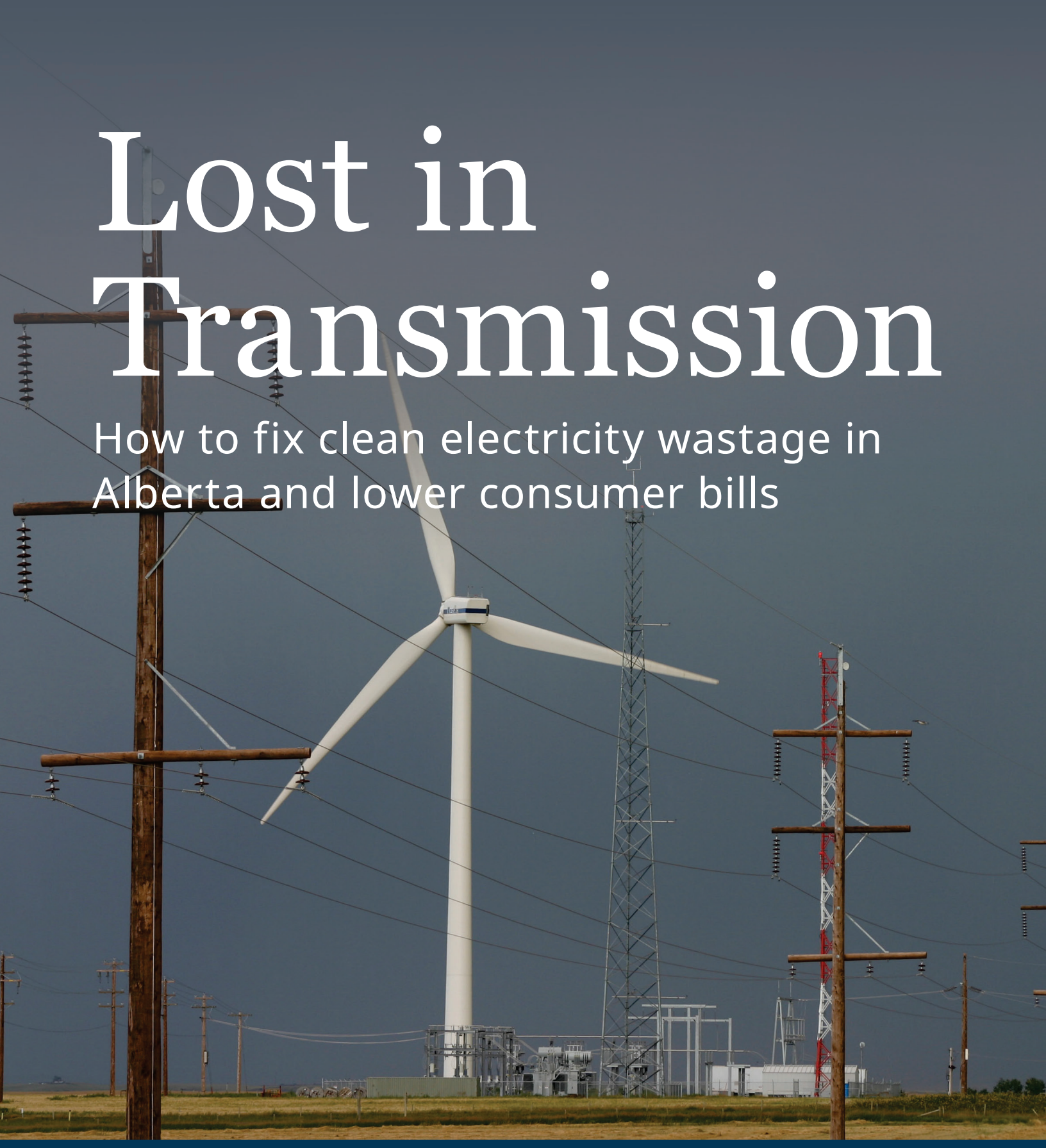

Lost in Transmission

How to fix clean electricity wastage in Alberta and lower consumer bills

May 2026

Will Noel

PEMBINA Institute

PEMBINA Institute

Lost in Transmission

How to fix clean electricity wastage in Alberta and lower consumer bills

Will Noel

May 2026

ISBN 1-897390-96-3

Recommended citation: Noel, Will. Lost in Transmission: How to fix clean electricity wastage in Alberta and lower consumer bills. The Pembina Institute, 2026.

The Pembina Institute
#802, 322 – 11 Avenue SW
Calgary, AB T2R 0C5
403-269-3344

www.pembina.org

x.com/pembina

bsky.app/profile/pembina.org

facebook.com/pembina.institute

linkedin.com/company/pembina-institute/

The Pembina Institute is a national non-partisan think tank that advocates for strong, effective policies to support Canada's clean energy transition. We use our expertise in clean energy analysis, our credibility as a leading authority on clean energy, and our extensive networks to advance realistic climate solutions in Canada.

Donate

Together, we can lead Canada's transition to clean energy. Your gift directly supports research to advance understanding and action on critical energy and environmental issues. Canadian charitable number 87578 7913 RR 0001; pembina.org/donate

Acknowledgements

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.

Contents

Figures

Executive summary

Alberta is wasting renewable energy at record rates. Unresolved transmission congestion is preventing existing wind and solar facilities from getting their product to market, forcing them to lower their output (known as curtailment). Our analysis finds that curtailment of wind and solar increased from almost nothing in 2020 to **more than 1,400 GWh in 2025**, representing roughly 8% of renewable generation that year. This is high by international standards.

