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Exploring Ontario’s Pathways to Net-Zero Electricity

Pembina Institute response to the IESO Pathways to Decarbonization report

by Jason Wang and Binnu Jeyakumar | May 12, 2023

Summary

The Ontario Independent Electricity System Operator’s (IESO) 2022 Pathways to Decarbonization (P2D) report is only the second report by a Canadian electricity system operator that outlines scenarios for decarbonizing the electricity sector. The P2D report examines two scenarios: a moratorium on new gas generation facilities in Ontario, and the decarbonization of Ontario’s electricity system. As the electricity sector is central to economy-wide decarbonization, it is encouraging to see efforts to understand the opportunities and challenges in preparing the grid to be more efficient.

The Government of Ontario has made significant investments in electrifying transportation and heavy industry (through support for electric vehicle manufacturing, new ultra-low overnight electricity price plan, etc.). Building on these investments, Ontario is well positioned to ensure that the province continues to produce clean electricity from resources like hydro, wind, and solar energy to power those transformations. Similarly, as Ontario competes with other provinces and the U.S. to attract businesses, it can draw in greater investments by providing them net-zero grid emissions to help meet their environmental, sustainability and governance (ESG) goals.

The province must plan now for how to **transform and modernize Ontario’s electricity system.**

The Pathways to Decarbonization report is a good foundational step for long-term energy planning and to deliver affordable, reliable, and cost-effective clean electricity to Ontarians. The Pembina Institute offers here comments and recommendations that the Ontario government and IESO may consider in order to understand how Ontario’s electricity sector can best support the province’s electrification efforts and energy transition, and take advantage of the economic opportunities available.

Recommendations in brief

1. Implement and add to the "no regret" actions in order to rapidly deploy non-emitting technologies

"No regret" actions should also include:

- strategies for securing the cheapest sources of electricity (wind and solar)
- strategies for expanding transmission interconnection

2. Explore options to reduce costs of new energy infrastructure

- The cost analysis should include cost reductions due to federal fiscal incentives and investments.
- The province should explore methods of direct corporate procurement of renewable energy, including sleeved power purchase agreements.

3. Develop additional decarbonization scenarios to align with a 2035 net-zero grid and take greater advantage of cheap clean energy solutions

- A comparative analysis should be undertaken of the IESO Pathways to Decarbonization modelling to that of other models to help identifying the reasons for discrepancies regarding achieving a net-zero grid by 2035, as well as the amount of gas capacity required for grid reliability.
- Additional scenarios should examine cost-efficient options for decarbonization:
  - Include greater penetration of clean energy resources – especially wind, solar, storage, demand-side management, energy efficiency, and transmission interconnections.
  - Consider a range of caps on energy resources, including a scenario where there is no cap.
  - Further examine Distributed Energy Resources in detail.
  - Clarify IESO's assessment of operability of different technologies.
  - Assess all emerging grid balancing technologies, not only hydrogen.
- Additional benefits analysis is necessary to ensure that net costs are examined.
  - Benefits should include avoided infrastructure costs.
  - Benefits should also include the wider impacts of energy transition (health, climate).
- The costs of the scenarios should be compared against baseline costs for the years 2035 and 2050, to help contextualize spending relative to business-as-usual.

1. Background

1.1 Electricity policy and market trends

Investment in clean energy and clean technology is rapidly growing in Canada and around the world, especially in building clean electricity infrastructure — mostly wind and solar energy — and electrifying transportation. In 2022, global investments in clean energy surpassed US$1.1 trillion, continuing a trend of accelerating growth.[1]

Declines in the cost of wind and solar alongside grid modernization, including demand-side management, are reshaping how electricity is supplied and managed. The benefits of this transformation include greater flexibility in terms of when and how much energy is consumed. Moving toward a clean grid has also been driven by external market forces, climate policy, and consumer demand.

Canada and its largest trading partner, the United States, both see net-zero electricity as a foundation for economy-wide decarbonization, and have committed to a decarbonized grid by 2035. The recently passed U.S. Inflation Reduction Act (IRA), which included substantial tax credits for solar and wind electricity, clean hydrogen production, and electricity grid modernization, is estimated to draw in US$978 billion in investments by 2030.[2]

More and more companies are prioritizing jurisdictions with a clean grid to locate operations. When, in 2022, LG Energy Solution announced its record-setting $5 billion investment in a new battery manufacturing facility — the largest private sector investment in Ontario to date[3] — Canada's leadership on renewables was cited as a determining factor.[4] Earlier that year, General Motors cited Quebec's low-cost, "zero-GHG hydroelectricity" as a key factor in choosing to build a $500 million facility near Trois-Rivières. Ontario stands to acquire additional, and

