Amped Up

Options for growing British Columbia’s electricity supply

Will Noel, Jessica McIlroy and David Pickup

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Summary

British Columbia boasts one of the cleanest power grids in the world due to its significant hydroelectric resources. This clean energy advantage, coupled with low electricity rates, positions the province well to achieve its climate goals while ensuring continued energy affordability.

BC Hydro, the Crown corporation responsible for operating and planning the province's electricity system, forecasts a significant increase in electricity demand, up to 41% by 2040, driven by a growing population and greater electrification and industrial development. To meet this rising demand, B.C. will need to substantially expand its generating capacity — by two- or three-times its current level. This report provides a comparative analysis of various power generation technologies to help guide future power procurements.

Wind and solar are ideal candidates for meeting B.C.’s short-term energy demand, with batteries, demand-side management, and existing hydroelectric facilities providing backup during low renewable generation and peak demand events. Larger infrastructure projects (e.g., new hydroelectric dams) and technologies that BC Hydro has less or no experience with (e.g., geothermal, nuclear) may face cost overruns and construction delays, making them less suitable for short-term needs, at least for now.

Regardless of the chosen path forward, there are certain “no-regret” actions that can benefit B.C.'s electricity system. These include investing in energy efficiency programs to offset demand growth, enabling demand-side participation to optimize energy consumption patterns among end users, and modernizing and growing grid infrastructure to ensure efficient and affordable electricity delivery. By implementing these measures, B.C. can continue to grow its clean energy supply while ensuring that energy stays reliable and affordable.

B.C. has shown leadership in partnering with First Nations on clean energy. The government should continue to demonstrate such leadership through promoting First Nations ownership and engaging and collaborating with First Nations in future electricity system developments.

Background

Due to its primarily hydroelectric-based electricity supply, British Columbia has one of the cleanest power grids in the world, emitting less than 20 grams of CO_2 per kilowatt-hour in 2023 (Figure 1). B.C. ratepayers also benefit from some of the lowest electricity rates in the country, after Manitoba (second lowest) and Quebec (lowest). This places B.C. in a strong position to achieve its climate goals while ensuring that energy remains affordable.

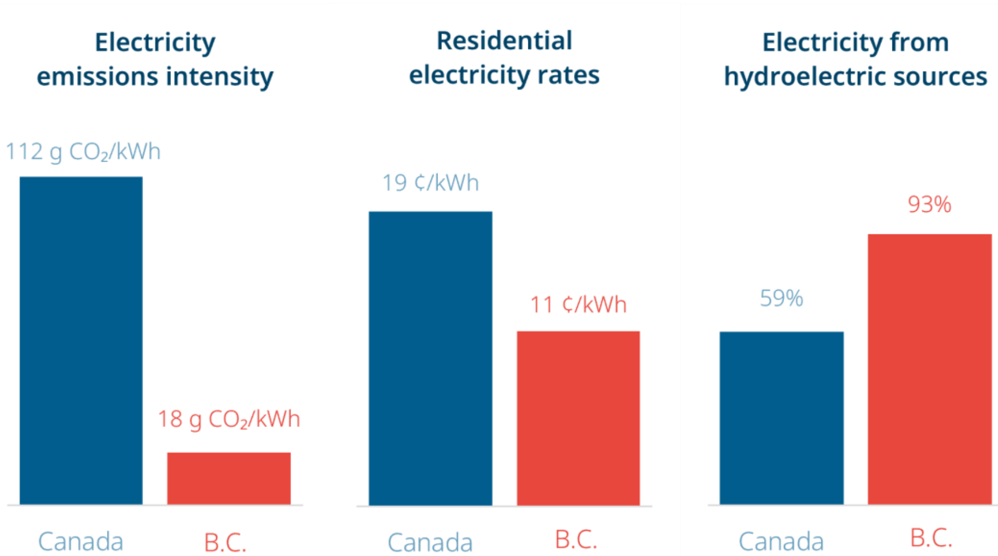

Figure 1. British Columbia electricity rates, emissions intensity, and hydroelectric generation relative to all of Canada (including B.C.), 2023

Data sources: Environment and Climate Change Canada,[1] energyhub.org[2]

B.C.'s electricity system is vertically integrated, meaning that most of the electricity generation, transmission, and distribution infrastructure is owned and operated by a Crown corporation, BC Hydro. The Crown utility is responsible for ensuring both adequate electricity supply and grid infrastructure to meet current and future demand. Recent forecasts from BC Hydro estimate that provincial electricity demand will increase between 22% and 41% by 2040 (Figure 2), driven by a growing population and greater electrification and industrial development. A similar study by the Canadian Climate Institute found that B.C. will need to double — or even triple — the installed capacity of its generating fleet between now and mid-century to meet rising demand.[3]

In this report, we provide a high-level overview of options for B.C. to grow its electricity sector in line with its clean energy strategy. As part of this overview, we compare different generation technologies based on several key characteristics and provide guidance on what the province should consider when procuring power.

