Comments on the IESO Pathways to Decarbonization Study

ERO number: 019-6647

By TR and Friends (May 10, 2023)

The author would like to thank the Ministry of Energy for the opportunity to comment on the IESO Pathways to Decarbonization (P2D) study.

The Author's Background

The author has been involved in processes for planning the future development of electricity systems several times since his work in 1976 with the Porter Commission. In his 30 years with the Ontario Government, he held positions within several Ministries including the Ministry of Energy and the Ministry of Environment. His comments about the P2D document are based on that experience and an ongoing interest in climate change.

Understanding the Current Issues

Climate Change is an important issue and eliminating greenhouse gas (GHG) emissions caused by our day-to-day activities is a key societal goal.

Electrical power systems can make use of generating technologies (including those based on wind or solar energy, nuclear power, or hydro-electric power) which emit no greenhouse gas emissions. With recent technology changes (especially electric vehicles and improved heat pumps) electricity can be used to economically eliminate the use of fossil fuels and thus their GHG emissions.

Moving away from fossil fuels used in transport and in heating in favour of electricity would require major increases in electricity generation resources, and the transmission system to support new generation.

In addition, Ontario is currently faced with the need to take several nuclear plants off-line for several years because of the need for refurbishment. New capacity or better demand management is needed to maintain adequate electricity supplies while those nuclear stations are unable to produce electricity.

The P2D study indicates that the required new generating capacity could be provided by building and using new generating stations fuelled by natural gas. These would substantially increase the electricity sector's greenhouse gas emissions. The use of natural gas may conflict (depending on the success and timing of the planned nuclear refurbishment) with the stated goal of the federal government to move to zero emissions electricity grids by 2035. It is also problematic since reducing GHG emissions whenever possible is important because all GHG emissions, even those before 2035, exacerbate the climate change problem.

The issues are made more complex by the fact that in electrical power systems the timing of the electricity generation must match the timing of the demand for the electricity (for lighting etc.).

The demand for electricity across the province or within communities typically varies second by second, hour by hour, and season by season.

New generating capacity based on new wind and solar generation which produces no GHG emissions might be able to provide adequate electricity supplies in the period of concern. The cost of new wind and solar generation has fallen considerably in recent years.

However, with the increased use of intermittent energy sources, the mismatch between when electricity is generated, and when it is needed can become greater. Investment to address that mismatch would be needed, and the performance of the technologies, or availability of the options needed, is uncertain in the Ontario environment.

Two novel solutions to the mismatch are being used to varying degrees in different parts of the world:

1. encouraging the use of electricity when greater electricity generation is occurring (ie the wind is blowing, or the sun is shining) using pricing incentives for customers ("generation driven" pricing).
2. installing battery-based energy storage facilities in the system. The costs of these systems have fallen in recent years and their capabilities have improved.

These solutions can augment the more traditional methods used to match generation to demand.

The traditional methods used in Ontario to match generation with electricity demands include:

- holding water back from the turbines at hydro-electric power stations as a form of energy storage, and allowing the water through the turbines at periods of high demand or low generation from other sources.
- using transmission lines to link with other power systems so that electricity can be exchanged when one system has extra generation capacity available, and another power system would benefit from electricity imports. (Ontario may have an opportunity to partner with Quebec through electricity exchange agreements that make use of Hydro Quebec's substantial hydro-electric storage capability.)

The P2D study explores the process of eliminating GHG emissions from the electricity grid. It responds to the request from the Minister of Energy to evaluate a moratorium on new natural gas generating stations in Ontario and to develop an achievable pathway to decarbonization in the electricity system.

Two scenarios are used to identify the potential opportunities and challenges to consider especially as the demand for electricity grows as the Ontario economy moves away from processes and fuels that release greenhouse gas emissions.

One scenario looks at the economics of a moratorium on building new natural gas fired plants. The report observes that: the natural gas fleet of generating stations provides flexibility for the

system and there is no “like-for-like” replacement for that fleet, so new technologies will be required. It also observes that in a period of rapid increase in the demand for electricity a significant investment in new infrastructure will be needed. The scenario envisages 8000 MW of natural gas generation continuing in the system in 2035 and beyond.