When curtailment occurs, other generators have to be called on. This means, on very sunny and windy days, Alberta ends up using larger than necessary amounts of natural gas for electricity generation.

This is currently having two key effects:

1. Electricity costs are higher than they would be without curtailment, as the system operator charges consumers a "rebalancing" fee every time it has to fill a gap in supply that is caused by curtailment. In 2025, this cost ratepayers just over $17 million.
2. Electricity emissions are similarly higher than they need to be, because existing wind and solar is not being fully used. For example, in 2025, renewable curtailment resulted in 1.4 $MtCO_2e$ (7%) more electricity emissions than would have occurred if curtailment had not taken place.

However, with the restructuring of the electricity market, starting in 2028 curtailment will have an even worse impact on consumer bills. Instead of charging a rebalancing fee, the system operator will reset the wholesale price of electricity based on the newest generator that is added to the grid when curtailment occurs. This means, even when the wind is blowing and sun is shining, if the transmission lines are not able to carry low-cost renewable electricity to market, the price of electricity will be ultimately set by higher-cost generators. In essence, the changes introduced under the restructured electricity market will dramatically increase the cost of curtailment borne by Albertan ratepayers.

Our analysis finds that, if these new market rules had been in place in 2025, wind and solar curtailment would have increased average electricity prices by approximately $5.4/MWh (13% higher than if congestion had not occurred). **In total, this would have driven up electricity costs for Albertans by $261 million in 2025 alone**.

Projected forward, our analysis shows that the construction cost of new transmission lines, which would dramatically decrease congestion and associated curtailment of renewables, could

be entirely covered by these consumer savings. Indeed, on a net basis, consumer bills would not just break even — they would be lower.

Further, building new transmission lines would dramatically improve the ability of renewables projects to generate revenues, which would therefore encourage more wind and solar developers to come back to the province and re-start Alberta's languishing renewable electricity sector. As more renewables are added to the grid, consumer bills would only decrease further.

Resolving congestion is therefore one of the most impactful things the province could do to encourage renewables investment to return to the province, ensuring affordable and stable electricity prices for Albertans. Unlocking more low-cost and low-emission electricity generation must be a core part of Alberta's emissions reduction plan, especially if it is serious about its commitment to net-zero by 2050, as was reaffirmed in their November 2025 Memorandum of Understanding with the Government of Canada.

In 2025, the Alberta Electric System Operator had identified two transmission lines in southern Alberta that — combined with a line already under construction in central Alberta — could resolve this issue. However, Alberta's new Transmission Regulations are likely to result in a delay, or possibly even cancellation, of the projects not already under construction. Instead, this report provides an economic case for those lines to be expedited.

1. Background

In its most recent Long-term Transmission Plan, released in 2025, the Alberta Electric System Operator (AESO) outlined plans to develop, among other things, two new transmission lines to alleviate congestion in the southeast and southwest portions of the province, at an estimated cost of $2.5 billion.[1] If built, the new lines would provide urgently needed additional transmission capacity between where power is being generated and where it is being consumed, in the same way that adding new lanes to a highway allows a greater flow of traffic. This matters to consumers because, when transmission lines are congested, low-cost renewable energy is wasted in a process known as curtailment.[2]

In the past, the Alberta Electric System Operator, as part of its transmission planning processes, explicitly sought to minimize congestion — recognizing the issues it creates for the grid and for consumers. However, Alberta is undertaking a major overhaul of its electricity system, most notably by restructuring its deregulated electricity market and reworking its transmission planning framework. The stated goal of these changes is to enable "a more efficient grid that supports affordability."[3] Under Alberta's new Transmission Regulations, it is possible that the proposed Southeast and Southwest lines will be delayed, or even cancelled, as the AESO switches to a process that assesses the economic performance of new infrastructure.

Ironically then, regulatory changes that were intended to promote affordability of Alberta's grid are at risk of doing the opposite, by wasting some of the lowest-cost energy resources.

This report seeks to provide an economic and environmental case for alleviating congestion in southern Alberta by comparing the consumer benefits of reduced curtailment to the cost of the transmission lines outlined in the AESO's long-term plan.

[1] Alberta Electric System Operator (AESO), *Long-Term Transmission Plan* (2025), 71. https://www.aeso.ca/assets/2025-AESO-Long-Term-Transmission-Plan.pdf

[2] Market Surveillance Administrator (MSA), *Wholesale Market Report: Q4 2025* (2026), 55. https://www.albertamsa.ca/assets/Documents/Wholesale-Market-Report-Q4-2025.pdf

[3] AESO, "Electricity Framework Transition." https://www.aeso.ca/transition/

What are congestion and curtailment?

Congestion occurs when a transmission line is full, meaning it cannot safely carry any more electricity. This concept is similar to traffic congestion, when commuters are stuck on busy roads. However, unlike people in their vehicles, electricity cannot simply sit and wait for the path to clear. In these instances, the energy ends up being wasted (or "curtailed"), meaning it must be made up for elsewhere, as shown in Figure 1.

