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## Re: IESO Pathways to Decarbonization Study

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?

General Electric and its Canadian affiliates (collectively "GE") agrees that a streamlined regulatory approval and permitting process would enable accelerated deployment of clean electricity infrastructure. Non-emitting technologies, gas-fired generation in line with federal Clean Electricity Regulations, and transmission lines connecting generation assets to load centres should receive expedited permitting.

In addition to greenfield projects, brownfield projects to retrofit, refurbish, or repower existing clean electricity infrastructure should also have streamlined permitting processes. Brownfield projects typically have shorter conception-to execution timelines versus greenfield clean generation or storage projects, enabling Ontario to accelerate its energy transition while increasing productivity. Additionally, brownfield projects can benefit from existing permits and environmental and/or impact assessments that have evaluated and addressed effects for local communities and wildlife.

Amid an inflationary global macroeconomic environment with supply chain constraints, more concerted cooperation will be required between the province, IESO, power producers, utilities, and original equipment manufacturers (OEM) and technology developers such as GE. As an OEM, GE has typically been involved at later stages of the project development or procurement cycles. Earlier engagement through long-term procurement plans from the province can enable supply chain partners to appropriately scale operations and obligations to power producers and utilities. The investment required by OEMs into increasing factors of production and resource allocation for domestic manufacturing are strategic decisions. Tools such as "frame agreements" with mid to long term timelines, can help all parties manage grid affordability and reliability while accelerating the buildout of energy infrastructure.

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?

GE agrees with the study's recommendation to begin work on planning and siting. Early site assessment and consultations with the public and Indigenous communities for strategically important projects is critical to accelerating Ontario's energy transition. For example, because the regulatory siting process for the Darlington New Nuclear Project (DNNP) was already completed, it gives Ontario a clear competitive advantage compared to other jurisdictions in building the West's first grid-scale SMR.

We believe permitting should be streamlined and regulatory barriers should be reduced where reasonable for energy infrastructure projects that support Ontario in achieving a net-zero grid. With projected increases in electricity demand, as highlighted in IESO's study, Ontario needs to lay the groundwork for future investments in non-emitting technologies, transmission systems, and decarbonization of emitting technologies.

While the federal government's investment tax credits for clean electricity, clean technology, clean hydrogen, and carbon capture, utilization, and storage (CCUS) will defray capital costs of new resources, provincial and municipal support will be needed to accelerate planning, siting, and permitting of new long-duration storage, nuclear, and hydro facilities.

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.**

### 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? 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?

GE does not consider this to be an either/or decision but rather a both/and. As IESO acknowledges, natural gas-fired generation is critical in providing short- and medium-term reliability to Ontario's grid but gas-fired assets will need to be decarbonized over time to meet expected federal Clean Electricity Regulations. Simultaneously, the province will need to procure more non-emitting electricity generation from renewables, storage, and nuclear.

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?**

GE commends the province's actions in recent months to reduce electricity costs, such as energy efficiency measures and the new ultra-low overnight electricity price plan.

Some opportunities to continue mitigating costs could include:

- Standardization on critical technologies can help drive productivity, reducing costs. Subsequent projects take advantage of early technology development work as well as the experiences of supply chain partners to "rinse and repeat" for additional sites.
    - For example, after completion of the first BWRX-300 through the DNNP, there will be substantial cost savings for additional units due to the modular nature of SMRs and learnings from building the first unit. For this reason, international partners are looking at building numerous units on numerous sites, often dozens. In order for Ontario to realize the full impact of the BWRX-300, we recommend numerous reactors to realize these savings.
- Retrofits, refurbishments, and repowering of existing electricity infrastructure. From an economic perspective, it makes sense to employ new capital to upgrade these projects in order to extend their useful lives and increase their efficiency, while also reusing certain attributes of the original facility. For example, retrofits can use existing civil and electrical works as well as critical infrastructure such as wind turbine generator (WTG) foundations and towers, canals/dams/dykes, or transmission equipment.
- Prioritize investments in technology areas where there are opportunities for project developers to share costs possibilities with the federal government. As mentioned previously, federal investment tax credits will include technologies such as renewables, storage, nuclear, abated gas, and inter-provincial transmission.
- Grid modernization is a key enabler for increasing the capacity factor and providing operator and regulatory oversight of the demands placed on the system with digital. The transmission build-out forecast for Ontario and the integration of additional capacity would benefit from a dedicated digital planning focus.
    - Transmission: Increased grid stability, forecasting, security with advanced energy management systems, wide area monitoring systems, and market management systems can help improve grid capacity by 25%.
    - Distribution: Improved grid reliability and efficiency with distributed energy resource-aware advanced distribution management solutions can reduce system interruption frequency and duration by up to 30%.