The second scenario, looking at an achievable pathway to decarbonize the electricity system while supporting a move across Ontario away from fossil fuel use in the transportation, industrial and residential sectors, envisages substantial use of natural gas in the years beyond 2035, large investments in new nuclear generating stations and intermittent energy sources, and eventual use on a large scale of hydrogen fueled generation to replace the use of natural gas.

The report notes several short-term and long-term issues and identifies a number of no regrets actions to ensure a readiness to respond to any future decarbonization policy.

Observations and Recommendations

Let me start by saying how impressed the author is by the amount of information that the IESO has released to assist interested parties in understanding the modelling and analysis carried out and the assumptions that drive the results described in the P2D document.

Observations and recommendations are as follows.

Addressing Climate Change. Climate Change is an important issue and the national commitment to reduce societal Greenhouse Gas (GHG) emissions is a key reason for the likely growth in the demand for electricity. The electricity system must evolve and operate in that new environment. Without clear direction from the Ontario government to the IESO and the OEB, the electricity system cannot be planned and operated to give climate change the emphasis it deserves. The IESO and Ontario Energy Board (OEB) must know whether the Ontario electricity system is to be developed and operated to meet the national objective of having zero GHG emissions electrical systems by 2035.

Recommendation: The government should direct the IESO and the OEB to make climate change (and national emissions reduction goals for the electricity sector) a key element of the planning, regulation, and operation of the Ontario electricity system.

Externalities. It is important to properly quantify the cost of externalities such as climate change and use that information in planning the future of the system. I believe the P2D study does not properly consider the need to avoid GHG emissions as it looks at options for the future, especially the short-term future. This is because the environmental externality costs used in the study are low for several reasons detailed later in this document. These low costs probably mean less new wind power, solar power and conservation are considered economic than would otherwise be the case.

Recommendation: System planning studies to support discussion of potential investments in the electricity system should use the best estimate available of the full externality cost associated with GHG emissions from natural gas fired generation.

Utility Scale Wind, Solar and Battery Capacity. Planners need to recognize the importance for the electricity system of the cost reductions that have recently occurred, and are likely to continue, for utility scale and consumer scale solar, and storage technologies, and for utility scale wind technologies. Costs and performance estimates from data sets around the world are useful but real-world data (regarding costs and performance) from Ontario is important and can only be acquired by competitive requests for Proposals (RFPs) to acquire solar, wind, and battery storage costs and performance data. The recent RFP by the IESO for new battery storage technology is a good first step.

For wind power it will be especially important to gain experience on the cost, performance and public acceptability of wind generation located offshore in the Great Lakes.

Better "generation driven" pricing systems can reduce the cost of matching available generation with electricity demand.

An agreement to electricity exchanges with Hydro Quebec could provide an effective method of matching electricity generation from an Ontario system which includes a large tranche of intermittent energy sources with electricity demands.

Up to date information, based on experience in Ontario, on technologies, electricity exchange agreements, and pricing systems will be useful in planning the appropriate strategy for expanding the electricity system in line with GHG reduction goals.

Recommendation: The electricity system should devote more resource to acquiring, on an ongoing basis, new utility scale wind, solar power, and battery storage capacity as a means of reducing GHG emissions and obtaining timely cost and performance data of these rapidly changing technologies. Better "generation driven" pricing systems should be instituted on a large enough scale, in appropriate areas of the province to test their cost and efficacy. Serious discussions with Quebec should be undertaken to explore the potential of electricity exchanges with Quebec to address possible generation/demand mismatches resulting from more aggressive use of wind power in Ontario.