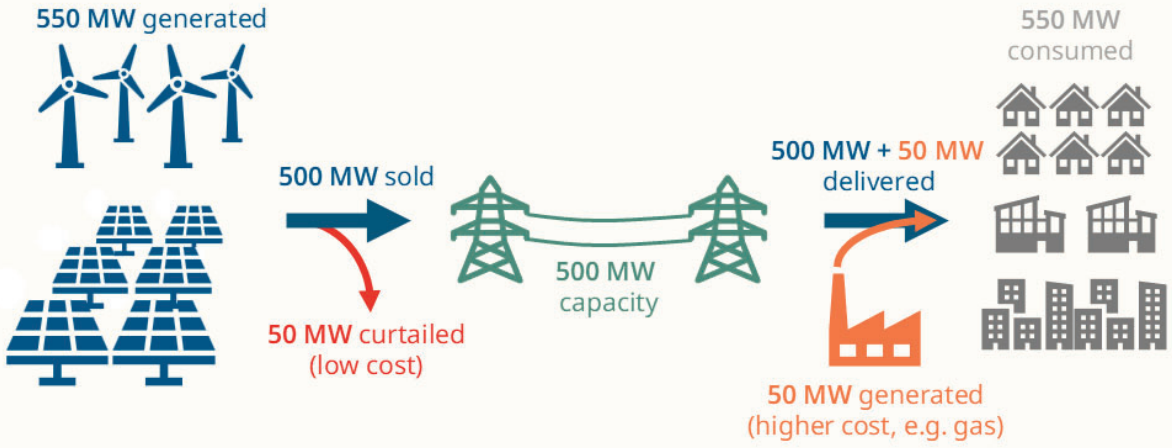

Figure 1. Diagram of transmission congestion-related curtailment

Unsurprisingly, congestion-related curtailment most negatively impacts wind and solar facilities that don't have on-site energy storage. This is because they — unlike other "dispatchable" technologies, such as hydroelectric (where water can be kept behind the dam), natural gas (where gas simply isn't burned) or wind/solar paired with a battery (where electricity can be put into the battery) — cannot withhold generation and save it for later when there's capacity on the line.

What does wind/solar curtailment look like?

Wind turbines are curtailed by pitching their blades out of the wind, which reduces or even stops their electricity generation. Solar curtailment is achieved by electrically disconnecting some panels to decrease total output to required levels.

This means that, on days that are very sunny and/or windy, the resource can still end up being wasted, as these renewable energy facilities lack the physical infrastructure to get their product to market.

2. Alberta is wasting more wind and solar energy every year

In 2020, a nominal amount of renewable energy was wasted in Alberta. Alberta's wind fleet experienced only 0.2 gigawatt-hours (GWh) of curtailment (less than 0.004% of total generation), and solar was not curtailed at all.

In the years since, congestion-driven curtailment of wind and solar has risen significantly. It reached over 1,400 GWh in 2025, representing 8% of total renewables generation for the year. In fact, the wasted electricity from wind and solar curtailment in 2025 is approximately equivalent to any of the following:

- Alberta's total wind generation in 2008 (Figure 2)
- The increase in Alberta's electricity demand between 2024 and 2025, meaning demand growth could have been entirely met by curtailed renewables
- The annual electricity demand of 200,000 homes

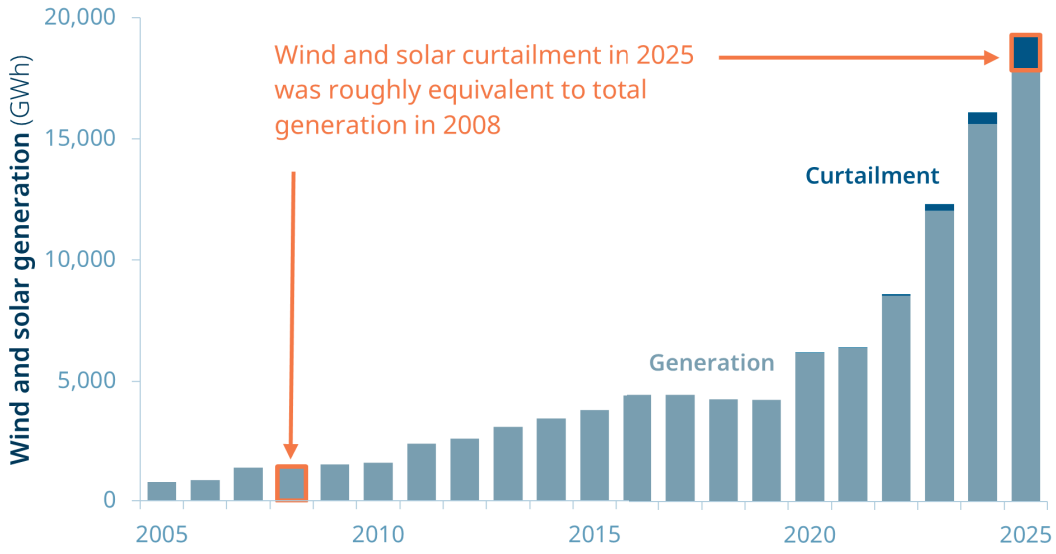

Figure 2. Alberta renewables generation and curtailment, 2005-2025

Data sources: Alberta Utilities Commission (AUC), AESO, Pembina Institute estimates using AESO data[4]

[4] Alberta Utilities Commission (AUC), "Annual Electricity Data: Total generation." https://www.auc.ab.ca/annual-electricity-data/

AESO, "Market Statistics Reports: Annual market statistics data file." https://www.aeso.ca/market/market-and-system-reporting/annual-market-statistic-reports/

AESO, "Energy Merit Order Report." https://developer-apim.aeso.ca/api-details#api=energymeritorder-api-v1&operation=getMeritOrderReport

Congestion and curtailment are a key cause of renewables stagnation

This wasted energy results in lower revenues for renewable energy developers,[5] with curtailment in Alberta being one of the primary issues that has undermined investor confidence in wind and solar in the province.[6]

Wasting wind and solar also exposes Albertans to higher, more volatile electricity prices as other generators (often natural gas) are called upon to bridge the gap (see next section).

