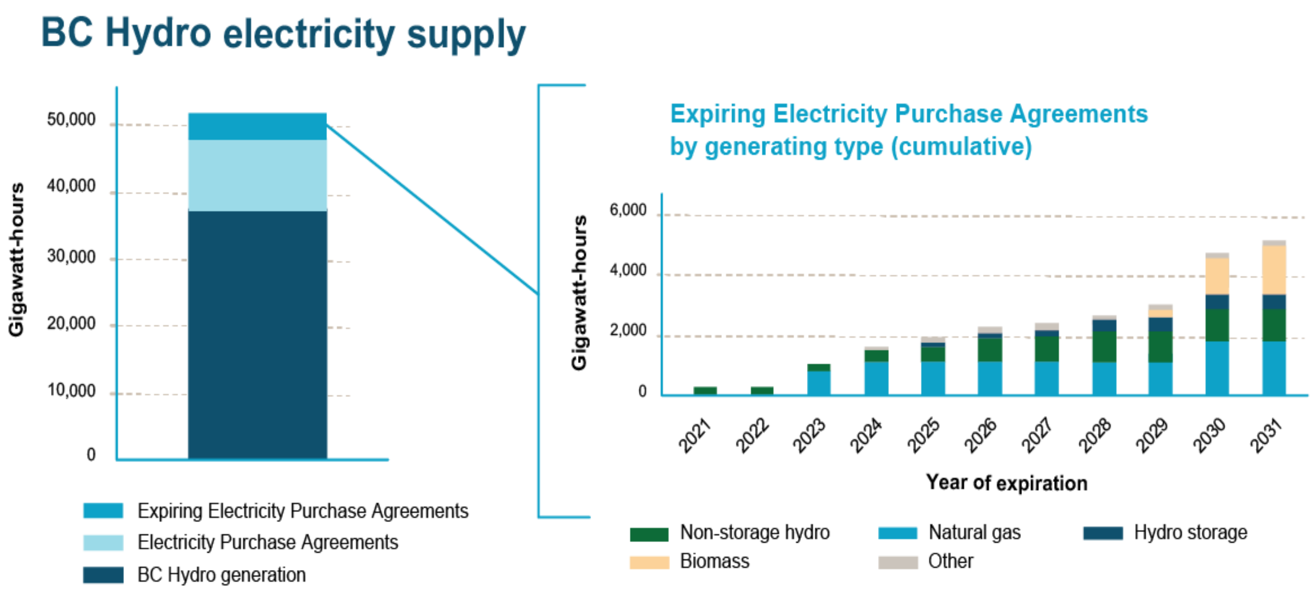
Current prices for the energy from existing electricity purchase agreements are significantly higher than the cost of generation from BC Hydro's heritage assets – like the W.A.C. Bennett Dam – as well as projected domestic and export market price forecasts. In addition, run-of-river projects are the most common in B.C. – with over 70 projects selling power to BC Hydro. Most of these can only be relied on during the spring freshet. The freshet is the snowmelt period from May to July. BC Hydro has historically had an oversupply of power during these months, which has resulted in the excess energy being sold on the market at very low prices.

BC Hydro's forecast increases to its cost of energy are primarily driven by increasing IPP energy costs under existing agreements, the terms of which are fixed. BC Hydro has been pursuing the renewal of expiring electricity purchase agreements where it has been cost-effective to do so. BC Hydro is committed to ensure that energy prices for IPPs are cost-effective and in the best interest of our customers.

BC Hydro does not have any active programs for the procurement of new energy resources from IPPs. Other than EPA renewals, the only expected new agreements are for a small number of new First Nations energy projects.

EPAs expiring over the next 20 years

Approximately 40 EPAs will expire in the next ten years, and another 30 EPAs expire in the following ten years. Associated with these expiring EPAs, there is roughly 10,000 GWh/yr of annual energy and 1,400 MW of peak capacity.