Distributed Energy Resources. Planners need to recognize the potential importance of changes to technologies and systems labelled Distributed Energy Resources (DERS) that are customer driven. They may, for example, allow dispersed storage systems such as those on electric vehicles to both absorb low-cost generation from intermittent energy systems and return it to the grid when generation costs rise. These systems could decrease the potential costs of using large tranches of solar and wind technologies. DERS have the potential to reduce the role of the centralized electricity system, improve the resilience of the electricity system, and lower total

energy costs to consumers. Ongoing information on these emerging options for consumers will be an important input to planning the development of the bulk electricity system.

Recommendation: The Ontario Government, in concert with the IESO, municipal utilities, the Ontario Energy Board, industry and consumers should devote more resource to demonstrating, on an ongoing basis, both the new technologies and the new pricing systems associated with Distributed Energy Resource systems (DERs).

Cost effective electricity conservation. Both the IESO and the Ontario government need to better recognize the potential for electricity conservation, efficiency improvement, and demand reduction. Greater recognition needs to be given to: the importance of reducing GHG emissions; the technology changes that are occurring; and the electricity price subsidies that are ongoing in the electricity system.

Recommendation: The government should ensure more aggressive action is taken to support energy conservation.

- It should revise its current modes of subsidizing the costs to consumers of the electricity system. Current modes discourage conservation/efficiency and encourage electricity use by all users rather than limiting subsidies to those that assist consumers who need financial assistance to meet basic electricity needs.
- The government and the electricity system should ramp up conservation/efficiency programs to drive to greater energy efficiency, reduce the environmental impacts of the energy system and lower total consumer energy costs.

Risks of Long lead Time Options. Planners need to recognize the importance of the risks associated with long lead time options such as nuclear power especially when the P2D study uses cost and performance data sets for nuclear plants that are very optimistic given experience in Canada and around the world.

Recommendation: The government and the electricity system planners should be sceptical of the projected cost, performance, and public acceptability of new nuclear stations, including those based on unproven technologies such as Small Modular Reactors.

The Process for Planning the Development of the Electricity System. The planning environment for the provincial electricity system is especially challenging because of the speed of recent technology development (and expected future technology development). The history in Ontario is of planning to build long lead time options such as nuclear power stations for bulk electricity generation even after shorter lead time options had become economically attractive and would reduce or obviate the need for the long lead time options.

Recommendation: Planning the development of the electricity system should take place in an open, transparent, and traceable process. The need for new generation (or demand management) in the short term should be used to provide better Ontario based information on

system development options for the long term based on wind, solar, batteries, conservation, and Demand Management and DERs.

Answers to the Questions Posed by the Ministry of Energy

Question #1
The IESO's Pathways Study recommends streamlining regulatory, approval and permitting processes, citing that it can take five to 10 years to site new clean generation and transmission infrastructure.

What are your thoughts on the appropriate regulatory requirements to achieve accelerated infrastructure buildout? Do you have specific ideas on how to streamline these processes?

Response: No comment.

Question #2
The IESO's Pathways Study recommends beginning work on planning and siting for new resources like new long-lived energy storage (e.g., pump storage), nuclear generation and waterpower facilities.

What are your expectations for early engagement and public or Indigenous consultations regarding the planning and siting of new generation and storage facilities?

Response: No comment.

Question #3
The IESO's Pathways Study shows that natural gas-fired generation will need to continue to play an important role in the system for reliability in the short to medium term. The IESO's assessment shows that most of the projected Ontario demand in 2035 can be met with the build out of non-emitting sources, but some natural gas will still be required to address local needs and provide the services necessary to operate the system reliably.

a. Do you believe additional investment in clean energy resources should be made in the short term to reduce the energy production of natural gas plants, even if this will increase costs to the electricity system and ratepayers?
b. What are your expectations for the total cost of energy to customers (i.e., electricity and other fuels) as a result of electrification and fuel switching?