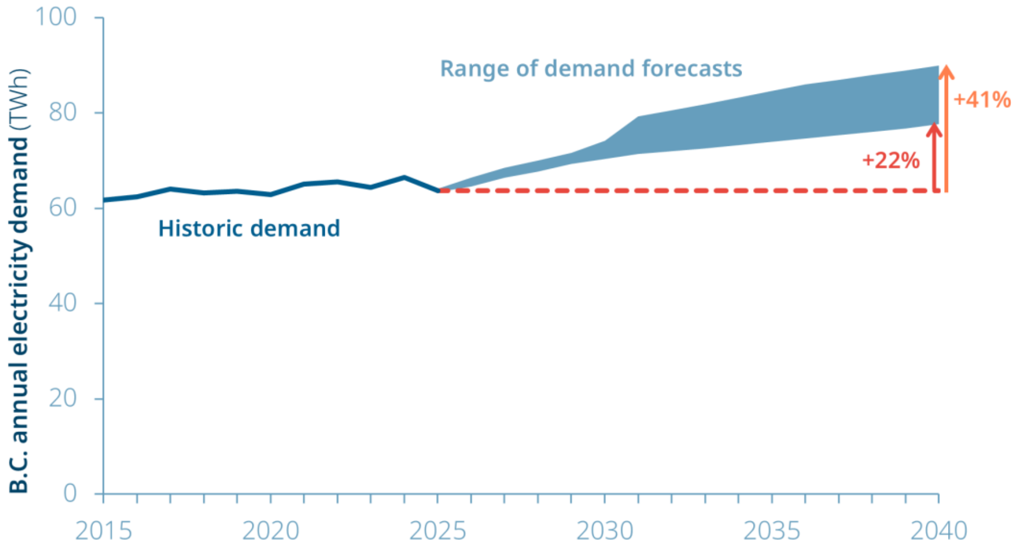

Figure 2. B.C. historical electricity demand (2015–2025) and demand forecast (2025–2040)

Data source: BC Hydro[4,5]

Comparing generation technologies

Given rising electricity demand, BC Hydro will conduct competitive energy procurements every two years to "ensure that B.C. has the clean electricity it needs... while keeping [electricity] rates affordable for people and businesses."[6] The 2024 Call for Power awarded contracts to one solar and nine wind projects, adding an additional 5,000 GWh per year of clean electricity to the B.C. electricity grid[7] — about the same amount that the newly constructed Site C hydroelectric dam will generate when it is fully operational.[8] This year, BC Hydro is running an identical energy procurement, one year ahead of its two-year cycle, building off the success of the 2024 Call for Power.[9] It is also seeking expressions of interest for a separate procurement targeting capacity rather than energy. [10] (we discuss the differences between the two in the next section)

Table 1 provides a list of the most common, commercially available power generation technologies (including wind/solar with batteries) in 2025, comparing them based on cost, development timelines, environmental impacts, and contribution to grid capacity. In planning for the coming decades, B.C. will need to weigh the benefits and trade-offs of these different technologies and how they can complement each other in order to grow an abundant, secure, affordable, and almost non-emitting provincial grid. In the next sections of this report, we set out fundamental considerations for making these comparisons, as well as a list of no-regret actions the province should take regardless of its chosen path forward.

Table 1. Comparison of common electricity generation technologies

Technology	Cost of energy	Development timeline	Greenhouse gas emissions	Other environmental impacts[a]	Contribution to capacity[b]
Biomass	○	◔	●[c]	◑[c]	◕
Geothermal	◔	◕	●	◕	◕
Natural gas	◑	◑	◔	◑	●
Nuclear	○	○	●	◑	◑
Reservoir hydro	◑	○	◕	◑	◕
Solar	◕	◕	●	◕	◔
Solar + battery	◑[d]	◕	●	◕	◑
Wind	◕	●	●	●	◔
Wind + battery	◑[d]	●	●	●	◑
Advantage ●--◕--◑--◔--○ Disadvantage					

Data sources: See Appendix A.

[a] Includes other air pollutants (SO_2 and NO_x), land and water use, and solid waste (e.g., from spent fuel).

[b] Includes dispatchability (ability to generate power when needed) and flexibility (ability to respond to fluctuations in demand).