Considerations for renewing EPAs

Many factors come in to play when considering whether to renew an individual EPA. These include:

Cost Effectiveness	IPPs with expiring contracts are expected to be able to renew EPAs at prices less than what was paid under the original agreements recognizing that they have typically recovered their initial capital investment over the original contract term.
BC Hydro's need for additional energy and capacity	BC Hydro's need for additional energy and capacity is determined by its Load Resource Balance. Further, an IPP facility's energy profile can be relevant – for example, some facilities may be able to provide more energy during the winter peak period when our need is greater, as compared to the freshet season when our need is less.
Dependable Capacity	EPAs with certain resource types (for example, storage hydro, biomass, natural gas) can also be a source of dependable capacity to help ensure the reliability of the BC Hydro system, especially during winter peak periods.
Clean or renewable resources	The majority of expiring EPAs are from clean or renewable resources, generating electricity within B.C.
Location	IPP facilities are located all around the province. • Some IPP facilities provide valuable local grid services to support the reliability of the BC Hydro system. • IPP facilities located in the Lower Mainland and Vancouver Island can increase the resilience of the region by lowering the dependence on electricity delivered through the Transmission system.
Term of Renewed EPA	BC Hydro and IPPs consider both short and long term agreements in the context of system need, remaining asset life, and the cost and availability of alternative resources or opportunities.
Environmental Impacts	EPA renewals will likely not result in new or incremental environmental impacts as the site for the generation facilities has already been constructed and developed. However, some IPPs may have ongoing environmental impacts that would need to be taken into consideration in the renewal of an EPA.
Indigenous interests	Some IPPs may be an important economic opportunity for Indigenous Nations.

This infosheet is sharing potential options for future supply.

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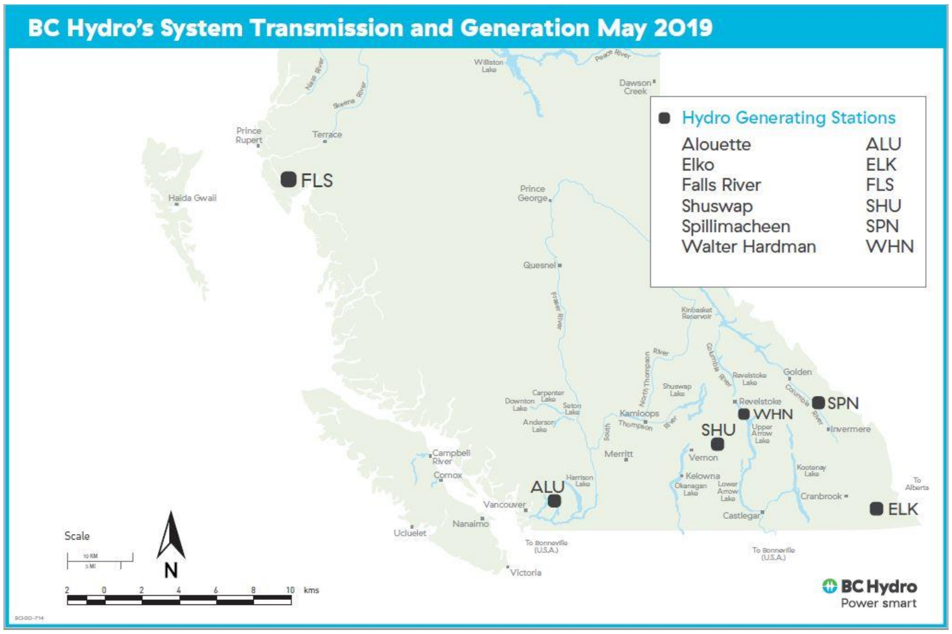
Small BC Hydro hydroelectric plants at, or reaching, end of life

BC Hydro has 30 heritage hydroelectric facilities. These facilities are comprised of civil assets (i.e. dams and associated structures) and long-life generation components. The life span of these civil assets can be upwards of 100 years. They also range in size where the largest seven facilities produce 90 per cent of BC Hydro's average annual energy while our seven smallest plants produce less than one per cent of our average annual energy.

We manage and maximize the lifecycle value of BC Hydro's assets through a mix of maintenance and capital investment. However, as several small facilities are now approaching end of life or are no longer operating, plans for these facilities are being developed on a case-by-case basis. These plans take into consideration factors including safety, environmental, and financial risks, in addition to the interests of Indigenous Nations and community stakeholders. In some cases, major re-investment may not provide cost-effective energy and alternative end of life options, such as decommissioning, are warranted for consideration. In other cases (for example, Alouette and Falls River), where considerable value may be derived due to their location close to where electricity is needed, refurbishment or redevelopment may be appropriate options.