Response: In answer to 3a, yes more clean energy sources should be acquired immediately and on an ongoing basis even if this raises system costs. Bringing new wind, solar and battery technologies online will reduce the need for and the use of natural gas if the battery storage is properly located. It will also provide important new information on the costs, performance and systems issues associated with these technologies. That information will be important in ongoing system planning processes. The P2D study does not adequately assess the total cost (system cost plus externality cost) of using natural gas since it uses an artificial carbon price

(transition prices set by the federal government) and a regulatory invention (the Ontario Emissions Performance Standard) which were designed to soften the impact of carbon pricing on industry where trade issues were important. Planning studies should use externality costs (carbon prices) which reflect the estimated damage caused by GHG emissions, or the carbon prices necessary to reach goals defined for society so that non-emitting sources can be properly evaluated from an economic perspective.

In answer to 3b above, if conservation and wind and solar potential is properly harnessed, and system expansion takes advantage of options such as interprovincial electricity trade, several studies (see for example: The Big Switch, Powering Canada's net Zero Future, May 2022, Canadian Climate Institute) have indicated that total consumer energy costs need not increase as net zero energy systems are pursued by electrifying more of the economy.

Question #4

The IESO's Pathways Study highlights emerging investment needs in new electricity infrastructure due to increasing electricity demand over the outlook of the study.
The IESO pathway assessment illustrates a system designed to meet projected demand peaks almost three times the size of today by 2050, at an estimated capital cost of $375 billion to $425 billion, in addition to the current system and committed procurements. Please see supporting materials for illustrative charts on capacity factor and cost by resource type.

Are you concerned with potential cost impacts associated with the investments needed? Do you have any specific ideas on how to reduce costs of new clean electricity infrastructure?

Response: The author is concerned about system expansion plans that makes use of long lead time options (new nuclear stations) that may appear to be economic based on cost and performance estimates by proponents. The concern is based on 2 issues:

1. **The cost and performance estimates for new nuclear stations are difficult for third parties to validate based on data from past projects which by their nature (large scale units of several hundred megawatts each and using slightly different designs in each station) are limited in number. In contrast the costs and performance of smaller scale, shorter lead time options (wind, solar, battery-based energy storage), can be evaluated against more robust data sets. Those data sets show substantial cost reductions in recent years, with a high likelihood of further future cost reductions.**
2. **Once started long lead time options will be difficult to cancel or complete without serious financial and environmental penalties if lower cost alternatives emerge. The use of nuclear power in Ontario has already lead to financially stranded assets now being supported by the Ontario Government through the Ontario Electricity Financial Corporation.**

Question #5

The IESO's Pathways Study recommends that for a zero-emissions grid by 2050, investment and innovation in hydrogen (or other low-carbon fuels) capacity could be required to replace the flexibility that natural gas currently provides the electricity system.

Do you have any comments or concerns regarding the development and adoption of hydrogen or other low-carbon fuels for use in electricity generation? What are your thoughts on balancing the need for investments in these emerging technologies and potential cost increases for electricity consumers?

Response: Hydrogen production, storage and transportation technologies may develop substantially over the years and hydrogen is a "wild card" that needs to be pursued and considered seriously. However, hydrogen should be considered in the context of the alternatives in Canada which include greater use of interprovincial electricity trade and new and evolving energy storage technologies. Interprovincial electricity trade especially after key interprovincial transmissions links are strengthened can make use of existing and new hydro-electric facilities which can offer long term storage and greater system flexibility. Utility scale battery systems have the ability to meet many of the roles played by natural gas or hydrogen based electricity generation technologies. Hydrogen production, storage and transportation technologies seem unlikely to be economic in the near term and greenhouse gas emissions need to be reduced as soon as economically possible. Using natural gas until hydrogen fuel is an economic alternative is not reasonable if there are better options available.

Question #6

The IESO's Pathways Study recommends greater investment in new non-emitting supply, including energy efficiency programs.

Following the end of the current 2021-2024 energy efficiency framework how could energy efficiency programs be enhanced to help meet electricity system needs and how should this programming be targeted to better address changing system needs as Ontario's demand forecast and electrification levels grow?

