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Pembina Institute Response to AESO Net-Zero Emissions Pathways Report

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Purpose

This note summarizes the key findings of the Alberta Electric System Operator's (AESO) *Net-Zero Emissions Pathways Report*, and aims to provide insight into the impacts of key assumptions on the outputs of the analysis. This report was a first-of-its-kind analysis for an independent system operator, and as such represents a milestone in the evolving dialogue on net-zero electricity generation in Canada.

Summary

The AESO's analysis indicates that there are multiple net-zero emissions pathways through which Alberta can deliver sufficient supply to meet growing demand for electricity. Furthermore, it can do so without compromising reliability for Albertans.

The Pembina Institute's considered analysis of the AESO's report leads us to conclude that, with some innovation in renewable energy and battery storage technology, cooperation on interprovincial transmission, demand-side management, and energy efficiency, Alberta can play its part in meeting Canada's net-zero grid by 2035 commitment.

The Pembina Institute would like to recommend that the AESO, in future iterations of its analysis, considers modifications in the following areas, which would materially impact results regarding the costs of grid decarbonization:

- Assumptions around the price of natural gas, including the risk of price instability associated with a commodity that is tied to global markets
- Assumptions around the availability of government funding for carbon capture and storage (CCS), and its impact on the price of abated thermal generation, given the exposure of this funding to political risks in the coming decades
- Assumptions around the price of renewables, including the current and projected cost of wind and solar
- The effect of the rising carbon price on affordability in all scenarios, including the baseline business-as-usual scenario which net-zero scenarios are compared against
- The cost-benefit of investment in interprovincial transmission, including the potential benefits such investment would have in providing low-carbon power during periods of peak demand in Alberta

Context

On June 27, 2022, the Alberta Electric System Operator (AESO) released its *Net-Zero Emissions Pathways Report*.[1] The Pembina Institute is grateful to have had the opportunity to provide feedback on the initial scope and assumptions of this important analysis.

The AESO's report analyzes the pathways by which Alberta's electricity grid could reach net-zero greenhouse gas emissions by 2035, in line with the Government of Canada's commitment for all electricity generation across the country. It provides further evidence that eliminating emissions from the electricity system is necessary to underpin the broader electrification and decarbonization of the Albertan and Canadian economy.

We look forward to further collaboration and engagement with the AESO as it incorporates this analysis into subsequent iterations of its Long-term Outlook (LTO) and Long-term Transmission Planning (LTP). In particular, we appreciate that the AESO recognizes this analysis is not intended to serve as a policy recommendation, but is instead intended to inform its own system forecasting and planning as well as allow for identification of future areas of research.

Key findings

- AESO concludes that Alberta's electricity market is capable of delivering sufficient supply to meet demand in a variety of net-zero scenarios, even during a net-zero transformation that will require greater capacity, as other parts of the economy, such as transportation, embrace electrification.
- In its analysis, the AESO uses a scenario-based approach, quantifying three potential supply-mix scenarios with variable amounts of renewables, storage, and thermal generation. These are:
    1. Dispatchable Dominant scenario
    2. First-Mover Advantage scenario
    3. Renewables and Storage Rush scenario
- The three scenarios have incrementally larger proportions of renewables and storage (and smaller proportions of thermal generation). The scenario with the highest proportion of renewables and storage (Renewables and Storage Rush scenario) was the most expensive, while the least expensive scenario had an intermediate amount of renewables and storage (First-Mover Advantage scenario).
- All three scenarios require a significant increase in generation, operating, and transmission expenditures relative to the AESO's 2021 LTO Reference Case, ranging

[1] AESO, *Net-Zero Emissions Pathways Report*. https://www.aeso.ca/market/net-zero-emissions-pathways/

from $44 billion to $52 billion. However, the AESO also notes that while electricity system costs are likely to increase, these costs will be offset, at least in part, by decreases in expenditure on other energy costs.

- If no new firm low-carbon power generation is built, the AESO concludes that Alberta's electricity grid, in order to remain reliable, will still produce annual residual emissions of 3.8-4.8 Mt CO_2e (which remains a significant level of emissions, compared to 29.3 Mt CO_2e in 2020).[2] As such, the application of offsets would be required to achieve a net-zero electricity system in 2035.

Considerations

Economics of generating technologies

The AESO report included key assumptions about the relative economics of generating technologies, which formed part of its determination of the optimal supply mix in the three scenarios. In the Dispatchable Dominant scenario, which is abated gas-dominant, one key assumption is that the economics of new abated thermal generation technologies would be supported by "investment tax credits and government support for CCS." This presents political uncertainties and risk for this scenario, which the AESO team acknowledges, stating "if cost assumptions [for natural gas generation with CCS] are not achieved and complete CCS strategies are not timely, projects may be delayed or cancelled." Additionally, these government supports to improve CCS economics are not included in the final accounting of costs, underrepresenting the total economy-wide cost of the scenario. We encourage the AESO to consider, in future iterations of this report, several opportunities for further research to more accurately reflect the total costs of the different net-zero supply mixes:

- compare the technologies on an unsubsidized basis;
- consider the same level of subsidies for all technologies; and/or
- reflect the total government expenditure in the final accounting of costs.