    - Asset management & analytics: increased geospatial network accuracy, office to field mobility, and artificial intelligence/machine learning insights can provide up to 20% plan, design as-built time savings.
- Utilize proceeds from the provincial industrial carbon pricing system to support emissions reductions projects in the power sector.

## 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?

It is possible to operate new units and upgrade existing units for operation on these fuels with relatively minor changes to the gas turbine and plant auxiliary equipment. For existing units, these upgrades can be scheduled with planned outages to minimize the time the plant is not generating power, and for new units these capabilities can be part of the initial plant configuration or phased in over time as hydrogen becomes available.

Therefore, the decision to build a gas-fired power plant today does not necessarily lock in $CO_2$ emissions at the original level for the entire life of the power plant. Future cost and technology breakthroughs may make hydrogen competitive as a zero-carbon dispatchable fuel source to complement renewables. Policies and incentives, such as the federal government's Clean Hydrogen Investment Tax Credit, are expected to foster development of hydrogen infrastructure and drive down costs. These have the potential to significantly increase the availability and affordability of hydrogen, similar to what the wind and solar photovoltaic industries experienced through targeted policies and incentives. Another pathway to net-zero carbon emissions for a gas turbine is through the use of either liquid or gaseous biofuels. Gas turbines are capable today of burning a wide variety of these carbon-neutral fuels.

With regards to hydrogen production, Ontario should enable all forms of low-carbon hydrogen production and could encourage co-location of production and end use through hubs to minimize transportation costs. With respect to IESO's model, hydrogen was assumed to have been produced outside Ontario and would have no demand impact. In the short- and-medium terms, there is a high likelihood that Ontario's primary methods of low-carbon hydrogen production will be through electrolysis powered by nuclear or renewables and will need to be produced within the province.

Furthermore, IESO's Pathways model did not include CCUS as an option to abate emissions from gas-fired generation. This potentially disregards CCUS on cogeneration assets used by the oil and gas and petrochemical industries in the Sarnia and Windsor areas, where Ontario has the best (albeit limited) potential to sequester $CO_2$. It also potentially disregards emerging $CO_2$ utilization technology that could provide alternatives to permanent sequestration. Although widespread carbon sequestration in Ontario is unlikely, the province is embarking on a process to create a $CO_2$ resource management framework and decarbonization planning should be aligned with regulatory changes**.**

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?**

Conservation and demand management programs that were announced in October 2022 are a positive start and should be built upon to include targeted supports for large-scale electricity users as well as residential customers. Specific partnerships with distribution utilities to enable integration and management of distributed energy resources within their footprint could also lead to wider scale adoption across the province.

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?**

GE strongly supports investing in large-scale hydroelectric assets because they are a sustainable, reliable, and dispatchable technology. With long permitting and regulatory lead times for hydroelectric projects, there needs to be a sense of urgency to accelerate approvals and early involvement by supply chain partners is critical to success. Ontario should seriously explore the construction of large-scale hydroelectric assets in all parts of the province where it is feasible to do so. For potential sites in Northern Ontario, this advanced feasibility analysis should extend to the transmission required to connect generating stations to load centres in Southern Ontario.