Clearly, this needless increase in natural gas use also increases electricity emissions.

[5] Curtailment cost developers over $10 million in lost revenue last year, with Capital Power alone losing $2.7 million. *Wholesale Market Report: Q4 2025*, 58.

[6] Jason Markusoff, "ATCO blames Alberta power policies as it devalues wind and solar projects by $408M," *CBC,* March 14, 2026. https://www.cbc.ca/news/canada/calgary/atco-blames-alberta-power-policies-as-it-devalues-wind-and-solar-projects-by-408m-9.7128473

3. How wasted renewable energy translates into higher consumer bills

Alberta's deregulated electricity market is unique in Canada. Every minute, the AESO dispatches electricity supply starting with the lowest cost options available, calling upon increasingly expensive generators until demand is met. At any given time, the wholesale electricity price is dictated according to the most expensive generator that is being dispatched. This means that when it is windy and sunny, and there's lots of renewable energy available, more expensive generators are pushed off the stack — and wholesale electricity prices in Alberta are relatively low. As shown in the top row of Figure 3, when there's enough wind and solar available, natural gas is not needed, and hydro sets the price.

However, the market is impacted when a renewable generator suffers congestion and curtailment. When this occurs, as shown on the second row of Figure 3, the line associated with wind and solar gets shorter — meaning that to meet demand, the AESO need to call upon the next least expensive generator in the queue to maintain sufficient supply. The AESO can see that this has happened due to curtailment of renewables — and that in the absence of curtailment, hydro *would* have set the price.

Therefore, the wholesale price remains the hydro price, but the natural gas generator is *exclusively* paid a higher wholesale price. This additional cost is then recovered from consumers through an AESO-administered tariff, known as a "transmission rebalancing charge." In 2025, when levels of renewables curtailment reached an all-time high, this rebalancing charge cost consumers just over $17 million.[7]

However, the cost of curtailment for consumers is set to get even worse under Alberta's new electricity market rules. As illustrated in the bottom row of Figure 3, under the new rules, when congestion occurs, instead of deploying the rebalancing charge, the *entire* wholesale electricity price will be re-set according to the price being charged by the *newly dispatched* generator.

[7] AESO, "Estimated Cost of Constraint Report."
http://ets.aeso.ca/ets_web/ip/Market/Reports/HistoricalEstimatedConstraintCostReportServlet

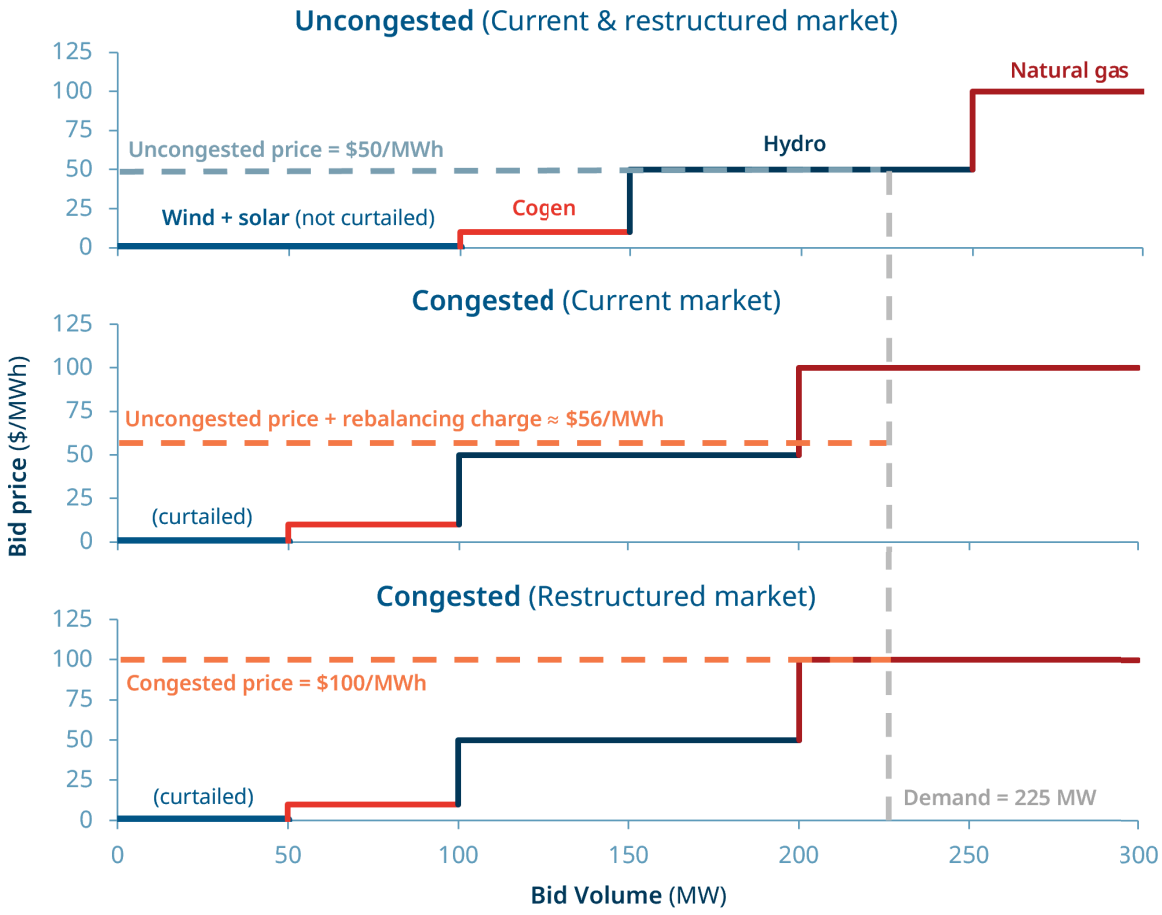

Figure 3. Hypothetical merit order showing the impact of renewable curtailment on wholesale electricity prices under both the current and restructured electricity market rules