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[1] David R Baker, "$1 Trillion Green Investment Matches Fossil Fuels for First Time," *Bloomberg New Energy Finance,* January 26, 2023. https://www.bloomberg.com/news/articles/2023-01-26/global-clean-energy-investments-match-fossil-fuel-for-first-time

[2] Ashna Aggarwal, Jacob Corvidae and Wendy Jaglom-Kurtz, *The Economic Tides Just Turned for States* (Rocky Mountain Institute, 2023). https://rmi.org/economic-tides-just-turned-for-states/

[3] Dave Waddell, "$5B Windsor battery plant the largest private sector investment in Ontario history," *Windsor Star,* March 23, 2022. https://windsorstar.com/news/local-news/windsor-battery-plant-the-largest-private-sector-investment-in-ontario-history

[4] Stellantis, "Stellantis and LG Energy Solution to Invest Over $5 Billion CAD in Joint Venture for First Large Scale Lithium-Ion Battery Production Plant in Canada," media release, March 23, 2022. https://www.stellantis.com/en/news/press-releases/2022/march/stellantis-and-lg-energy-solution-to-invest-over-5-billion-cad-in-joint-venture-for-first-large-scale-lithium-Ion-battery-production-plant-in-canada

significant, private sector investments by virtue of maintaining a largely non-emitting grid and implementing strategies that demonstrate the province is moving to a net-zero grid by 2035.

Following these investment and policy trends, the federal government has announced billions of dollars in tax credits for clean energy and clean tech and will soon release the Clean Electricity Regulations to support a net-zero grid by 2035.[5] Provinces can leverage the federal funding and policy certainty to invest in their own grids.

With investors looking to the U.S. to capitalize on its substantial policy support and with the Clean Electricity Regulations, which are expected to be finalized in 2023, it is to Ontario's economic advantage to plan with these contexts in mind. Ontario has been a Canadian leader in reducing GHG emissions from its electricity sector. In the early 2010s, Ontario phased out coal and built more solar and wind energy capacity than anywhere else in Canada.[6] Ontario's greenhouse gas emissions in 2020 were 22% lower than emission levels in 2005. With a 31.6 $MtCO_2e$/year reduction just from electricity (an 89% decline in that sector),[7] the electricity sector was responsible for 60% of Ontario's greenhouse gas mitigation progress.[8]

The Government of Ontario has demonstrated its interest in pursuing private sector expertise and resources in a competitive market. With the net-zero grid target only 12 years away, Ontario must now make key decisions on how it will go about an investment opportunity to continue to transform its electricity system in ways that will offer clean, affordable, and reliable energy for decades to come.

1.2 Ontario IESO's carbon reduction studies

Ontario's government has already been working with stakeholders and the Independent Electric System Operator to explore several policy options for ensuring Ontario's electricity system can continue to be low-carbon, affordable, and reliable. While Ontario's grid is only 10.4%[9] emitting right now, it is increasingly generating electricity from gas. In fact, the Canada

[5] A net-zero grid 2035 target was announced at COP26 in November 2021 and departmental engagement started in April 2022.

[6] CanREA, *By the Numbers Annual Data Release* (2023). https://renewablesassociation.ca/wp-content/uploads/2023/01/CanREA-Renewable-Project-Data-General-2023-01-17.pdf

[7] Government of Canada, *2020 National Inventory Report, Part 3* (2022), 67. https://publications.gc.ca/collections/collection_2022/eccc/En81-4-2020-3-eng.pdf

[8] Ontario's greenhouse gas emissions in 2005 and 2020 were 203 and 150 $MtCO_2e$ (overall) and 35.3 and 3.7 $MtCO_2e$ (electricity sector).

[9] IESO, "2022 Year in Review." https://www.ieso.ca/en/Corporate-IESO/Media/Year-End-Data

Energy Regulator expects that from 2023 on, Ontario will produce more electricity from gas than any other province save Alberta.[10]

In 2021 and 2022, energy minister Todd Smith asked the IESO to 1) evaluate the impacts of phasing out gas-fired electricity generation by 2030 and, 2) to explore the feasibility of a moratorium on new gas generators and of an "achievable" pathway to phase out gas-fired electricity and achieve zero emissions.[11] In October 2021 the IESO responded to the first request in its report, Decarbonization and Ontario's Electricity System,[12] and to the second request in its December 2022 report, Pathways to Decarbonization (P2D).[13] Significantly, Ontario is the only province other than Alberta where the electricity system operator has produced a report providing scenarios for decarbonizing the electricity sector.[14]

The 2021 Decarbonization report concluded that, absent gas-fired electricity in Ontario's energy mix, Ontario would face rolling blackouts by 2030, and the reliability of the energy system would be compromised. The 2022 P2D report found in its Moratorium modelling scenario that a gas moratorium could be implemented in 2027 while retaining reliability in the system; the report's Pathways scenario provides one pathway to decarbonizing the electricity system by 2050.