As a strategy for the integrated power system, the IRP will not be making decisions on any of these plants specifically, but will examine the principles we should consider when decisions are needed. Decisions for each plant will be subject to its own decisions making - and possibly regulatory - process.

Plants that are at or approaching their end of life



Clean Power 2040 information sheet
Learn more about Clean Power 2040. Join us as we plan for the future.

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Shuswap

The Shuswap River facility was originally built in 1929 and is located 35 km east of Vernon on the Shuswap River. Unit 1 has been out of service since 2013. It should be noted that in the case of Shuswap, BC Hydro is further along in the planning process and a project to assess long term facility options is already ongoing.

Spillimacheen

The Spillimacheen facility was originally built in 1955 and is located 55 km south of Golden on the Spillimacheen River. The facility has been out of service since 2019.

Walter Hardman

The Walter Hardman facility was originally built in 1960 and is located 25 km south of Revelstoke in the Cranberry Creek watershed.

Elko

The Elko facility was originally built in 1924 and is located 70 km southeast of Cranbrook on the Elk River. The facility has been out of service since 2014.

Alouette

The Alouette facility was originally built in 1928 and is located 67 km east of Vancouver on the Alouette river. The facility has been out of service since 2010.

Falls River

The Falls River facility was originally built in 1930 and is located 50 km southeast of Prince Rupert on Big Falls River.

The potential future of small plants reaching or at the end of their useful life

In general, the future of the above listed plants will be considered on a case-by-case basis. High level alternatives that may be considered in order to establish a leading alternative include:

- **Redevelop**: new dams and generation units replace the old ones to take advantage of existing features of the site. A component by component replacement strategy could also extend the life of the facility.
- **Temporary generation shut down retaining option to redevelop**: a reduced level of maintenance of civil and mechanical assets continues to mitigate safety or environmental issues. Options may be retained to resume generation if needed in the future.
- **A permanent shutdown (decommission)**: operations of generating facilities are permanently ceased, and all or a portion of the assets are physically removed.
- **Divestiture**: BC Hydro is no longer the owner and/or operator of the facility, nor accountable for the issues or risks at the site.

While we will look at each plant's future individually, there are some commonalities to consider in determining next steps:

Financial	These plants provide limited system benefits beyond their energy or capacity contributions. Apart from Falls River and Alouette, these facilities have minimal upstream water storage and are generally operated as run-of-river, producing much of their energy during freshet. At first look and based solely on the value of their energy to BC Hydro, re-investment in these facilities is likely uneconomic at this time relative to other resource options available to BC Hydro. Re-investment in these facilities could provide reliable energy over a 50+ year timeframe, however, the needs and cost of new energy supplies in the future is uncertain.
Safety and operational risks	As ageing facilities reach their end of life, asset performance declines and the risk of in-service failures increases. In addition, standards and regulations in place at the time of construction may no longer meet today's requirements. Significant re-investment may be required to sustain safe and reliable long-term operations consistent with modern standards, which impact the previously mentioned financial picture.
Environment	In comparison to new sources of energy, these plants are at sites already developed and are likely to have minimal incremental environmental impact if their operations were to continue. However, there may be opportunities to restore habitats or realize other environmental benefits by discontinuing operations of these facilities.
Regulatory/Legal	As designated Heritage Assets, BC Hydro's generating facilities are regulated by the B.C. Utilities Commission Act, the Clean Energy Act and the Water Sustainability Act. In addition, Water Licenses and Water Use Plans for each facility govern how and where we use and store water resources. Working within these frameworks may constrain the choices available in order to comply with these regulatory or legal obligations.
Indigenous interests	Indigenous Nations in the area may have an interest in the small plant facility. These interests could include economic development opportunities associated with redevelopment, the environmental benefits of decommissioning or some other combination of interests. We want to hear from affected Nations what their interests are. We recognize that interest may vary depending on the facility or the Indigenous Nation.

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Generation resource options

New electricity supply choices

Clean Power 2040 is looking to how you and the rest of British Columbia will use electricity 10 or 20 years from now. We're asking what will be needed and how will it be supplied.