Our analysis finds that this will lead to a significant overall increase in consumer costs. For example, if the new market rules had already been in place in 2025, curtailment of wind and solar would have resulted in a $5.4/MWh (or 13%) increase in electricity prices (Figure 4).

Curtailment of renewables does not only impact prices. Clearly, wasting wind and solar energy and instead using, for example, natural gas or (historically) coal, also results in higher annual emissions. In 2025, emissions in Alberta's electricity sector were 1.4 $MtCO_2e$ (~7%) higher than they would have been without curtailment.

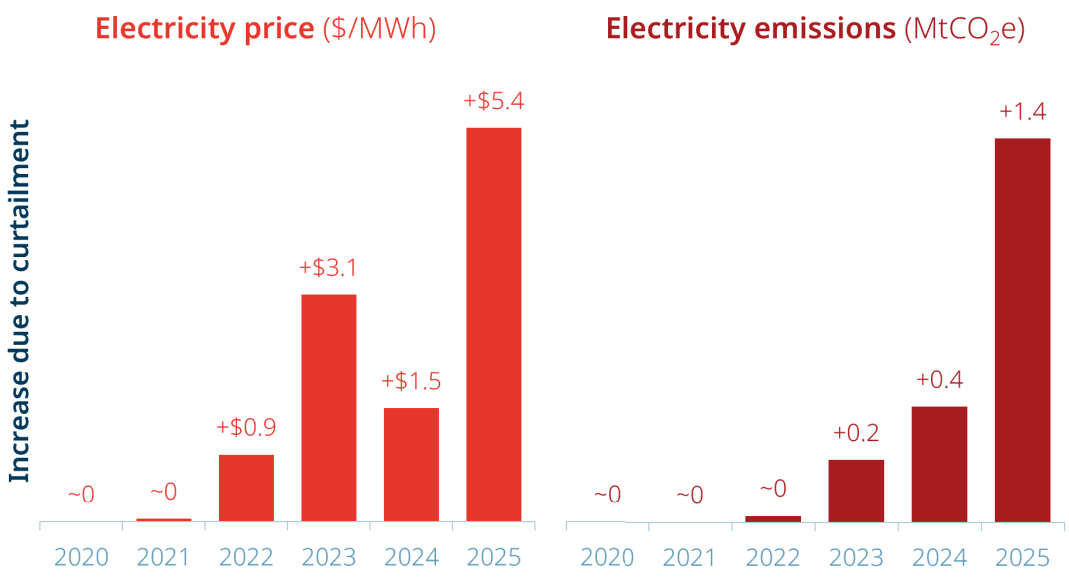

Figure 4. Increases in wholesale electricity price and emissions driven by renewables curtailment under new market rules, 2020-2025

4. Proactive grid planning is crucial for renewables

The majority of Alberta's electricity wastage is occurring in the southern region of the province, where most of the wind and solar fleet is located due to favourable weather conditions (Figure 5). However, as these generators are located away from major demand centres such as Calgary and Edmonton, they require long-distance transmission lines to carry the electricity from where it is generated to where it can be consumed.

This means that, as more wind and solar projects are built and come online, the system operator must anticipate where additional transmission is likely to be needed in future. This is something the AESO has previously done well; for example, as marked on Figure 5, a new $500 million transmission line is currently under construction to accommodate the growth in wind and solar development that is occurring east of Red Deer.

Before changes to the transmission planning framework went through, there's evidence that the AESO previously identified similar forward planning may be needed for southern Alberta, where renewables were also proliferating quickly. Its 2022 Long-term Transmission Plan noted that "the existing system could potentially accommodate another 2,000 MW of renewables generation in the Southwest and Southeast."[8] Since the publication of that report in January 2022, wind capacity has grown by 3,400 MW and solar by 1,100 MW — totalling more than double the threshold identified by the AESO.

How other jurisdictions are reducing curtailment

In 2025, Alberta generated 20% of its electricity from wind and solar, with a curtailment rate of 8% (without curtailment, wind and solar would have provided ~21%). Globally, jurisdictions with similar wind and solar shares are curtailing between 0.1 and 4.2%.[9] On top of investing in grid expansion, leading jurisdictions are minimizing energy waste in the short term

[8] AESO, *Long-Term Transmission Plan* (2022), 19. https://www.aeso.ca/assets/Uploads/grid/ltp/AESO-2022-Long-term-Transmission-Plan.pdf

[9] International Energy Agency, "Annual VRE shares in generation and technical curtailment for selected countries and regions," (2025). https://www.iea.org/data-and-statistics/charts/annual-vre-shares-in-generation-and-technical-curtailment-for-selected-countries-and-regions

through investing in energy storage (California)[10] and by incentivizing behavioural changes by offering low-cost or free power when renewables are abundant (Australia[11] and the UK[12]).