[c] CO_2 emissions are treated as closed loop, so net-zero, based on best practices outlined in current regulation requirements applicable to bioenergy. Also, the large volume of water absorbed and released by healthy forests is treated as a positive feature.[11]

[d] Assumes costs will fall in the short term based on sizeable reductions in historical battery prices and a continuation of this trend.[12]

Considerations when selecting technologies

Energy versus capacity

When planning for future electricity demand, it is important to consider both energy and capacity.

> **Energy** is the cumulative amount of electricity consumed or supplied over a specific (often relatively long) time.
>
> **Capacity** is the amount of power supply available at any instant, to match demand.

To ensure reliability, power systems must be able to generate enough electricity over the year to match energy demand and always have enough installed capacity available for dispatch, especially during daily and annual peak demand events (see Figure 3).

With low operating costs, short development timelines, and no operating emissions, wind and solar are ideal candidates for meeting rising energy demand in both the short- and long-term. And, in hydro-rich regions like B.C., wind and solar enable hydroelectric dams to withhold generation, storing that energy for later use. However, as both wind and solar operations are contingent on local weather and time of day, neither can meet the entire system's needs without some degree of backup — often a combination of hydro, natural gas, battery storage, interties, and demand response. Yet, several jurisdictions around the world are already meeting over 30% (and as high as 70%) of their annual electricity needs with wind and solar alone, without any notable decreases in reliability or affordability.[13] As such, it is unlikely that B.C. will encounter these issues by developing more wind and solar, as it is currently meeting only 3% of its demand with those sources.[14]

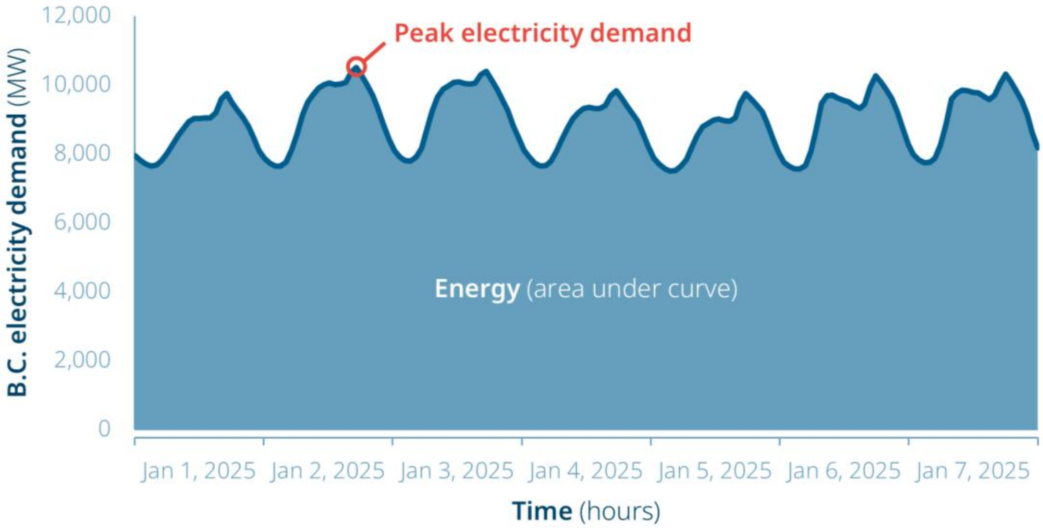

Figure 3. B.C. hourly electricity demand, January 1–7, 2025

Data source: BC Hydro[15]

Batteries and demand-side management (DSM) programs are proven, cost-effective methods to add capacity to meet rising peak electricity demand, while also providing load-shifting services that redistribute energy from peak times to off-peak hours. Co-locating batteries with renewables is mutually beneficial; wind and solar are strong *energy* resources and batteries are strong *capacity* resources, so combined they offer the best of both worlds. Co-location reduces the risk of needing to curtail wind and solar generation during low demand since batteries can store that electricity for when demand increases. It also allows for more effective use of existing transmission infrastructure through a shared grid connection. Co-location achieves all this without any notable increases to project development timelines compared with a standalone wind or solar project.

Technologies with longer lead times for development and construction (e.g., hydroelectric dams, nuclear) or less technical maturity in a western Canadian context (e.g., geothermal, nuclear) are unable to be deployed quickly enough to meet short-term demand growth.[16] At some point this may change, especially as enhanced geothermal systems (utilizing human-made reservoirs rather than naturally occurring fractures) become economically viable. For now though, these technologies should only be considered for longer-term needs, especially due to uncertainties in development timelines and upfront costs, which are discussed below. Any consideration of these technologies in future power procurements should be made in parallel with procurements of lower-cost, quicker-to-deploy solutions to ensure that short-term energy and power demand growth is met with the most feasible and competitive options.