BC Hydro maintains an inventory of potential resource options that could be used in the future to meet the needs of our customers – either on the demand side to decrease load, or on the supply side to increase generation. This note will focus exclusively on new generation resource options, which consists of new (greenfield) generation facilities as well as options to expand BC Hydro's existing generation facilities.

Our inventory describes the costs and availability of potential generation resource options, at a high level. This inventory doesn't represent the generation options that BC Hydro will necessarily develop or acquire; instead, it represents options to choose from that can inform our planning decisions.

The work to update the 2020 Generation Resource Options was segmented into three categories:

- **Evolving Resources**: technical working groups consisting of external experts were formed to build an understanding of the cost and performance of generation resource options that have experienced significant technology and market developments (for example, battery resources, wind and solar). The costs of these options were updated based on input from developers and suppliers as well as technical experts.

- **Existing Resources**: the resource options from the 2015 Resource Options Update, with some updates to reflect recent research and literature reviews, is sufficient for existing resources that have not experienced significant technology and market developments, such as run-of-river hydro.

- **Emerging Resources**: these generation resource options are not sufficiently mature to be analyzed on a quantitative basis but have been characterized on a qualitative basis so that they can be considered, as required, going forward. Initial options included in this category are hydrogen and fuel cells, emerging solar (including floating solar), emerging storage (for example, flow batteries), emerging customer-side generation (for example, vehicle to grid) and emerging renewable resources (e.g. wave and tidal resources).

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<tr><th>Existing</th><th>Evolving</th><th>Emerging</th></tr>
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BC Hydro asset upgrades (Resource Smart)
Biomass
Geothermal
Municipal Solid Waste
Natural gas
Pumped storage
Run-of-river hydro

</td>
<td>
Solar

Distributed scale
Utility Scale

Wind

Batteries

Utility scale

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<td>
Hydrogen and fuel cells

Emerging Customer Generation
Emerging Renewables
Emerging Solar
Emerging Storage

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To learn more about the process of updating this inventory, click here.

Generation resource options by resource type

Different generation options bring different benefits. Some increase our energy supply – the amount of electricity available to consume in a given year. Some increase our capacity – the maximum amount of electricity we can generate at any given moment. Some options are intermittent – which means they can only generate electricity at certain times, like when the sun is shining or the wind is blowing. Other options are dependable like our hydroelectric facilities which means they're always available and some options are flexible also like our hydroelectric facilities, which means we can increase or decrease their generation according to customer needs at any given time. The location of generation options also matters – if electricity is generated close to where it is consumed, then the infrastructure to get it where it needs to be is more limited. However, if there is a large distance between where the electricity is generated and where it is consumed, then additional system upgrades may be required to deliver it.

In our resource options inventory, we characterize each individual resource option in terms of its financial, technical, environmental and economic development attributes. In order to compare different generation resource options, we present here a simplified view of the cost-effectiveness of the different resources in terms of their Unit Energy Cost (UEC) or Unit Capacity Cost (UCC)

- A UEC expressed in $/MWh is a measure of cost-effectiveness for resources that primarily produce energy rather than capacity. It does not provide a perfect apples-to-apples comparison of different energy resources. Rather, it represents the potential bid price of the energy delivered to the grid. Although this allows some comparability between resources, UECs don't reflect system wide benefits (like firmness of energy) that some resources provide that others do not. Further analysis on this and other elements will take place as part of the decision framework and portfolio analysis component of the IRP to characterize the costs and benefits of energy resources from a utility perspective.
- The UCC at POI metric (expressed in $/kW-yr) also does not provide a perfect apples-to-apples comparison of capacity-focused resources and should be considered to be a preliminary indication of relative cost. Similar to UECs, UCCs provide some ability to compare, but miss out on the system benefits provided by a subset of these resources and also do not include the price of carbon for natural gas at this level. Carbon taxes are included in later in the analysis as well. Further analysis of capacity resources that considers the costs and benefits from the point of view of the utility, occurs in the Decision Framework and Portfolio Analysis component of the IRP.

The table below provides an overview of different generation options along with some other considerations. Other attributes and potential system benefits (such as contributions to grid stability and dependability) are examined when we undertake modeling and options analysis work, later in our planning process.