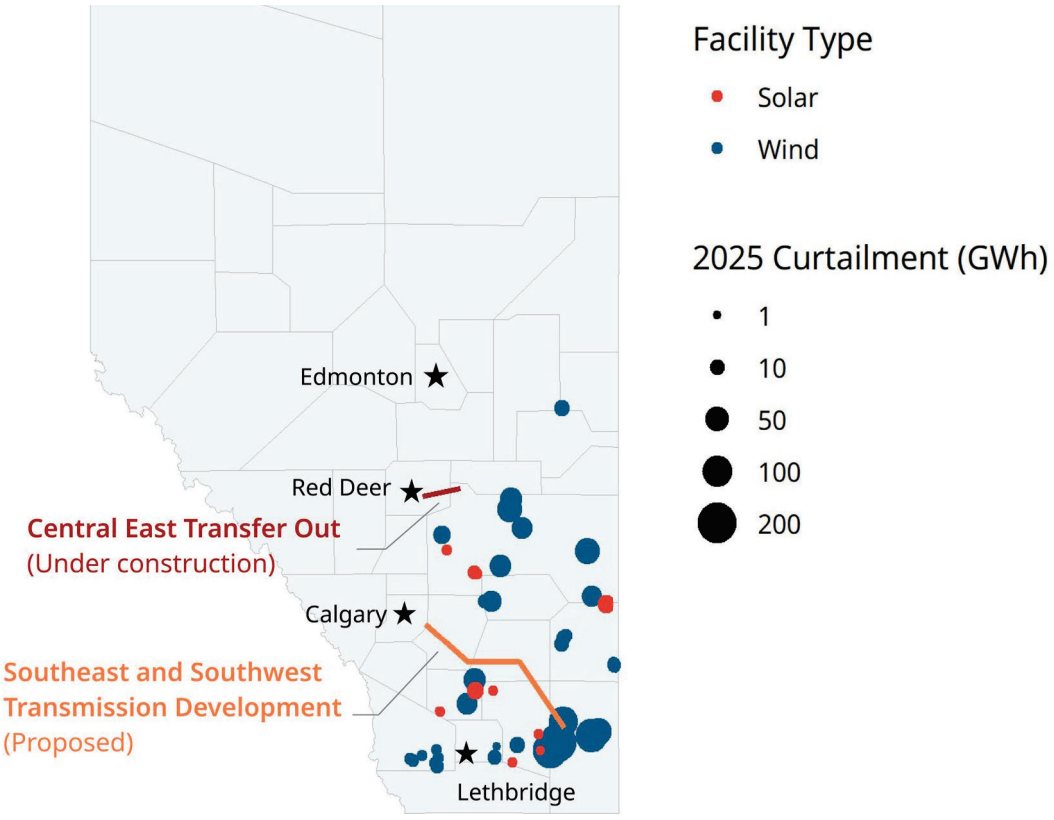

Figure 5. Wind and solar curtailment in Alberta by resource, 2025

[10] John Fitzgerald Weaver, "California solar curtailment down 12% on back of batteries," *PV Magazine*, July 22, 2025. https://pv-magazine-usa.com/2025/07/22/california-solar-curtailment-down-12-on-back-of-batteries/

[11] Fran Rimrod, "What Australia's energy regulator wants you to know about offering free hours of power," *Australian Broadcasting Corporation*, March 14, 2026. https://www.abc.net.au/news/2026-03-14/free-power-part-of-aer-dfo-draft-release/106446770

[12] Jillian Ambrose, "Run the dishwasher, plug in the car: how Great Britain plans to use record wind and solar power," *The Guardian,* April 14, 2026. https://www.theguardian.com/environment/2026/apr/14/run-dishwasher-plug-car-how-great-britain-plans-use-record-wind-solar-power

5. New transmission lines pay for themselves with consumer savings

Under the upcoming changes to Alberta's Transmission Regulation, the province will undertake cost-benefit analyses to identify appropriate investments in transmission infrastructure, rather than developing transmission projects with the sole objective of minimizing congestion. As such, a new transmission line that would relieve congestion — and thus would very likely have been built under the old "zero congestion" framework — would not necessarily go ahead under the new "optimal planning" framework.[13]

Nevertheless, our analysis finds that under forthcoming changes to the electricity market rules, the congestion and curtailment issues in southern Alberta will soon be having such an impact on electricity prices that investment in new transmission lines in this area of the province should still be economically justified under the new "optimal planning" approach. Note that while the cost of transmission would be borne by *all* ratepayers (i.e. not just those in the south), the corresponding decrease in price would similarly benefit *all* ratepayers as well.

By combining congestion-related wholesale price increases (outlined in Figure 4) with retail statistics data,[14] we find that **between 2023 and 2025 consumers would have saved $483 million if renewables were not curtailed**. Savings in 2025 alone would have been as much as $261 million, which roughly translates to $30 per household.

Finally, we find that **consumer savings from reduced curtailment would outweigh the cost of building the new transmission lines immediately.** In other words, the cost of building new transmission lines (amortized over 30 years) is less than the amount that ratepayers will save due to reduced curtailment from building said lines (Figure 6).

This figure includes:

- The $2.5 billion lines previously planned in the southeast and southwest portions of the province, per the costs outlined in AESO's 2025 long-term plan
- The $500 million line currently under construction east of Red Deer.

