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Towards the economic, orderly and efficient development of electricity generation in Alberta

Pembina Institute written submission

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Summary

Alberta's current market structure was set up for a grid featuring few, large, and inflexible thermal generators. While the market has enabled some growth of the renewables sector, the **market and regulations need to be modernized** to enable more growth and to reflect a decentralized system that rewards **flexibility, emission reductions, and cost-effectiveness**. These changes should be technology-neutral.

Our modelling finds that **with existing technologies** like interties and energy storage, renewable energy can be **reliably integrated into Alberta's grid to deliver up to 58%** of annual generation **cost-effectively. International modelling suggests that up to 80% is achievable in general**. Many global jurisdictions have already been able to bring on much more renewable energy than Alberta and are actively sharing their best practices.

The new paradigm includes a **suite of technologies and regulations** including interties, energy storage ranging from diurnal to seasonal, demand repsonse, distributed energy resources, and non-wire alternatives in the transmission and distribution systems.

The Pembina Institute recommends:

1. The Government of Alberta immediately **proclaim Bill 22** to enable the implementation of storage and non-wire alternatives.
2. The Government of Alberta **develop a clear, detailed net-zero electricity plan** and provide **net-zero mandates** to the Alberta Electric System Operator (AESO) and to the Alberta Utilities Commission (AUC).
3. The AESO and AUC **encourage the rapid adoption of technological reliability and infrastructure innovations** like grid-enhancing technologies, dynamic line ratings, transmission reconductoring, and non-wire alternatives.

Context: Renewables are needed for rapid decarbonization

Economy-wide decarbonization depends on clean electricity, and technical solutions already exist for the electricity sector. As the global clean energy transition is critical for addressing climate change, **it is imperative that the electricity sector decarbonize as quickly as possible**.

Alberta's current grid challenges related to integrating more renewable energy are due to insufficient long-term planning.[1] While modernizing the grid and increasing Alberta's use of low-carbon generators will require upfront investment, it will provide the **lowest all-in delivered energy cost for consumers** long-term. Solar and wind energy are the lowest-cost forms of producing electricity today and their capital costs continue to decline. Studies and other jurisdictions' experiences have shown that even when paired with technologies that provide special grid services, like storage, demand flexibility, interties, and synchronous condensers, they still provide the lowest overall cost of delivered electricity.

A recent study conducted by the Pembina Institute and the University of Alberta found that a grid with around 60% renewable energy and 40% abated gas assets will allow Alberta to nearly decarbonize its grid while maintaining reliability and will save a typical Alberta household $600 per year.[2]

The Pembina Institute welcomes the province's review of its approach to the economic, orderly and efficient development of renewable electricity generation. If changes to the market and to regulations maintain fair, efficient, and open competition for all forms of electricity, Alberta will be able to maintain its renewable energy advantage and economic investment.

The impact of renewables on electric system reliability

Defining reliability

The Government of Alberta has directed the Alberta Utilities Commission (AUC) to inquire into and report on the "impact the increasing growth of renewables has to both generation supply mix and electricity system reliability."[3] While electricity reliability involves a large set of parameters,[4] the government's direction did not specify which forms of reliability it hopes the Commission can investigate. London Economics International's (LEI) report for the inquiry, solicited by the Commission, focused only on supply adequacy, which is only one measure of reliability.[5]

The Government of Alberta should direct the AUC and the Alberta Electric System Operator (AESO) to develop a clear, detailed net-zero electricity plan and give them mandates to achieve net-zero emitting electricity. This would ensure system reliability and affordability are optimized for an emissions outcome that is also in the public interest.

The Pembina Institute submits the below key findings from other independent assessments of supply adequacy for the Alberta electricity system and comparable jurisdictions. Pembina also submits information relevant to other important aspects of system reliability, including flexibility, frequency and voltage regulation and black-start capabilities.

Supply adequacy is about flexibility

Adequacy is defined by the North American Electricity Reliability Corporation (NERC), of which Alberta is a member, as the "ability of the electricity system to supply [electricity] requirements … at all times."[6] Since electricity demand is variable, the supply must respond dynamically. To date, system operators like the AESO have needed to manage variability in all forms of generation, adjusting to demand and to unexpected events.

To respond to variability, system operators depend on flexibility in supply. They may draw upon backup generators (i.e., operating or contingency reserves), imports from neighbouring grids, or demand-side management measures reducing consumer use. Alberta has so far been a relatively isolated grid and with only voluntary demand response mechanisms. As the electricity system trends towards more decentralized generation, further forms of flexibility are necessary.