Generation Resource Type	Generation Resource Description	Indicative Cost (at Point of Interconnect to the grid) if built in 2020 *Note: additional costs may be required to deliver electricity to the customer*	Availability and other attributes
ENERGY RESOURCES			
Biomass	Combustion of surplus biomass (i.e., saw mill residues, logging wastes or standing timber that is in excess of the needs of the forestry industry) to drive turbines for the production of electricity. Provides dependable power	$125 – 446/MWh, depending primarily on the type of biomass used as fuel	The lowest cost biomass resources depend on saw mill wood wastes and roadside logging woodwastes, which are primarily located in the BC Coast and West Kootenay regions. The generation potential from these low-cost resources is less than 150 MW in total. Higher cost resources that depend on standing timber are more plentiful (more than 300 MW) and are primarily found in the coastal mountain areas.
Geothermal	Deep geothermal wells draw hot fluids to the surface, where the heat is converted to electricity using conventional thermal generation. Provides dependable power	As low as ~$90/MWh for high temperature resources, but >$140/MWh for moderate and low temperature resources.	There are no utility-scale geothermal resources producing electricity in BC today. Significant efforts to advance geothermal in the 1980s and again in the early 2000s failed to confirm geothermal resources sufficient for large-scale electricity production. Economically viable geothermal resources in BC have not yet been proven, but there are indications of several geothermal resources in the province, some of which (~200 MW) are located close to the Lower Mainland. Geothermal facilities can also provide high quality heat for local users. Generation is reliable and consistent, providing capacity as well as energy throughout the year. Development of geothermal resources requires confirmation drilling to prove sufficient heat and fluid flow to support long-term electricity generation. Confirmation drilling is expensive (~$5M per well) with significant risk of failure. There are therefore no guarantees as to the overall cost and development timeline for prospective geothermal resources.

Generation Resource Type	Generation Resource Description	Indicative Cost (at Point of Interconnect to the grid) if built in 2020 *Note: additional costs may be required to deliver electricity to the customer*	Availability and other attributes
ENERGY RESOURCES			
Municipal Solid Waste	Incineration of collected solid wastes produces heat to drive thermal generators. Provides dependable power	~$450 /MWh, but revenues from electricity sales are typically not the primary driver for these facilities.	New municipal solid waste facilities can face opposition from local stakeholders due to perceptions about increased local air emissions and odours.
Natural Gas (CCGT)	Combustion of natural gas in highly efficient Combined Cycle Gas Turbine (CCGT) provides reliable energy and capacity all year round Provides dependable power	As low as $76/MWh, after accounting for fuel costs and GHG taxes	Unlike all other resource options, natural gas generation is not considered a clean or renewable resource and is subject to clean energy policy considerations.
Run of River Hydro	Hydroelectric facilities that make use of existing river flows for electricity generation. Provides intermittent power	As low as $85/MWh, to >$500 / MWh depending on size and location	Run-of-river hydro typically delivers more energy during the freshet season (late spring and early summer when snow melt brings higher water flow into the rivers), when BC Hydro typically has less of a need for energy.
Small Storage Hydro	Hydro-electric facilities that include dams and pondage for limited energy storage (less than 16 hours of peak generation) Provides flexible power	$75 – 150/MWh Costs vary with location, size and duration of energy storage	Number of resources identified (~4,000 GWh / year) based on a minimum 20 MW of capacity.
Solar – distribution scale	Small solar farms or solar gardens in urban areas, covering up to 60 hectares with ground-mounted photovoltaic panels, connected to distribution system. Provides intermittent power	$115 – 140/MWh	Limited resources (<700 GWh / year) based on amount of land available in urban areas where the distribution system is sufficiently robust to manage the increased generation. Energy generating primarily in summer months and exclusively during daylight hours on days when the sun is shining. Does not provide generation during system peak electricity use periods.