[13] Infrastructure may also be built if it is necessary to comply with reliability standards or is mandated through provincial legislation. AESO, *Optimal Transmission Planning Framework: Methodology and process* (2026), 5-6. https://www.aeso.ca/assets/Uploads/future-of-electricity/OTP-Framework-Final.pdf

[14] MSA, "Retail Statistics." https://www.albertamsa.ca/documents/retail-and-rate-cap/retail-statistics

We estimate these three projects would cost $224 million per year over 30 years, or around $25 per household per year. Given the annual per-household savings we calculated for 2025 (above), this therefore equates to at least an annual net reduction in bills per household of approximately $5. Further details of this estimate can be found in the Appendix.

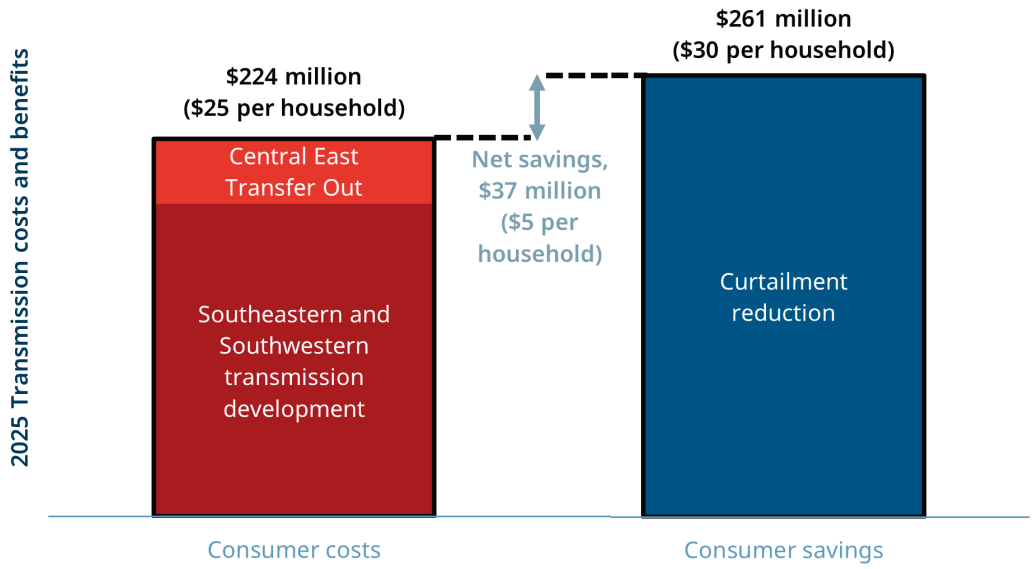

Figure 6. Comparison of consumer costs and benefits of mitigating transmission congestion in southern and central Alberta under market restructuring, 2025

This assessment of the potential impact on consumer bills is a conservative estimate. Given that Alberta's electricity prices will soon start to increase as a result of demand growth, especially from data centres, the impact of curtailment on electricity bills will likely grow in tandem. This means, with every passing year, the economic case for building the transmission lines and therefore resolving congestion and curtailment of renewables will further improve.

In addition, these estimates only include the benefits of reduced congestion and curtailment of *existing* renewable energy capacity. They do not encompass the additional impact that any brand-new wind and solar projects would have in further driving down electricity prices. Further, such projects would be far more likely to move forward if developers felt confident they would not experience curtailment; **in other words, building this transmission would provide a substantial fix to one of the most pertinent issues that has caused renewable energy investment to dry up in Alberta in the last few years**. If wind and solar investment begins to proliferate once again in Alberta, this would do even more to reduce electricity bills for Albertans.

6. Conclusion

As global investment in wind and solar grows, operators of electricity grids around the world are racing to concurrently expand and modernize relevant infrastructure, especially transmission. While some curtailment is to be expected — especially as wind and solar investment outpaces grid expansion — Alberta's steep increase in the volume of wasted renewable energy in the last few years is concerning, and out of step with international trends.

By reducing curtailment of its wind and solar fleet, Albertans would save hundreds of millions on their utility bills, even when considering the cost of building new transmission lines (a cost that will ultimately be passed to ratepayers). Further, if it shows that it is serious about tackling congestion, Alberta could begin to restore waning investor sentiment in its renewables industry. It is hard to overstate how vital this is, if the province is to grow its electricity supply to meet rapidly growing demand without inflating costs for consumers. If Alberta and the AESO want to ensure an affordable transition to net-zero by 2050 — a key outcome of the ongoing Memorandum of Understanding negotiations with the federal government — minimizing the province's wasted wind and solar generation is a crucial first step.

To that end, we recommend that **Alberta fast-tracks the development of the Southeast and Southwest transmission lines highlighted in the AESO's 2025 Long-term Transmission Plan.** Building these lines would alleviate the majority of the congestion in southern Alberta, not only allowing existing renewable energy projects to operate without being curtailed, but also increasing the likelihood that more low-cost renewables will be added to Alberta's grid in the coming years. This means cost savings for Albertans would continue to grow over time as renewable energy developers seek to take advantage of the increased transmission capacity.

Appendix A. Methodology

A.1 Estimating wind and solar curtailment

Unlike many other jurisdictions, Alberta does not readily provide renewable curtailment data Rather, this data is contained within the AESOs Energy Merit Order dataset, which is available on a 60-day time lag relative to the data it is presenting.[15] Here, the AESO provides, among other things, facility-level offer data (e.g. offer price in $/MWh, offer volume in MW) for all market participants, including those that were not dispatched.