Both these scenarios provide insights into important challenges that will need to be addressed in transitioning to an expanded and modern electricity system (e.g., permitting, labour capacity). P2D's Pathways scenario implements the July 2021 draft Clean Electricity Regulations framework. Its main insight for 2035 is that the Portland and York Energy Centers (unabated gas plants with 550 and 393 MW capacity) will need to retire. Without these sites, Toronto and York would need new electricity supplied by either new regional generation or additional transmission capacity to other regions, with the latter being difficult to scale by 2035.

[10] Canada Energy Regulator, "Electricity Generation," *Canada's Energy Future 2021 – Data Appendices* (2022). https://apps.cer-rec.gc.ca/ftrppndc/dflt.aspx?GoCTemplateCulture=en-CA

[11] *Letter from The Honourable Todd Smith to Lesly Gallinger* (October 2021). https://ieso.ca/-/media/Files/IESO/Document-Library/corporate/ministerial-directives/Letter-from-Minister-Gas-Phase-Out-Impact-Assessment.ashx

[12] IESO, *Decarbonization and Ontario's Electricity System: Assessing the impacts of phasing our natural gas generation by 2030* (2021). https://ieso.ca/-/media/Files/IESO/Document-Library/gas-phase-out/Decarbonization-and-Ontarios-Electricity-System.ashx

[13] IESO, *Pathways to Decarbonization* (2022). https://www.ieso.ca/en/Learn/The-Evolving-Grid/Pathways-to-Decarbonization

[14] The Alberta Electric System Operator conducted the first system operator net zero grid analysis, and for the 2035 timeline, in 2022. https://www.aeso.ca/future-of-electricity/net-zero-emissions-pathways/

2. Alternative pathways for a clean, affordable and reliable grid

Solar, wind, storage, transmission interconnections, and demand-side management employ technologies that are cost-effective and reliable. The P2D report did not include modelling scenarios that optimized renewables, clean technology, and energy efficiency measures, which could potentially allow Ontario to achieve a net-zero grid much earlier than 2050. The combination of renewable energy sources, transmission interconnections, and demand-side management provides reliability equivalent to the current generation mix while improving resilience and is more cost-effective than the business-as-usual approach.

This section first offers a perspective on reliability, then details options that can help Ontario to decarbonize its grid at a pace that is aligned with corporate demand and U.S. trends, while maintaining reliability and affordability. The Pembina Institute respectfully suggests that the IESO undertake additional policy analysis based on the perspectives and alternatives outlined here, with the expectation that these will assist the Government of Ontario to confidently chart a credible path towards its goals of reducing emissions while meeting the energy needs of Ontarians and businesses.

2.1 Reliability in the modern grid

The P2D report concludes that 5 GW of combined cycle and 3 GW of simple cycle gas power plants are required in 2035 in the Moratorium scenario to meet anticipated energy demands. The Pathways scenario utilizes hydrogen plants in similar ways. While there can be a role for gas-fired generation (or hydrogen within retrofitted gas turbines) in a net-zero grid, the consideration of other variables may lead to an alternative conclusion:

- Appendix B, Section 3 of the P2D report describes the different operability services that the grid requires, including frequency support and balancing, inertial and primary frequency response, regulation service, operating reserve, and ramping capability. These descriptions clarify the parameters for the services that the IESO requires from generation sources. However, the report does not explain how non-emitting sources are evaluated in the provision of the same services. Sharing this information would show how the IESO assesses all the available options.
- The P2D report notes that gas power plants are "capable of providing continuous, flexible energy year-round and under all weather conditions" and that there is no "like-for-like replacement." However, gas power plants are not consistently in operation (due to planned and unplanned outages), and may also be de-rated (i.e., operate at a capacity

lower than their name plate capacity) for several reasons including environmental factors such as high ambient temperatures. Operability services do not need to be provided in their entirety by a single generation source. Alternatives should be considered especially where the alternatives may well be more economical. In analyses conducted by the Pembina Institute and the Rocky Mountain Institute, portfolios of solar and wind combined with energy storage and demand side management can largely provide the same services as gas, and in a more cost-effective manner.[15] It would be to Ontario's benefit to undertake a thorough examination of these readily available solutions.

- Analyses undertaken by the University of Victoria for the David Suzuki Foundation[16] and by Power Advisory for The Atmospheric Fund (TAF),[17] employing several different net-zero grid scenarios using hourly dispatch models, found that Ontario's grid can remain reliable absent the expansion of gas capacity. In these scenarios, a portfolio of transmission, storage, demand response, and emergency gas backup — not exceeding 2.2 $MtCO_2e$ of annual emissions — were sufficient to ensure the grid's reliability.[18]

The P2D Pathways scenario also concludes that federal Clean Electricity Regulations, even with a 25-year end of prescribed life, will be challenging as it will only allow for 2 GW of gas, which is not adequate gas capacity.[19] This conclusion merits a comparison to the aforementioned models that suggest low-gas systems can be reliable. Moreover, the Clean Electricity Regulations will allow for exemptions for gas plants with low capacity factors as backup capacity. Much of the installed gas capacity could qualify for this exemption depending on their capacity factor.