Uncertainties in timelines and upfront costs

Cost overruns occur when final project costs exceed initial budget estimates: a common occurrence in large infrastructure projects. Large, centralized power plants are among the most susceptible developments to going over budget, with nuclear power plants and hydroelectric dams around the world seeing mean cost overruns of 120% and 75%, respectively — significantly higher than wind (13%), solar (1%), and transmission lines (8%).[17] Large power plant developments are also often struck with delays in construction timelines. For example, research by the International Energy Agency (IEA) found that recent nuclear power projects saw an average construction delay of six to seven years, with some delays exceeding a decade.[18] It is important to note, however, that delays and cost overruns of nuclear facilities appeared to be less likely (and less severe) in jurisdictions with greater experience in their construction (e.g., China, South Korea) with some exceptions, such as Flamanville 3 in France. In Canada, recently completed large hydroelectric facilities have seen delays of one to five years and cost overruns ranging from 34% to 82% (Table 2).

Table 2. Construction delays and cost overruns at select global nuclear plants and Canadian hydroelectric facilities commissioned between 2019 and 2024

Project name (location)	Technology	Construction delay (years)	Cost overrun
Barakah 1 to 4 (UAE)	Nuclear	3	39%
Flamanville 3 (France)	Nuclear	12	244%
Kakrapar 3 & 4 (India)	Nuclear	5	25%
Olikiluoto 3 (Finland)	Nuclear	13	118%
Ostrovets 1 & 2 (Belarus)	Nuclear	5	156%
Saeul 1 & 2 (South Korea)	Nuclear	3	30%
Vogtle 3 & 4 (U.S.)	Nuclear	6	163%
Zhangzhou 1 & 2 (China)	Nuclear	1	22%
Keeyask (Manitoba)	Hydro	2	34%
Muskrat Falls (Newfoundland)	Hydro	5	72%
Site C (British Columbia)	Hydro	1	82%

Data sources: IEA,[19] World Nuclear Association,[20,21] Schneider et al.,[22] Yicai Global,[23] NS Energy,[24] BC Hydro,[25] Government of British Columbia,[26] The Narwhal,[27] Nalco Energy,[28] Atlantic Business,[29] CBC,[30] and Keeyask Hydropower Limited Partnership.[31]

Cost overruns and construction delays in the power sector can have significant and long-lasting impacts on electricity affordability and reliability. Projects that far exceed their initial budgets will recoup those costs through some combination of higher electricity prices and government assistance, placing the financial burden on ratepayers and taxpayers, respectively. Delays in construction timelines can lead to tight market conditions, further increasing electricity prices and risking supply and demand imbalances, which can lead to load shedding or, in the most extreme case, rolling blackouts. Considering these risks in system planning and power procurements is therefore crucial to safeguarding consumers and ensuring adequate electricity supply.

No-regret actions

Whether B.C. remains focused on hydroelectricity, shifts strongly towards wind and solar, or opts for a balanced mix of the two, there are measures that can benefit the province’s electricity system, regardless of the chosen path. Implementing the following “no-regret” actions would enable electricity to be generated, used, and transported more efficiently; lower consumers’ energy costs; and bolster grid flexibility.

1. **Continue to invest in energy efficiency programs,** enabling consumers to use less energy for the same uses while decreasing their utility bills. Energy efficiency is the lowest-cost option for meeting rising electricity demand, as saving energy is cheaper than generating more. For example, in 2024, BC Hydro’s energy efficiency program saw net costs of -$8/MWh i.e. total system savings actually outweighed investment.[32] A similar program in Ontario saved nearly 1,700 GWh of electricity in 2023 at a net cost of $20/MWh.[33] For comparison, both programs were more cost effective than the 2017 wind power auction in Alberta that delivered an average bid cost of $37/MWh, considered one of the lowest-cost renewable procurements in Canada to date.[34] We are encouraged to see BC Hydro actively seeking partners, through the proposed “PowerSmart” Request for Expressions of Interest, to deploy market-ready demand-side management technologies, complementing its existing Energy Efficiency Plan.[35]
2. **Further enable and incentivize demand-side participation in electricity operations.** This would shift consumers’ electricity usage to more optimal times, improve grid efficiency, and enhance reliability — all while reducing costs and carbon emissions. Demand-side measures can be applied at a household level through smart electric-vehicle charging and thermostats, among other examples. They can also be done at a larger scale, such as at commercial and industrial facilities, and can include dynamic pricing, participation in grid-balancing services, and automated demand response programs (e.g., by ramping down or shutting off equipment during peak demand events). These measures allow consumers and businesses to save on their energy bills while helping utilities manage electricity load. Continuing to advance demand-side management would also allow for more customer-owned distributed energy resources such as rooftop solar, supporting decentralization of the distribution system, enabling greater resiliency and local participation in energy generation, and reducing transmission and distribution costs.
3. **Grow and modernize grid infrastructure.** Grid infrastructure is the backbone of an electricity system, delivering power from generators to consumers. As electricity demand grows and system needs get more complex, infrastructure should be expanded (both within the province and to other external jurisdictions) and modernized to keep electricity delivery efficient and affordable. Grid-enhancing technologies like dynamic line ratings can improve existing grid infrastructure by enabling real-time monitoring of power-line conditions (e.g., temperature, wind speed).[36] Similarly, advanced conductors can replace the steel core of transmission lines with lighter alternatives like carbon fibre,