In a typical hour, wind and solar generators' available and dispatched capacity are both entered to be equal to their maximum installed capacity (despite actual generation being based on weather conditions, as published in a different dataset).[16] However, this changes during curtailment events, when the difference between available and dispatched capacity is approximately equal to the volume of wasted energy. This is demonstrated in Figure 7 below, which shows the estimated curtailment of the Travers Solar Farm on May 4, 2023, both as published in the Merit Order data and transformed into a more understandable fashion. Note that these values closely align with those published by the Market Surveillance Administrator.[17]

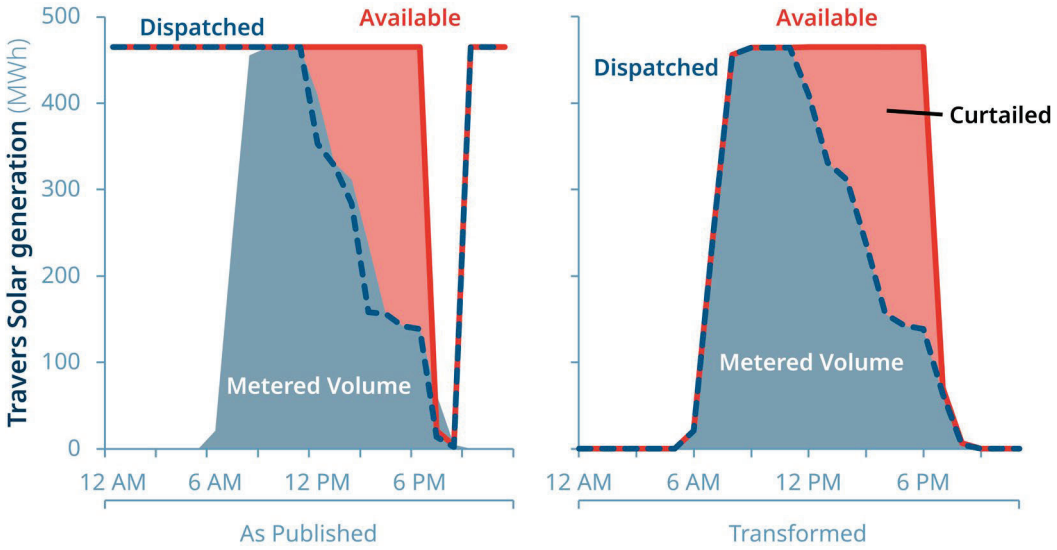

Figure 7. Example of estimating curtailment using AESO merit order data

[15] "Energy Merit Order Report."

[16] AESO, "Metered Volume Report." https://developer-apim.aeso.ca/api-details#api=meteredvolume-api-v1&operation=getMeteredVolumeReport

[17] MSA, *Wholesale Market Report: Q2 2023,* (2023), 59. https://www.albertamsa.ca/assets/Documents/Quarterly-Report-for-Q2-2023.pdf

A.2 Estimating price and emissions increases from curtailment under the restructured energy market

Once curtailment has been estimated for all renewable energy generators in all hours, the increase in cost driven by congestion is calculated by determining the generator (or generators) that would have been displaced if the curtailed wind and solar in that hour were able to be delivered to market. This is done by adding the curtailed renewables back into the merit order. For example, the hypothetical merit order is shown in Figure 3, both with and without renewable curtailment. Here, when the wind and solar are curtailed, the gas plant is then required to ramp up to meet demand, leading to a marginal price of $100/MWh. However, when curtailment is removed, the gas plant is not required, and the marginal price decreases to $50/MWh.

From here, we can estimate the difference in emissions by multiplying the difference in generation of the marginal units (here, the gas plant) by their respective emissions intensities. For the purpose of this report, we assume a 1,000 t/GWh emission intensity for coal, 600 for simple cycle natural gas, 550 for gas-fired steam, 400 for combined cycle natural gas, and 200 for cogeneration.

A.3 Estimating annual transmission costs

In their 2025 Long-term Transmission Plan, the AESO identified two new transmission lines between Whitla and Linden that would alleviate growing congestion issues in southern Alberta, at a cost of $2.5 billion.[18] Combined with the cost of the Central East Transfer Out project that is already under construction ($513 million),[19] applying a 6.2% weighted-average cost of capital,[20] and assuming a finance period of 30 years, the cost of these transmission lines would be approximately $224 million per year.

Then, by dividing by the AESO's estimated Demand Transmission Service (DTS) energy forecast,[21] we can estimate the impact of this transmission per unit of energy consumed. For example, the AESO estimates a DTS demand of 64,972,000 MWh in 2030, meaning that the delivery charge associated with these transmission lines would be approximately $3.45/MWh.

[18] *Long-Term Transmission Plan*, 71

[19] "Central East Transfer Out Transmission Development."

[20] U.S. Energy Information Administration, *Levelized Costs of New Generation Resources in the Annual Energy Outlook 2022* (2022), 6. https://www.eia.gov/outlooks/aeo/pdf/electricity_generation.pdf

[21] AESO, *2025 Transmission Rate Outlook*, 2. https://www.aeso.ca/assets/Uploads/TRO_Factsheet_2025-WEB.pdf

Photo: David Dodge, Pembina Institute

PEMBINA Institute

www.pembina.org

x.com/pembina bsky.app/profile/pembina.org

facebook.com/pembina.institute linkedin.com/company/pembina-institute/