[15] Jan Gorski and Binnu Jeyakumar, *Reliable, affordable: The economic case for scaling up clean energy portfolios* (Pembina Institute, 2019). https://www.pembina.org/pub/reliable-affordable-economic-case-scaling-clean-energy-portfolios

[16] Tom Green and Stephen Thomas, *Shifting Power: Zero-Emissions Electricity Across Canada by 2035* (David Suzuki Foundation, 2022). https://davidsuzuki.org/science-learning-centre-article/Shifting-Power-Zero-Emissions-Electricity-Across-Canada-by-2035/

[17] Power Advisory, *Scenarios for a Net-Zero Electricity System in Ontario* (The Atmospheric Fund, 2022). https://taf.ca/publications/scenarios-for-a-net-zero-electricity-system-in-ontario/

[18] Peninsula Clean Energy, a California electricity distributor, deployed an interesting methodology that may be of interest to the IESO. In examining the operability and the relative costs of providing hour-by-hour clean energy at 90, 95, 99 and 100%, they found that 99% clean energy cost only 3% more than a 90% system. The last 1% needed to reach 100% necessitated 28% more renewables capacity to be built. Insights like this are helpful for robust long-term planning. *Achieving 24/7 Renewable Energy by 2025* (2023). https://www.peninsulacleanenergy.com/wp-content/uploads/2023/01/24-7-white-paper-2023.pdf

[19] IESO, *Pathways to Decarbonization: Appendix B* (2022), 27. The report uses 'end of potential life (EOPL),' while 'end of prescribed life' is the term used in the Clean Electricity Regulations draft framework.

2.2 Exploring alternatives

The discussion of low-emission, low-cost technologies below outlines ways that future studies can focus on sensitivity or uncertainty analysis and scenario development efforts to include these options. We also address concerns regarding these technologies raised in the P2D report.

2.2.1 Solar and wind

Today, solar and wind are the top-producing sources of electricity in Europe.[20] The IEA expects solar and wind assets to produce more electricity than coal globally by early 2025 as they continue to grow exponentially worldwide. A main growth driver for renewables is continuing cost declines, a trend not shared by gas or nuclear assets.[21]

The P2D report limits the total capacity of onshore wind in several zones to a total of 15.8 GW due to siting quality, regulatory requirements, and proximity to transmission infrastructure.[22] In the Pathways scenario, the new onshore wind selected by the model totals 15.1 GW, reaching the imposed cap in most of the zones. As wind turbine technology continues to evolve, including the production of larger rotor sizes that will increase output and capacity,[23,24] it is likely that more capacity will be available than was recognized in the Pathways scenario. A sensitivity analysis or additional scenarios should explore the implications of an increased onshore wind limit and higher capacity factors, as well as a scenario where there is no cap.

According to the P2D Pathways scenario, when Ontario moves from peak energy demand in summer to peak energy demand in winter, solar electricity capacity stops growing and stabilizes at around 6 GW. With solar poised to become the cheapest form of electricity production worldwide[25] this conclusion is surprising. It would be interesting to understand which parameters may lead to solar as a larger proportion of the overall energy mix. For example, modelling should also present a scenario where cost declines faster than expected; a sensitivity analysis on the costs of both wind and solar in the future would be of value as the

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[20] Daisy Dunne, "Wind and solar were EU's top electricity source in 2022 for first time ever," *Carbon Brief,* January 31, 2023. https://www.carbonbrief.org/wind-and-solar-were-eus-top-electricity-source-in-2022-for-first-time-ever/

[21] Abhishek Malhotra and Tobias S. Schmidt, "Accelerating Low-Carbon Innovation", *Joule* 4, no. 11 (2020). https://doi.org/10.1016/j.joule.2020.09.004

[22] *Pathways to Decarbonization*, 12.

[23] David Roberts, "These huge new wind turbines are a marvel. They're also the future," *Vox,* May 20, 2019. https://www.vox.com/energy-and-environment/2018/3/8/17084158/wind-turbine-power-energy-blades

[24] Will Noel et al., "Mapping the evolution of Canada's wind energy fleet," *Renewable and Sustainable Energy Reviews* no. 167 (2022). https://doi.org/10.1016/j.rser.2022.112690

[25] Simon Evans, "Solar is now 'cheapest electricity in history', confirms IEA," *Carbon Brief,* October 13, 2020. https://www.carbonbrief.org/solar-is-now-cheapest-electricity-in-history-confirms-iea/

province determines the best means of meeting future energy requirements while ensuring sustainability.