Additionally, while the AESO analysis potentially underestimates the total costs for abated thermal generation, it also potentially overestimates costs for renewables. The analysis assumes a levelized cost of electricity (LCOE) for wind at $40/MWh to $80/MWh and for solar at $85/MWh to $200/MWh.[3] These projections are in fact considerably higher than current market prices for wind and solar power. In 2017-18, wind projects procured through the AESO's

[2] Environment and Climate Change Canada, "Canada's Official Greenhouse Gas Inventory" https://data.ec.gc.ca/data/substances/monitor/canada-s-official-greenhouse-gas-inventory/B-Economic-Sector/?lang=en

[3] Values extrapolated from *Net-Zero Emissions Pathways Report,* 64, Figure 34: Levelized Cost of Electricity and Levelized Avoided Cost of Electricity for Select Low-Carbon Generation Technologies.

Renewable Electricity Program (REP)[4] competitive process had average weighted bid prices of $37.35/MWh to $40.14/MWh. In 2019, new solar projects had an average total cost of $48/MWh.[5]

Even with current commodity price and supply chain constraints, these prices are projected to decline further over the next five years.[6] If the input prices used in the AESO's analysis more accurately reflected the current and projected market prices for wind and solar, it is likely that the renewables-dominant scenarios would be significantly less expensive than the report demonstrates. We encourage the AESO to consider updating their economic assumptions for generating technologies to better reflect existing market conditions in future iterations of this work.

Natural gas price assumptions

The absence of sensitivity analysis in the AESO report underestimates the commodity price risk of a dispatchable-dominant supply mix. In its analysis, the AESO forecasts the price of natural gas to range from a low of $2.97/GJ in 2024 to $4.26/GJ in 2041 ($3.75/GJ in 2035). Current natural gas prices in 2022 are already above these forecasts; the average natural gas price from January-April this year was $4.40/GJ,[7] and was nearly double that in June.[8] While these high natural gas prices are due to exceptional circumstances, including the Russian invasion of Ukraine, it outlines the risky nature of a supply mix that is subject to volatile commodity prices. Additionally, assumptions around natural gas input costs were not updated for the LTO "business-as-usual" reference case (against which the net-zero scenarios were compared), projecting lower relative natural gas costs in every year from 2022-2041. If the cost of natural gas were updated in the LTO reference case analysis to be the same as the assumptions made for the net-zero scenarios, the cost of the LTO reference case would be higher than is demonstrated in the report. We recognize that the AESO needs to make certain assumptions to simplify its analysis, including setting assumptions on the price of natural gas; however, we encourage the AESO to include natural gas price sensitivity analysis in future work in this area and in future iterations of LTOs and LTPs, to more fully consider the price risks associated with a dispatchable-dominant grid.

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[4] AESO, "Renewable Electricity Program." https://www.aeso.ca/market/renewable-electricity-program/rep-results/

[5] Canadian Solar Industries Association, "Three New Solar Electricity Facilities in Alberta Contracted At Lower Cost than Natural Gas," *Cision*, February 15, 2019. https://www.newswire.ca/news-releases/three-new-solar-electricity-facilities-in-alberta-contracted-at-lower-cost-than-natural-gas-800812984.html

[6] International Energy Agency, "Renewables 2021." https://www.iea.org/reports/renewables-2021

[7] Government of Alberta "Economic Dashboard – Natural Gas Price." https://economicdashboard.alberta.ca/naturalgasprice

[8] Gas Alberta, "Alberta Natural Gas Prices – Current Month" https://www.gasalberta.com/gas-market/market-prices

Carbon pricing assumptions

Again, based on a comparison with the LTO reference case, the AESO's report notes that the three pathways would require $44-$52 billion in additional system costs to achieve net-zero by 2035. However, carbon pricing in the LTO reference case is static at $50/tonne, but increases to $170/tonne in the net-zero scenarios (which is the accurate trajectory of the carbon price under the current framework). If the LTO were updated to include the $170/tonne carbon price in line with federal policy, the reference case would be significantly more expensive than it currently appears in the analysis, and the net-zero scenarios — while still more expensive than the reference case — would be relatively less expensive in comparison.

In addition, the high-performance benchmark for electricity generation under the Technology Innovation and Emissions Reduction (TIER) regulation declines to zero by 2035 for the net-zero scenarios, but remains constant at 0.37 tCO_2e/MWh in the LTO reference case. Consequently, in the analysis, the proportion of electricity sector emissions subject to carbon pricing is higher in the net-zero scenarios than in the LTO reference case. The current analysis therefore overestimates the total additional cost of net-zero as a result of this carbon pricing distinction. In future iterations of this work, we encourage the AESO to incorporate the federal carbon pricing regime into their business-as-usual case to produce a more accurate comparison between the various scenarios.