It is important to note that terms like "baseload" generation have created a mental model for many electricity system stakeholders and watchers that is limited and even dangerous.[7] The term implies that firm, large generators meet a minimum volume of demand that is almost always present (i.e. baseload), and that fast-burst dispatchable generation (e.g. peaker plants, energy storage, geothermal) is fundamentally necessary to meet the variable demand that sits above that baseload. However, using the term this way conflates an observation about aggregate demand with the power supplied by some specific forms of generation.

Just as renewable energy availability is variable, bulky thermal assets are also subject to maintenance, weather, or other unexpected operating conditions. As a recent example, Alberta's January 2024 widespread grid alert was exacerbated by the unavailability of a large thermal asset undergoing planned maintenance, derating of several plants due to the extreme cold, and the sudden shutdown of one gas power plant.[8]

Increased flexibility is needed and can be delivered through many mechanisms including expanding transmission capabilities (intra- and inter-provincial), introducing demand response approaches, grid-scale energy storage, [9] and low-carbon dispatchable generators. In particular, existing transmission infrastructure can be upgraded through re-conductoring, grid-enhancing technologies, dynamic line ratings,[10] and increasing use of non-wire alternatives. Our modelling indicates that renewables could account for 45-58% of annual delivered electricity in a clean, reliable, and affordable Alberta grid.[11] In general, peer-reviewed modelling studies have found that integrating renewable energy generation on electricity grids can be done with existing and available technologies easily and cost-effectively for up to 80% of annual delivered electricity.[12,13,14]

Other key reliability features

Alberta's market and electricity regulations need to be modernized to recognize these options and allow them to fairly compete to provide these reliability services. Some important aspects of reliability, such as frequency response, inertia, and voltage regulation, can be provided cost-effectively by a suite of technical options, including through wind and solar power plants,[15] many of which the AESO's 2023 Reliability Roadmap included.[16] Highlights from these options include:

1. Frequency and reactive power regulation: Wind turbines' rotational inertia can be used for frequency regulation[17] as has already been piloted in Alberta.[18] Synchronous condensers can provide similar services cost-effectively.
2. Grid-forming technologies: Smart energy management control units would allow solar, wind, and storage to provide reliability services such as black-start capabilities in a similar manner as peaker plants, and would provide robustness to low system strength.[19,20]

Jurisdictions like South Australia, California, Texas and Northern Ireland have been able to bring on hourly renewable energy generation levels of over 100% and annual volumes up to 40%[21] (while others have reached well beyond 80%[22]). These jurisdictions are now leading in the deployment of these additional reliability technologies.

System operators and electricity regulators from these and other jurisdictions have formed international working groups, such as the Global Power System Transformation Consortium and the Energy Systems Integration Group, to collaborate and support each other's technical efforts to integrate more renewable energy. They are collaborating across borders to share learnings and best practices in integrating renewable energy within their systems. The Pembina Institute recommends the AUC and the AESO engage further with these organizations. Pembina also recommends the Government of Alberta explore participation in the Southwest Power Pool Markets+ initiative to develop regional clean, reliable, and cost-saving electricity system synergies. This initiative includes British Columbia and several central and western American states.

Comments on expert reports

The Pembina Institute submits the following additional comments on specific elements of the expert reports solicited by the AUC.

In general, these reports focus on Alberta's existing electricity market structure. LEI's report says that the predicted outcomes of electricity bill increases "assume a continuation of the status quo — the current energy-only electricity market design and associated policies."[23] However, Alberta's current market structure is already being transformed. As LEI says, its predicted impact to electricity bills "could be averted with balanced and thoughtful modifications to the current electricity market design…" However, those changes were "outside the scope of LEI's study."[24]

The AESO is already considering market design changes through the Market Pathways and Executives' Working Group processes, and the Government of Alberta is considering creating a Crown Corporation that would own generators. These ongoing processes and studies could result in market changes that, in turn, could significantly reduce reliability risks. By not considering "balanced and thoughtful modifications" to Alberta's current market structure, the LEI technical modelling study commissioned by the AUC has limited value in informing the most cost-effective pathways to ensure that Alberta's electricity system is reliable over time.

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[1] Jason Wang, *Transmission Policy in Alberta* (Pembina Institute, 2023). https://www.pembina.org/reports/2023-11-30-pembina-institute-transmission-policy-submission.pdf

[2] Will Noel and Binnu Jeyakumar, *Zeroing In* (Pembina Institute, 2023). https://www.pembina.org/pub/zeroing-in

[3] O.C. 171/2023.