Historically, there has been skepticism that wind and solar electricity can make up a substantial proportion of a grid's energy mix, or penetration. But this is no longer the case. In Texas and in California, renewables have produced more than 70% of the grid's energy supply.[26] Solar, wind, and batteries are expected to generate more than 80% of the state of South Australia's electricity in 2024,[27] and the British National Grid, with a demand volume and capacity mix similar to Ontario's[28] believes it will reach the U.K. government's net-zero grid 2035 goal ahead of schedule.[29] In 2021, renewables contributed 10% of the total electricity generated in Alberta[30] and in 2019, 9% in Ontario.[31]

Timing needs to be a consideration as well. Renewables will need to be scaled up to meet capacity requirements. But given the rate of deployment, factoring in permitting; financing; community engagement; engineering, procurement, and construction; and other variables, the time horizon for building out solar and wind generation is shrinking. However, in net-zero grid pathways identified in the 2022 TAF report, which add a similar amount of solar and wind as P2D's Pathways scenario, the rate of deployment of wind and solar assets are comparable to the peak year of Ontario's Feed-in-Tariff program, which TAF calls "high but achievable." [32] One method of supporting rapid renewable deployment is corporate procurement.

2.2.2 Short- and medium-duration storage

Electricity storage plays an important reliability role by providing supply adequacy, helping renewables integrate into the market. Ontario is already home to many of Canada's largest

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[26] As of May 10, 2023, ERCOT's record stood at 71.3%. ERCOT, "Renewable Integration Report." https://www.ercot.com/mp/data-products/data-product-details?id=NP4-760-ER. For an hour in 2022, California produced 103% of its demand using wind and solar. California Independent System Operator, *Key Statistics: Peaks for May 2022*. http://www.caiso.com/Documents/Key-Statistics-May-2022.pdf

[27] Government of South Australia, "Renewable Energy." https://www.safa.sa.gov.au/environmental-s-governance/energy

[28] That is, a similar proportion of thermal (including large-scale nuclear and non-peaking gas plants) and non-thermal assets.

[29] National Grid ESO, "Future Energy Scenarios 2022: Net zero." https://www.nationalgrideso.com/future-energy/future-energy-scenarios-fes/net-zero

[30] From wind, solar, and hydro. Alberta Utility Commission, "Annual Electricity Data – Installed Capacity and Total Generation." https://www.auc.ab.ca/annual-electricity-data/

[31] From wind and solar. Canada Energy Regulator, "Provincial and Territorial Energy Profiles – Ontario." https://www.cer-rec.gc.ca/en/data-analysis/energy-markets/provincial-territorial-energy-profiles/provincial-territorial-energy-profiles-ontario.html

[32] *Scenarios for a Net-Zero Electricity System in Ontario,* 15.

energy storage developments. The IESO's announced battery procurement, along with financial support from the Canada Infrastructure Bank's announced financing options and federal tax credits, are milestones towards strengthening the storage market.

It is surprising that the Pathways scenario finds only 2 GW of storage power capacity in 2050 and 2.5 GW in the Moratorium scenario. The current growth rate for battery storage in the U.S. exceeds even solar electricity's rate of expansion and by 2025 it may surpass pumped hydro in power capacity,[33,34] the long-standing paradigm for energy storage that represents over 99% of global electricity storage in 2012.[35] Installations to date have been without the U.S. Inflation Reduction Act's incentives and Canada's investment tax credit. With these new supports, the storage sector is sure to maintain momentum until 2035.

In addition, a recent Clean Energy Canada report showed that pairing four- and eight-hour batteries with solar and wind assets can provide better levelized costs than new gas assets.[36] Like wind and solar, battery storage has seen tremendous cost declines. For instance, Bloomberg New Energy Finance expects that by 2026 lithium-ion battery costs will fall below US$100/kWh,[37] the critical point where the total upfront cost of electric vehicles will match internal combustion vehicles. Grid-scale storage prices are higher than for EVs, but the cost trend is similar.[38] There are also ongoing developments in other chemistries that rely less on critical minerals like lithium and cobalt, and this is expected to drive costs down.