Interprovincial transmission

In its analysis, the AESO assumes that the structure of Alberta's electricity market remains as it is today, with no additional interties, hydro generation, or small modular reactors. We understand that the AESO excluded these technologies from its analysis due to their high capital costs, timelines for construction, and, for interties in particular, the regulatory challenge of connecting Alberta's competitive market with neighbouring regulated markets. We welcome the AESO's conclusion that, even in the absence of interprovincial transmission, Alberta is capable of reliably delivering electricity in a variety of net-zero scenarios. However, we would also like to highlight Pembina Institute research which indicates that new transmission infrastructure is expected to lower the costs of "deep decarbonization".[9] As such, we would like to put forward the additional analysis that the building of new interprovincial transmission would in fact make the AESO's net-zero scenarios more reliable and affordable.

[9] Jan Gorski, Binnu Jeyakumar, Spencer Williams, *Connecting provinces for clean electricity grids: Regional collaboration to unlock the power of hydro, wind and solar to decarbonize Canada's economy* (Pembina Institute, 2021). https://www.pembina.org/pub/connecting-provinces-clean-electricity-grids

Another key takeaway from the AESO's analysis is that the absence of new interprovincial transmission would limit the ability of Alberta to transition away from legacy unabated gas. As long as these unabated gas assets are required to meet peaks in demand — even if these are intermittent — Alberta's electricity grid will continue to have residual emissions. However, new interprovincial transmission capacity could displace these thermal assets and provide low-carbon power during peak demand. This further underscores the need for regional cooperation between the provinces and the federal government to build interties between provinces to accelerate the decarbonization of Canada's electricity grids and the broader economy. Recognizing the long regulatory, planning, and construction timelines for interprovincial transmission projects, this analysis further emphasizes the need for policymakers and regulators to begin planning today. In Budget 2022, the federal government announced $250 million in funding to support pre-development activities of national electricity projects, such as interprovincial transmission lines.[10] As a key regulatory and planning body, we encourage the AESO to consider the impacts of interprovincial transmission in future iterations of this report, as well as in its LTOs and LTPs, to support these pre-development activities.

Conclusion

As a first-of-its-kind piece of analysis, the AESO's report provides an initial evaluation of the uncertainties, trade-offs, and opportunities associated with Alberta's transformation to a net-zero electricity system. The report serves as a starting point for collective understanding that can be used to inform further discussion, planning, and research on the net-zero transition, while recognizing it will be an iterative process. As previously mentioned, we recognize that the findings of this report, as noted by the AESO modelling team, are "not intended to represent a specific policy or technology recommendation."

At the Pembina Institute, we have been discouraged to see certain stakeholders using the AESO's report as a means to discredit the overall feasibility of net-zero electricity systems. Rather, this report provides evidence that, while some uncertainties remain, a transformation to net-zero greenhouse gas emissions is feasible. With some innovation in renewable energy and battery storage technology, cooperation on interprovincial transmission, demand-side management, and energy efficiency, Alberta can play its part in meeting Canada's net-zero grid by 2035 commitment. Furthermore, it can do so without compromising reliability for Albertans.

As we have outlined above, it is our considered view that certain assumptions of the AESO's report could be clarified to more clearly lay out the challenges and opportunities of the net-

[10] Department of Finance Canada, "Clean Air and a Strong Economy." https://www.canada.ca/en/department-finance/news/2022/04/clean-air-and-a-strong-economy.html

zero transition. We encourage the AESO to evaluate the impacts of these assumptions and conduct further analysis to determine their impacts on the model.

Again, we would like to commend the AESO for undertaking this ambitious research and look forward to future iterations of this work, which will continue to move our collective dialogue forward. The Pembina Institute is eager to collaborate with the AESO and other stakeholders to contribute to further progress on decarbonization of Alberta's electricity system in the near future.

Pembina Institute work on net-zero grids

The Pembina Institute has been a leader on research into net-zero electricity systems for years, and has produced numerous reports that detail how the Alberta electricity system can transition to net-zero emissions while maintaining system reliability and affordability. A detailed list of Pembina Institute research into net-zero grids in Alberta is provided below.

Pembina Institute reports

- Gorski, J., Binnu Jeyakumar, and Spencer Williams (2021). *Connecting provinces for clean electricity grids.* https://www.pembina.org/pub/connecting-provinces-clean-electricity-grids
- Brown, G., Kaitlin Olmstead, and Binnu Jeyakumar (2021). *Progress from Coal to Clean.* https://www.pembina.org/pub/progress-coal-clean
- Gorski, J. and Binnu Jeyakumar (2019). *Reliable, affordable: The economic case for scaling up clean energy portfolios.* https://www.pembina.org/pub/reliable-affordable-economic-case-scaling-clean-energy-portfolios
- Thibault, B. and James Glave (2014). *Power to Change: How Alberta can green its grid and embrace clean energy.* https://www.pembina.org/pub/power-change
- Bell, J. and Weis, T. (2009) .*Greening the Grid: Power Alberta's Future with Renewable Energy.* https://www.pembina.org/pub/greening-grid