[4] The Alberta Electric System Operator's Alberta Reliability Standards contains more than 40 specific standards. https://www.aeso.ca/rules-standards-and-tariff/alberta-reliability-standards/

[5] London Economics International, *Module B Study: Overview of Modeling Results and Key Findings*, Exhibit 28542-X0049.01 (2024). https://media.www.auc.ab.ca/prd-wp-uploads/regulatory_documents/Reference/London%20Economics%20International%20LLC%20-%20Module%20B%20report.pdf

[6] NERC, *Glossary of Terms*. https://www.nerc.com/pa/Stand/Glossary%20of%20Terms/Glossary_of_Terms.pdf

[7] Sara Hastings-Simon and Binnu Jeyakumar, "Baseload myths and why we need to change how we look at our grid," *Pembina Institute,* August 3, 2017. https://www.pembina.org/blog/baseload-myths-and-why-we-need-change-how-we-look-our-grid

[8] Jeremy Sines, "Wind and sun helped system through power crunch: Alberta electricity operator," *The Canadian Press,* January 15, 2024. https://www.nationalobserver.com/2024/01/15/news/wind-sun-power-crunch-alberta-electricity-operator

[9] Solas Energy Consulting, *Energy Storage in Alberta and Renewable Energy Generation: An Alberta Perspective on Energy Storage, Applications, Barriers and Greenhouse Gas Emission Reductions* (2017). https://albertainnovates.ca/wp-content/uploads/2020/07/Solas-Energy-Consulting-Energy-Storage-in-Alberta-and-Renewable-Energy-Generation-1-1.pdf

[10] The Alberta Market Surveillance Administrator recently reviewed the history of dynamic line ratings in Alberta and other jurisdictions, including pilot programs and a recommendation for the AESO to study and implement them. Alberta Market Surveillance Administrator, *Quarterly Report for Q4 2023* (2024), 53-56. https://www.albertamsa.ca/assets/Documents/Quarterly-Report-for-Q4-2023.pdf

[11] *Zeroing In*, 28-39.

[12] Kristina M.E. Pearson and Sara Hastings-Simon, "The mid-transition in the electricity sector: impacts of growing wind and solar electricity on generation costs and natural gas generation in Alberta," *Environmental Research: Infrastructure and Sustainability* 3 (2023). https://iopscience.iop.org/article/10.1088/2634-4505/ad0c3f/meta

[13] P. Denholm, P. Brown, W. Cole, et al., *Examining Supply-Side Options to Achieve 100% Clean Electricity by 2035* (NREL, 2022). https://www.nrel.gov/docs/fy22osti/81644.pdf

[14] P.J. Heptonstall and R.J.K. Gross, "A systematic review of the costs and impacts of integrating variable renewables into power grids," *Nature Energy* 6 (2021), 72–83. https://doi.org/10.1038/s41560-020-00695-4

[15] Deepak Ramasubramanian, "A Continuum of Capabilities in an Inverter-Based Resource will be Important for Future System Reliability," *Energy Systems Integration Group*, January 29, 2024. https://www.esig.energy/a-continuum-of-capabilities-in-an-inverter-based-resource-will-be-important-for-future-system-reliability/

[16] AESO, *AESO 2023 Reliability Requirements Roadmap*, 70. https://www.aeso.ca/assets/Uploads/future-of-electricity/AESO-2023-Reliability-Requirements-Roadmap.pdf

[17] NREL, "Active Power Control by Wind Power." https://www.nrel.gov/grid/active-power-control.html

[18] ENERCON, *Demonstrating the Value of Wind Farm Inertial Response Functionalities to the Alberta Transmission System* (2022). https://albertainnovates.ca/wp-content/uploads/2022/04/ENERCON-E28093-Demonstrating-the-Value-of-Wind-Farm-Inertial-Response-Functionalities-to-the-Alberta-Transmission-System.pdf

[19] NERC, *Grid Forming Technology: Bulk Power System Reliability Considerations* (2021). https://www.nerc.com/comm/RSTC_Reliability_Guidelines/White_Paper_Grid_Forming_Technology.pdf

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[21] Pearson and Hastings-Simon, "The mid-transition in the electricity sector."

[22] Heptonstall and Gross, "A systematic review of the costs and impacts of integrating variable renewables into power grids."

[23] *Module B Study,* Exhibit 28542-X0049.01, 6.

[24] *Module B Study,* Exhibit 28542-X0049.01, 6.