Medium-duration storage adds additional economic value to renewables, potentially allowing renewable electricity generation to fully replace gas assets. In fact, Ontario has demonstrated how effective medium-duration storage is. OPG's Niagara Pump Generating Station Reservoir is Canada's only pumped hydro storage site and been in operation since 1957, undergoing an expansion and refurbishment in 2016. The proposed Ontario Pumped Storage and Marmora

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[33] U.S. Energy Information Administration, "U.S. battery storage capacity will increase significantly by 2025," December 8, 2022. https://www.eia.gov/todayinenergy/detail.php?id=54939

[34] U.S. battery storage capacity is expected to exceed pumped hydro's 23 GW of capacity in 2024. U.S. Energy Information Administration, "Hydropower explained" (2023). https://www.eia.gov/energyexplained/hydropower/where-hydropower-is-generated.php

[35] Xing Luo et al., "Overview of current development in electrical energy storage technologies and the application potential in power system operation," *Applied Energy* 7 (2015). https://doi.org/10.1016/j.apenergy.2014.09.081

[36] The report found that the LCOE of solar paired with four-hour battery storage is already cheaper than any gas option, and one with an eight-hour battery will be cheaper by 2032. Wind with the same pairings is 47 and 27% cheaper, respectively, than a CCGT unit and 52% cheaper than a gas peaker already. Clean Energy Canada, *A Renewables Powerhouse* (2023), 7. https://cleanenergycanada.org/report/a-renewables-powerhouse/

[37] Bloomberg New Energy Finance, *$1 Trillion Green Investment Matches Fossil Fuels for First Time* (2022). https://about.bnef.com/blog/lithium-ion-battery-pack-prices-rise-for-first-time-to-an-average-of-151-kwh/

[38] Wesley Cole, A. Will Frazier, and Chad Augustine, *Cost Projections for Utility-Scale Battery Storage: 2021 Update* (NREL, 2021). https://www.nrel.gov/docs/fy21osti/79236.pdf

projects are non-lithium options that demonstrate the technical potential and developer interest in storage of this kind.[39] Also located in Ontario is one of the world's first compressed air commercial pilot projects, developed by Hydrostor. These types of projects are expected to continue to generate investor interest.

Additional modelling analysis should include scenarios where storage plays a larger role in the energy mix.

2.2.3 Transmission

Building out intra- and interprovincial transmission will increase the flexibility of Canada's and Ontario's grids.

While the P2D report provides valuable insight in intra-provincial transmission, more exploration is needed of the potential for interties with Quebec and the northwest connection to Manitoba. P2D's Appendix A shows that a maximum of 3.8 GW in new transmission capacity is available with Quebec. In the David Suzuki Foundation's report, they found that 10.5 GW of capacity would be helpful to ensure energy adequacy for both provinces.[40] We recognize the difficulties in adding intertie capacity. But overcoming these challenges could unlock more low-cost pathways to decarbonization, especially since federal budget funding is available to support transmission developments.

2.2.4 Distributed energy resources (DERs)

DERs include small-scale solar and storage, waterpower, electric vehicle-to-building or -to-grid, and various conservation and demand management (CDM)[41] solutions like energy efficiency improvements and demand response. These technologies have tremendous potential to minimize the costs of Ontario's energy transformation, especially CDM, which directly saves Ontarians on their bills by reducing net energy needs. DERs can reduce the difference between the minimum and maximum demand seen on the grid, keeping wholesale electricity prices lower. Combined with the ability to generate electricity regionally, DERs can also minimize transmission infrastructure upgrades. A 2022 IESO and Dunsky report on the potential of DERs estimated 2.1 to 4.2 GW of transmission investment can be avoided through DER benefits,

[39] TC Energy also has proposed a 75 MW 37-hour (2.8 GWh) pumped hydro project in Alberta. Similarly, Montem Energy is proposing a 320 MW 15-hour (4.8 GWh) in southern Alberta.

[40] David Suzuki Foundation, *Shifting Power: Zero-Emissions Electricity Across Canada by 2035*.

[41] Also referred to demand-side management (DSM).

saving Ontario billions of dollars.[42] This report also finds between 9.2 and 12.1 GW (summer) of DER capacity in 2032 compared to the 3.7 and 6.7 GW that P2D's Moratorium and Pathways scenario find in 2035 and 2050, respectively. The P2D report notes that this research "… shows that DERs have the potential to help meet Ontario's future electricity demand, and they are gaining momentum in Ontario."

The Government of Ontario and the IESO are already exploring mechanisms to further integrate DERs and CDM mechanisms into its grid, and the Pembina Institute supports these efforts. We agree with the recommendations in the IESO and Dunsky DER report to expedite the utilization of high-value high-potential DER measures through market reforms and tailored programs. In subsequent grid decarbonization studies, we recommend the IESO more thoroughly include the potential of DERs and CDMs.