Generation Resource Type	Generation Resource Description	Indicative Cost (at Point of Interconnect to the grid) if built in 2020 *Note: additional costs may be required to deliver electricity to the customer*	Availability and other attributes
ENERGY RESOURCES			
Solar – rooftop	Photovoltaic panels located on customer rooftops delivering energy directly to the customer to offset their load. Provides intermittent power	$195/MWh – commercial $215/MWh – residential Costs expected to decline at similar rate to Large Scale Solar.	Theoretically, more than 6,000 GWh / year of energy is available if every technically viable rooftop were covered with solar panels. Electricity is generated primarily in summer months and exclusively during daylight hours on days when the sun is shining. Does not provide generation during system peak periods.
Solar – utility scale	Large solar farms, covering up to 20 square kilometers with ground-mounted photovoltaic panels, delivering energy to the transmission system. Provides intermittent power	$95-120/MWh Costs expected to decline with wide uncertainty bands, could be $60/MWh in 10 years	Abundant utility-scale solar resources (>20,000 GWh / year). The lowest cost solar resources are clustered around Prince George and Kelowna regions Electricity is generated primarily in summer months and exclusively during daylight hours on days when the sun is shining. Does not provide generation during system peak periods.
Wind - offshore	Very large wind turbines anchored to the offshore shelf regions of the Province. Provides intermittent power	$125-445/MWh Costs expected to decline over time	Abundant resource – more than 50,000 GWh / year of offshore wind energy available offshore of BC. Offshore wind energy in North America remains in the very early stages of deployment.
Wind - onshore	Large wind turbines clustered into wind farms in rural areas Provides intermittent power	$55 – $300/MWh	Abundant resource – more than 50,000 GWh / year of onshore wind energy is available in British Columbia. Most of the lowest cost wind resources are clustered within the Peace Region. Although there is only generation when the wind is blowing, wind resources can be relied upon to generate some energy during winter peak periods.

Generation Resource Type	Generation Resource Description	Indicative Cost (at Point of Interconnect to the grid) if built in 2020 *Note: additional costs may be required to deliver electricity to the customer*	Availability and other attributes
CAPACITY RESOURCES			
Battery storage	Rechargeable Lithium Ion Battery resources can provide relatively short duration (up to 4 hours) of peak energy generation. Large scale is >50 MW for up to 4 hours Small scale is several kW deployed at a customer premise.	$ 165 – 230/kW-year for large scale and 4-hours of storage The costs of battery storage facilities are projected to fall rapidly over the next decade. By 2030, the cost of a four-hour battery storage facility is estimated to be as low as $113/kW-year.	Battery systems are modular and therefore capable of growing in size over time to match load growth. Battery systems have relatively short lead times due to simple permitting and construction. These facilities consume energy rather than produce it, with energy efficiency typically around 90%.
Natural Gas (SCGT)	Combustion of natural gas in Single Cycle Gas Turbines (SCGT) on an as-needed basis.	As low as $67/kW-year, but not including cost of fuel or GHG taxes.	Unlike all other resource options, natural gas generation is not considered a Clean or Renewable Resource and is subject to clean energy policy considerations.
Pumped Storage	Conventional hydroelectric generation facility, but turbine can also function as a pump to fill an upstream reservoir. Upstream reservoir provides stored energy for use during peak periods.	Large-scale (500 to 1000 MW plant) ~ $100/kW-year Small-scale (100 to 200 MW plant) > $500/kW-year	Pumped storage facilities have long lead times due to complex permitting and construction. Duration of energy storage is typically between 6 – 8 hours. These facilities consume energy rather than produce it, with energy efficiency typically between 70-80%.
Upgrades to existing BC Hydro generation	Some of BC Hydro's larger hydroelectric facilities present opportunities to upgrade or expand generation. Addition of a sixth unit to the Revelstoke Generating Station and upgrades to Units 1 through 5 at the GM Shrum Generating Facility would provide 588 MW of additional capacity in total. Some smaller BC Hydro facilities are reaching the end of their life and present a redevelopment opportunity. Redevelopment of Alouette and Falls River would provide 45 MW of capacity in total.	Sixth Unit at Revelstoke: $57–$64/kW-year depending on implementation schedule. Units 1 through 5 upgrades at GM Shrum: ~$47/kW-year. Alouette redevelopment: $316/kW-yr Falls River redevelopment: $420/kW-yr	Some upgrades have lead times up to eight years due to permitting and construction, while other upgrades, such as turbine replacements, may have lead times as short as one.

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