Response: The potential for cost effective electricity conservation is huge but capturing that potential is difficult in part because of significant institutional challenges. The studies of the potential for economic electricity conservation (specifically the IESO/OEB Achievable Potential Study released in 2019) used in the P2D study have underestimated the potential for several reasons:

- **it has not included appropriate externality costs;**
- **it did not consider using Codes and standards (such as the Building Code, or regulations under Ontario's Energy Efficiency Act) to drive conservation in appropriate areas since it did not have a commitment from government for the best use of codes and standards which are under the control of governments;**
- **it was not able to consider the full impact of taxpayer subsidies of the electricity system;**

- **it was not updated for the P2D report as new technologies and methods were developed.**

Delivery of conservation programs can be improved, but specific recommendations on the delivery of conservation programs are beyond the scope of these comments.

Question #7
The IESO's Pathways Study includes a scenario for over 650 MW of new large hydroelectric capacity to meet system needs in 2050.

A recently released assessment estimates that there may be potential to develop 3,000 to 4,000 megawatts of new hydroelectric generation capacity in northern Ontario and 1,000 megawatts in southern Ontario.

What are your thoughts on the potential for development of new hydroelectric generation in Ontario by private-, Indigenous- and government-owned developers?

While the capital costs for hydroelectric generation may be higher than nuclear, wind, solar, and natural gas, do you support investing in large scale hydroelectric assets that may operate for over a hundred years?

Response: No comment.

Question #8
The IESO's Pathways Study suggest that significant transmission capacity will be needed to help balance intermittent sources of electricity (e.g., wind and solar) and to ensure cost-effective supply can be delivered to meet growing demands from electrification and economic growth.

Transmission will also be required to balance intermittent supply with dispatchable supply (such as natural gas and energy storage) and meet demand in regions with retiring assets.

What steps should be taken to ensure that transmission corridors can be preserved, and lines can be built as quickly and cost effectively as possible?

Response: The author agrees that new transmission facilities may be needed, but I offer no further comments about siting and planning issues.

Question #9
Do you have any additional feedback on the IESO's "no-regret" recommendations?

Response: The no regrets actions undertaken by the IESO, the government and the regulator should include action to:

- **ensure adequate flexibility in resource acquisition given the rapidly changing technology landscape, and**
- **obtain better information on an ongoing basis on the costs and benefits of new short lead-time technologies and systems which may obviate the need for risky investment in long lead time options.**

Further information

Further information is presented below on: externalities costs; the costs of wind, and solar energy, and battery technologies; electricity conservation; Distributed Energy Resources (DERs); and nuclear power.

Externality Costs

Planning studies such as the P2D study should be designed to assist society and decision makers in how to meet goals for the electricity system. These goals will include, amongst others, some degree of cost minimization while maintaining a reliable electricity system, and most importantly, within the current context, some degree of attention to environmental goals.

For this sort of study, it is important to consider the environmental externality costs appropriately. The P2D study does not use the full externality cost of greenhouse gas emissions. It fails in 2 ways:

1. It uses the carbon prices defined by the federal government which are designed to avoid price shocks to consumers. In 2022 that price was $50/tonneCO2e as opposed to the estimate "full" carbon price of $170/tonneCO2e. The full carbon price should be used for the full period of the study to estimate the cost of using natural gas fired generation.
2. It uses the Ontario's Emissions Performance Standard whereby the environmental externality cost is applied only to the emissions above the defined emissions rate base. In 2022 this was 370 tonneCO2e/GWh. The impact of the use of the (EPS) in the early years of the study is to reduce the environmental cost of using natural gas by over 80%.

Costs of Wind and Solar Energy and Battery Technologies

The cost of electricity from wind and solar powered generating plants are affected by several factors including, most importantly, the capital cost of the plants, the performance (electricity generation) of the plants over their life.

The use of wind and solar powered generation, and battery storage facilities has increased around the world. As experience is gained with the technologies, there has been a significant reduction in the capital costs of such plants, and significant improvement in the performance of the plants. Those cost reductions are expected to continue (see for instance Empirically Grounded Technology Forecasts and the Energy Transition, Rupert Way et al., Joule, September 2022).