2.2.5 Uncertainties in technological solutions

Both the P2D report and the 2021 Decarbonization and Ontario's Electricity System report acknowledge that technologies that can be used to completely replace gas assets might not exist yet. To manage these uncertainties for decision-making, it would be most useful to develop modelling scenarios that utilize each of the replacement technologies to compare the implications of each pathway.[43]

In P2D's Pathways scenario, there would be 15 GW of hydrogen-fired (or low-carbon fuel)[44]generation capacity in 2050, much of which would be retrofits of existing gas-fired facilities. While hydrogen can have a role in reducing electricity sector emissions, hydrogen for peaking may not materialize in the ways the report assumes. For example, hydrogen supply might be prioritized for use in other, harder-to-decarbonize sectors. Further, P2D assumes that all hydrogen will be imported, which means the suppliers may also use it to decarbonize their own electricity systems and heavy industry. Non-hydrogen options could win over hydrogen in balancing the grid.

That said, clean hydrogen and other low-carbon fuels could play a role in long-duration storage. As noted in P2D, "the IESO should pursue a deeper understanding of the role of long duration storage such as pumped water and compressed air, contributing to reliability needs in 2030." Exploring scenarios with these technologies available and conducting uncertainty and

[42] Dunsky Energy and Climate Advisors, *Ontario's Distributed Energy Resources (DER) Potential Study – Volume I: Results & Recommendations* (IESO, 2022). https://ieso.ca/en/Sector-Participants/Engagement-Initiatives/Engagements/DER-Potential-Study

[43] An exploratory modelling scenario approach can reveal insights like which technologies might be most robust to external factors outside of the IESO or the Government of Ontario's control.

[44] P2D models low-carbon fuels as imported blue hydrogen combusted in simple cycle turbines.

sensitivity analyses on their build and operating parameters could show which of these technologies should be the focus of innovation support.[45]

3. Costs and benefits of modernization

Modernizing and decarbonizing the electricity system while generating enough energy to meet growing demand will require billions of dollars to deliver a systematic transformation to support grid decarbonization, but both public and private investors are already supporting innovation and implementation. In 2022, government and private investment into decarbonization globally passed US$1.1 trillion and is continuing to grow. Moreover, these outcomes will mean consumers will see energy efficiency and decarbonization benefits. When assessing the costs of net-zero pathways, we recommend that they are put into context by comparing with alternative scenarios including a reference business-as-usual scenario.

Specifically, we recommend that the IESO:

1) **Contextualize anticipated spending relative to a business-as-usual trajectory**.[46] As noted in P2D, there is no emitting baseline scenario to compare the Pathways scenario against, as there is with the Moratorium scenario.

   Spending on grid modernization is driven by factors other than just decarbonization. Electricity demand is already rising due to the increasing decarbonization of transportation, heating, and industry. The costs of additional policy-driven ambitions should be measured against these trends, not in isolation.

2) **Account for direct and indirect costs and benefits of modernizing the grid.** Investing in modernizing the electricity system brings tremendous benefits, such as avoiding certain grid infrastructure and generation build, that should be considered, when reporting on net costs. When evaluating grid decarbonization as a policy measure, additional benefits to health, environment and avoided climate impacts should also be considered.

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[45] Jason R Wang and Patrick Steinmann, *Exploring a Simulation Model of Canadian Energy Policy* (Energy Modelling Initiative, 2021), 18. https://emi-ime.ca/wp-content/uploads/2021/03/EMI-2020-Wang_report_Exploring-a-Simulation-Model_Steinmann.pdf

[46] The 2022 TAF report maintained wholesale electricity costs within 3% of the 2017-2021 average across their net-zero grid 2035 scenarios. They also found that using gas instead of wind and solar would yield 19-30% higher wholesale costs.

3) **Conduct sensitivity and uncertainty analysis, using multiple scenarios, to make transparent the impacts of key cost input assumptions.** For example, results from energy system models are sensitive to the fluctuating cost of natural gas. Other analyses — including the IESO's Annual Planning Outlook — can use a similar approach to characterize the influence of key inputs on the models.

Not all costs of build-out will be shouldered by Ontarians. The federal government has committed funding to support the delivery of clean energy technologies, infrastructure, and manufacturing throughout the country. Budget 2023 itself added an additional $59.8 billion to these sectors.[47] Further, as referenced in P2D, as consumers continue to adopt electric vehicles and heat pumps, net energy costs may drop due to efficiency gains. Greater consumer savings can also be unlocked through modernized electricity regulations, government-funded investments, and supportive policy.

In addition to federal and provincial funding, private sector investments in clean energy can be directed to decarbonizing the grid. The IESO procurement processes have illuminated developer interest in Ontario. Connecting developers directly to clean electricity buyers through sleeved Power Purchase Agreements (PPAs) allows projects to secure better financing and lower net costs. PPAs have enabled the massive deployment of renewables throughout the U.S. and Alberta, and have been shown to work in integrated electricity markets.[48] Beyond initial private sector investment through project development, corporate procurement is needed as large industrial emitters move to meet climate targets.