We are encouraged to see more than 650 MW of new large hydro included as part of IESO's model, but this could be an underestimation of potential capacity additions through 2050 as it discounts the role of refurbishments of existing hydro facilities in unlocking additional capacity. Modernization programs often encompass the rehabilitation or replacement of key equipment such as the turbine, stator, rotor, shaft, wicket gates, and other major components. Due to the age of some existing hydro assets, replacing components with modern equipment leverages advancements in technology. For older facilities, using newer, more efficient and powerful equipment increases both MW capacity and the efficiency of hydro units, increasing annual energy production by 5%-10% or higher, depending on the facility. OPG in 2021 began embarking on a 22-year turbine/generator overhaul program to repair or replace key components of ~75% of its hydro units. It would be beneficial to understand the potential of refurbishments to increase capacity and annual energy production elsewhere within OPG's fleet and among private and Indigenous-owned stations.

## 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?

Ontario needs to develop an integrated plan aligning generation and transmission with forecasted commercial and household demand by location within the province. Medium- and long-term siting of generation and dedicated transmission assets must be done with a holistic understanding of the grid system's demands. Stakeholder engagement should also extend to how inter-provincial or bi-national transmission planning can support reliability, affordability, and sustainability for Ontarians.

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

**Nuclear**
GE was encouraged to see the continued important role for nuclear, power, both SMRs and large-scale reactors, in Ontario's future electricity mix. GE believes SMRs will play a critical role in Ontario's clean energy future. The BWRX-300 is projected to have up to 60% less capital cost per MW when compared with the typical water-cooled SMR. Using a combination of modular and open-top construction techniques, the BWRX-300 can be constructed in 24-36 months while achieving an approximate 90 percent volume reduction in plant layout. In addition, reducing the building volume by about 50 percent per MW should also account for 50 percent less concrete per MW. Investing in additional SMRs at other sites in the province can result in productivity benefits by leveraging standardization, common design, and supply chain experience. SMRs can also be built in succession at the same site to increase overall capacity.

In addition to advancing new nuclear generation, consideration should be given to a comprehensive refurbishment of the Pickering Nuclear Generating station as a "no-regret" decision through a long-term life extension plan. Pickering provides 15% of Ontario's power today and a long-term life extension would enable the site to continue providing reliable, non-emitting baseload power through 2050.

**Wind**
GE was also encouraged to see 900 MW of new wind forecasted in the Moratorium scenario as well as 17.6 GW of new wind in the Pathways scenario. Recent procurements in Ontario have not included wind power, a trend that needs to be reversed to support decarbonization of Ontario's grid. These future procurements should also include a pathway for wind farm repowering.

Wind farm owners can retrofit existing wind turbine generators of a wind farm to increase the life of the asset, while improving its generation and reliability profile. They can exchange components of the WTG drive train and/or full nacelle, swapping and increasing the rotor size. This is done while maintaining the wind turbine's tower foundation and with minimal needed alterations to the wind farm's balance of plant. RePower extends the life of an existing wind farm asset by an additional 20 years or more, enabling the asset to continue providing zero-carbon electricity for longer. This also grows annual energy output by 5%-45% through increased nameplate capacity and/or increased swept area, higher availability and less downtime, rotor expansions that enable the WTG to capture and create energy from lower wind speeds, effectively increasing the capacity of the wind farm, making energy when otherwise it would have made little or none. Through RePowering, WTGs also receive upgrades to their digital and controls systems, improving load management and cybersecurity.

Furthermore, in the Pathways scenario, the model capped onshore wind at 15.8 GW, leaving a role for 1.8 GW of offshore wind. Canada currently does not have a regulatory regime for offshore wind and although one is being developed, it is focused on Atlantic Canada. If Ontario is considering offshore wind as a technology beyond 2035, it should begin laying the groundwork for projects as there would be considerable logistical challenges with siting offshore wind on the Great Lakes.

**Grid**
From a grid perspective, we were encouraged to see the role of demand response and recognition that transmission buildout would be required. In addition to these initiatives, Ontario should look to decarbonize the grid itself by replacing $SF_6$ as an insulating gas for electrical transmission equipment. In 2020, for example, Hydro One Networks emitted 64,250 tonnes of $CO_2$ equivalent in the form of $SF_6$, which would have made it the 90$^{th}$-largest emitter in the province according to Environment Canada's Greenhouse Gas Reporting Program.

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