Wind powered electricity generation located in large bodies of water with significant wind resources such as the Great Lakes can lead to major energy cost reductions over land-based systems.

Because of the recent cost reduction, and the anticipated future cost reductions it is important that Ontario continue to acquire appropriate levels of new wind and solar capacity, and new utility scale battery systems to verify what actual costs and performance in Ontario are. The 2018 pause in the acquisition of new solar and wind generation has lead to a serious gap in knowledge of up to date wind and solar plant costs and performance in the Ontario environment.

The study notes that for moratorium scenario, 2500 MW of battery storage is considered in the base supply mix (resources expected to be in place in 2024), and that no further battery storage was added in the period 2024 – 2035. If more aggressive use of wind power were considered in that period, presumably greater battery storage would be attractive and the need for the use of natural gas would be reduced.

Electricity Conservation

The potential for cost effective electricity conservation has been consistently underestimated in Ontario. This tradition continues in the P2D study. The potential for economic electricity conservation, efficiency gains and demand reduction (often labelled Demand Management) is underestimated in the P2D study for several reasons.

Because the societal costs of electricity production using natural gas been underestimated (see Externality Costs above), the marginal cost of electricity production (especially in the decade following the 2022 start date for calculations) has been underestimated. This affects the estimate of the amount of Demand Management that would be considered economic.

The technologies considered for conservation are based on a study reported in 2019 (in the Navigant, Achievable Potential Study). That study needs to be updated to use externality costs more in keeping with current government targets, a more complete range of methods for achieving Demand Management (specifically by considering aggressive Government Codes and Standards), and an update of technologies associate with Demand Management.

The Ontario Government subsidizes electricity costs in Ontario through several mechanisms including the government assuming the stranded debt (largely associated with the nuclear stations in Ontario) left after the reorganization of the Ontario electricity system in 1998 (see the Annual report of the Ontario Electricity Financing Authority Annual Report), and the electricity price subsidies documented by in 2022 report by Ontario's Financial Accountability Officer entitled “Ontario's Energy and Electricity Subsidy Programs”. Both subsidies will tend to reduce the amount of electricity conservation and DERs consumers will pursue.

Distributed Energy Resources

New and/or increasingly cost-effective technologies are changing the way energy can be produced, delivered, and consumed. These technologies (a group of them labelled Distributed Energy Systems) are characterized by greater consumer-driven adoption (including greater adoption among industrial and commercial customers), and falling technology costs relative to grid supply costs.

These technologies include: Vehicle to Building/Grid (V2B/G) battery storage offered by electric vehicles; demand reduction technologies and software; rooftop solar with distributed storage.

Utilities in Ontario face new opportunities and risks. Consumer adoption of these technologies may change how centralized electricity systems are used. These technologies can enhance efficiency of utility service and/or displace conventional infrastructure. They can create opportunities for better service at lower cost but also exacerbates uncertainty risk for consumers and traditional utilities.

Regulatory adaptation can help mitigate risks and help consumers benefit from emerging opportunities.

A recent IESO study (Dunsky, Ontario's Distributed Energy Resources (DER) Potential Study, September 2022) was apparently not considered in the P2D study. It shows DERs can have a substantial impact on the timing of the need for new bulk electricity generation.

Nuclear Power

Over one-half of Ontario's current electricity generation is based on nuclear power.

The nuclear generating stations were built over a period of several decades with operation starting in the 1970s. Ontario now has a substantial operating history for the plants. The average lifetime capacity factor for the stations is approximately 77% (See Nuclear Safety Commission (nuclearsafety.gc.ca/eng/the-commission/hearings/cmd/pdf/cmd18-h6/CMD18-H6-40.pdf)).

The P2D study (see P2D Appendix A lines 35, 36) assumes capacity factors (for both new 600 MW units and new 200 MW SMRs) of 93%. Such a high estimate of capacity factor has a major impact on the estimated costs of power from the stations and should be treated with scepticism.