doubling the volume of power the lines can carry while using the existing poles and towers.[37] Investing in these technologies, while continuing to grow clean energy, will enable B.C. to affordably and reliably meet rising electricity demand.

B.C.'s partnerships with First Nations on electricity

B.C. is leading the way on First Nations partnership in the clean energy economy, and provincial policy on electricity will need to involve First Nations.

In the calls for power, B.C. advanced economic reconciliation with First Nations, as well as self-determination, through First Nations engagement and ownership requirements. While lessons are still being learned on how best to structure calls for power in B.C., it is worth examining the processes and outcome for the 2024 Call for Power and the current processes (and eventual outcome) for the 2025 Call for Power.

When assessing generation technologies, B.C. should ensure strong partnerships and collaboration at all stages. This approach should extend to the other energy policy areas discussed in our report: energy efficiency programs and other demand-side measures, and grid infrastructure improvements.

Any support provided by B.C. should be ongoing and meet the needs of First Nations facing funding and other capacity constraints in participating in the clean energy economy.

B.C. should also encourage the federal government to continue to support First Nations participation in clean energy development, including through funding opportunities with the Canada Infrastructure Bank. Canada has committed to equity and economic participation for First Nations communities through the United Nations Declaration on the Rights of Indigenous Peoples Act. B.C. can emphasize that clean energy development offers an excellent opportunity for Canada to deliver on these commitments.

Appendix A. Data sources for comparing technologies

Levelized cost of energy

Lazard, *Levelized cost of Energy+* (2024)

National Renewable Energy Laboratory, *Annual Technology Baseline* (2024)

Clean Energy Canada, *A Renewables Powerhouse* (2023)

Project development timelines

U.S. Energy Information Administration, *Capital Cost and Performance Characteristics for Utility-Scale Electric Power Generating Technologies* (2024)

Land use

U.S. Energy Information Administration, *Capital Cost and Performance Characteristics for Utility-Scale Electric Power Generating Technologies* (2024)

Our World in Data, *How does the land use of different electricity sources compare?* (2022)

Water use

Yi Jin et al., *Water use of electricity technologies: A global meta-analysis* (2019)

CO_2, SO_2, and NO_x emissions intensity

U.S. Energy Information Administration, *Emissions by plant and by region* (2024)

Our World in Data, *What are the Safest and Cleanest Sources of Energy?* (2020)

Waste, flexibility and availability

Electric Power Research Institute, *Generation Technologies Assessment* (2010)

The Pembina Institute recognizes that the work we steward and those we serve span the lands of many Indigenous Peoples. We respectfully acknowledge that our organization is headquartered in the traditional territories of Treaty 7, comprising the Blackfoot Confederacy (Siksika, Piikani and Kainai Nations); the Stoney Nakoda Nations (Goodstoney, Chiniki and Bearspaw First Nations); and the Tsuut'ina Nation. These lands are also home to the Otipemisiwak Métis Government (Districts 5 and 6).

These acknowledgements are part of the start of a journey of several generations. We share them in the spirit of truth, justice and reconciliation, and to contribute to a more equitable and inclusive future for all.

Endnotes

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[10] BC Hydro, "Request for Expressions of Interest for Capacity." https://www.bchydro.com/work-with-us/selling-clean-energy/2025-rfeoi-capacity.html

[11] For example, Canada's Clean Fuel Regulations require that the harvesting of forest-based biomass feedstock be under a forest management plan that includes practices such as promoting timely forest regeneration, mitigating adverse effects on soil quantity and quality, and maintaining connectivity of watercourses.

Government of Canada, *Clean Fuel Regulations,* SOR/2022-140, s. 52. https://laws-lois.justice.gc.ca/eng/regulations/SOR-2022-140/index.html

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