[47] Government of Canada, *Budget 2023 - A Made-in-Canada Plan*, 76. https://www.budget.canada.ca/2023/pdf/budget-2023-en.pdf

[48] While vPPAs in Canada are associated with Alberta's wholesale market, most U.S. states operate regulated markets and use sleeved PPAs to enable corporate procurement. Sleeved PPAs allow regulated utilities to function as an intermediary between developers and end buyers while supporting the rapid deployment of renewable electricity by the private sector.

4. Conclusion and recommendations

Understanding the pathways to transforming and modernizing the electricity system — policy and investment options, impacts of uncertainties, and trade-offs between them — is critical to delivering these changes with reliability and cost-effectively.

The IESO's P2D report is good foundational step for long-term energy planning and to deliver affordable, reliable, and cost-effective clean electricity to Ontarians. We encourage the IESO and the Government of Ontario to investigate other energy transition pathways to build on the province's clean energy advantage and to ensure that Ontario can continue to serve a growing population and support clean economic growth such as electric vehicle and battery manufacturing. We recommend the following actions and considerations to better understand the impacts and trade-offs between policy and investment options:

1. Implement and add to the "no regret" actions in order to rapidly deploy non-emitting technologies

The list of "no regret" actions recommended by the IESO are actions necessary to advance the rapid deployment of non-emitting technologies, regardless of the timeline for decarbonizing the grid. It is encouraging to see the inclusion of demand-side measures, transmission, and storage, which can provide the flexibility needed for the grid of the future. Stakeholder engagement, providing regulatory and policy certainty, and ensuring transparency in monitoring progress are all critical.

We recommend that "no regret" actions should also include:

- strategies for securing the cheapest sources of electricity (wind and solar)
- strategies for expanding transmission interconnection

2. Explore options to reduce costs of new energy infrastructure

Additional examination is needed of greater penetration and utilization of clean energy options that can help reduce overall system costs.

We recommend:

- The cost analysis should include cost reductions due to federal fiscal incentives and investments such as the investment tax credits for clean energy under Budget 2023.
- The province should explore methods of direct corporate procurement of renewable energy. Modelling should explore the potential benefits of sleeved power purchase agreements and the changes needed to support corporate procurement.

Additional scenarios to examine cost-reduction options are outlined in more detail in the next recommendation.

3. Develop additional decarbonization scenarios to align with a 2035 net-zero grid and take greater advantage of cheap clean energy solutions

Given that corporate ESG targets and competitive jurisdictions, namely the U.S., are aligning with the goal of a net-zero grid by 2035, modelling a 2035 net-zero grid is necessary to have productive conversations on accelerating grid decarbonization. We recommend that additional decarbonization scenarios be developed to more thoroughly explore options.

We recommend:

- A comparative analysis should be undertaken of the IESO Pathways to Decarbonization modelling to that of other models, such as the ones produced by the David Suzuki Foundation and by The Atmospheric Fund. Such an analysis would be helpful in identifying the reasons for discrepancies between the IESO's analysis and other models regarding achieving a net-zero grid by 2035, as well as the amount of gas capacity required for grid reliability. This comparative analysis should also specifically examine the P2D report conclusion that 2 GW of gas (under an assumed Clean Electricity Regulations with a 25-year end of prescribed life) would be insufficient for grid reliability.
- Additional scenarios should examine cost-efficient options for decarbonization:
    - Include greater penetration of clean energy resources including wind, solar, storage, demand-side management, energy efficiency and transmission interconnections.
    - Consider a range of caps on energy resources — if caps are indeed employed, as in for onshore wind in the P2D report — including a scenario where there is no cap.
    - Further examine Distributed Energy Resources in detail because of the cost-effective grid reliability services they provide.
    - Clarify IESO's assessment of operability of different technologies, particularly the non-emitting generating sources, in order to ensure that their services to the grid are fully taken advantage of and any assumptions on limitations are thoroughly examined. The report's description of the operability services, their importance, and potential challenges is a great inclusion and should be built upon for this recommendation.
    - Assess all emerging grid balancing technologies, not only hydrogen. Use uncertainty and sensitivity analyses on key cost and performance parameters to manage developmental uncertainties.
- Additional benefits analysis is necessary to ensure that both costs *and* benefits are examined; that is, net costs. This would help stakeholders and decision-makers

understand the overall impact of the different alternatives and do a meaningful comparison among them.

  - Benefits should include avoided infrastructure costs, such as from development of distributed energy resources.
  - Benefits should also include the wider impacts of energy transition such as lower health costs and avoided climate change impacts.

- The costs of the scenarios should be compared against baseline costs for the years 2035 and 2050, if current policies continued. This will help contextualize spending relative to business-as-usual.

We welcome a further discussion of any of these recommendations, and where there may be opportunity for innovative solutions.