Connection Approach for Small Modular Nuclear Reactors at the Existing Darlington Nuclear Generation Station

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1. Executive Summary

The Ontario Government is taking action to enable the decarbonization of the economy. The government's Powering Ontario's Growth (POG) report, published July 10, 2023, describes some of these actions, which require a significant expansion of the power system. As part of this work, Ontario Power Generation (OPG), together with the government, is planning to build additional nuclear generation at the Darlington nuclear generation station (NGS) site. The initial announcement for the first Small Modular Reactor (SMR) was made in December 2021 and reaffirmed in July 2023 with a schedule to connect to the grid by 2027, followed by three additional SMRs, planned to come into service by 2035.[1]

After the initial announcement in December 2021, to connect the first SMR at Darlington, a plan was developed to build a new 230 kV double circuit line between Bowmanville SS and Clarington TS to connect the new SMR generation to the 230 kV bus at Clarington TS.[2] This work was advanced in 2022. However, in light of the POG report, the initial plan was quickly reassessed in the fall of 2023 to ensure the approach to connecting the SMR project appropriately considered the different possible ways the transmission system will need to be expanded to meet system needs.

After carefully considering the limitations of the existing system along with expected changes, the IESO recommends:

- The connection of OPG's SMRs to the 500 kV system; and
- The initiation of an IESO led bulk system study to determine the scope of network expansion required on the 500 kV system between Bowmanville to Cherrywood.

To achieve the first SMR grid connection timeline in 2027 and subsequent three units by 2035, a coordinated and phased approach is required to plan and build transmission infrastructure. This also allows for the connection of the facility to proceed in parallel with the planning and implementation of a comprehensive network expansion for the eastern GTA system.

Based on information currently available, the IESO recommends the following phased approach:

- A temporary connection of the first SMR using two of the existing Bowmanville to Lennox 500 kV circuits, enabling the targeted 2027 grid connection date for the SMR;
- Expansion of 500 kV Bowmanville SS to enable the second SMR to connect; and
- Subsequent connection of the remaining planned SMR units to the new 500 kV Bowmanville SS expansion by 2035.

[1] While the first SMR is planned to be in commercial operation in 2029, OPG requires the grid connection of the project to be energized in 2027 for the project to proceed on schedule.

[2] While the line would be initially operated at 230 kV it was designed as a 500 kV line with bundled conductors to allow for sufficient capacity to connect the four SMR units along with providing future flexibility to connect the facility to the 500 kV system.

While this work is underway, the IESO will carry out a bulk system study and publish a report in June 2025 to confirm the scope of the 500 kV reinforcement and network expansion needed. This study work will proceed as part of the Southern and Central Ontario Bulk Study, which will begin in early 2024. The scope of this study and information on study timelines will be available in the IESO's 2023 Annual Planning Outlook.

The IESO requests that Hydro One provide regular updates to the IESO as work progresses, including updates on costs, the proposed layout of the new Bowmanville SS, any updates to stated in-service dates, and confirmation of connection details, including preferred connection circuits and impacts on reliability.

2. Background

OPG's first SMR which is currently under development, is scheduled to be connected to the grid by 2027, with the other three SMRs scheduled to be in service by 2035. All four SMRs will be located on the Darlington NGS site. While this project has been progressing through the various stages of planning and development, the Province's recently released POG report identified OPG's SMR program as one mechanism in its broader plan for meeting growing electricity demand in the 2030s.

Prior to the publication of the POG report, in 2021 OPG worked with IESO and Hydro One to identify a preferred connection approach, with a focus on the connection of the first SMR unit. Two potential connection options were considered:

- Connection to the 230 kV system at Clarington TS; and
- Connection to the 500 kV system at Bowmanville SS.

Based on the limitations of the existing 500 kV and 230 kV systems and the generation connected to or planned for the system at the time, the 230 kV connection option was the preferred approach to connect the project. While both options required system reinforcement, at that time, the 230 kV reinforcements identified were determined to be easier to implement and manage. This is because the existing 500 kV corridor between Bowmanville and Cherrywood is congested and connecting the SMRs directly to the 500 kV network would worsen this phenomenon, increasing the need for generation rejection under a number of contingencies.[3] Potential options to alleviate the congestion issue include upgrading the Bowmanville to Cherrywood 500 kV corridor.

The findings from the IESO's Pathways to Decarbonization study completed in late 2022 and the subsequent direction from the Province's POG report in July, 2023, identified a number of system changes that will impact the need and timing of an expansion of the existing Bowmanville to Cherrywood 500 kV corridor. With a much higher urgency to reinforce the 500 kV system, and a need to accommodate four SMR units by 2035, the initial 230 kV connection plan was revisited after July 2023. These changes form the basis for re-evaluating the preferred connection arrangement for OPG's SMR project at Darlington NGS.

[3] This issue is currently managed by the GTA East Remedial Action Scheme (RAS). The study identified a need to expand the existing RAS if the SMR project connected to the 500 kV system.

3. Analysis

The two connection options that were evaluated in earlier studies with OPG and Hydro One were reassessed following the publication of the Province's POG plan, in July 2023.

1. Initial connection of the SMR project to the 230 kV system at Clarington TS
    - This option would require a new double circuit 230 kV line from the Darlington NGS site to Clarington TS, and new 230 kV terminations at Clarington TS to connect the circuits.[4]
2. Initial connection of the SMR project to the 500 kV system at Bowmanville SS
    - This option would require an interim connection arrangement where the first SMR unit connects directly to two existing 500 kV circuits. An expansion of Bowmanville SS would be needed for the final connection arrangement of all four units. This option also assumes that further reinforcement of the 500 kV network between Bowmanville and Cherrywood, beyond the expansion of Bowmanville SS, will be needed.

The original assessment preferred the Clarington 230 kV connection option, since the 500 kV option would have required expanding the Bowmanville to Cherrywood 500 kV corridor only for the purpose of connecting the SMR project and/or greatly increasing the frequency and magnitude of generation armed for rejection following the loss of the existing circuits in the corridor using the GTA East RAS.

This reassessment focuses on understanding the policy and system changes that have emerged since the original study that indicate a broader need to expand the Bowmanville to Cherrywood corridor to meet long-term provincial needs. If the 500 kV corridor is expanded in the medium- to long-term, connecting the four OPG SMRs to the 500 kV Bowmanville SS would be preferred over a 230 kV connection at Clarington TS.

The load in the GTA is supplied by local generation and through three main transmission interfaces. The local generation includes Pickering NGS and three gas plants – Portland GS, Sithe Goreway GS and Halton Hills GS. The three interfaces are Flow East Towards Toronto (FETT), Flow South (FS) and the 500 kV circuits between Bowmanville and Cherrywood.

There are a number of expected future changes that will affect supply to the GTA. These changes would drive the need to reinforce or alleviate the Bowmanville to Cherrywood 500 kV corridor.

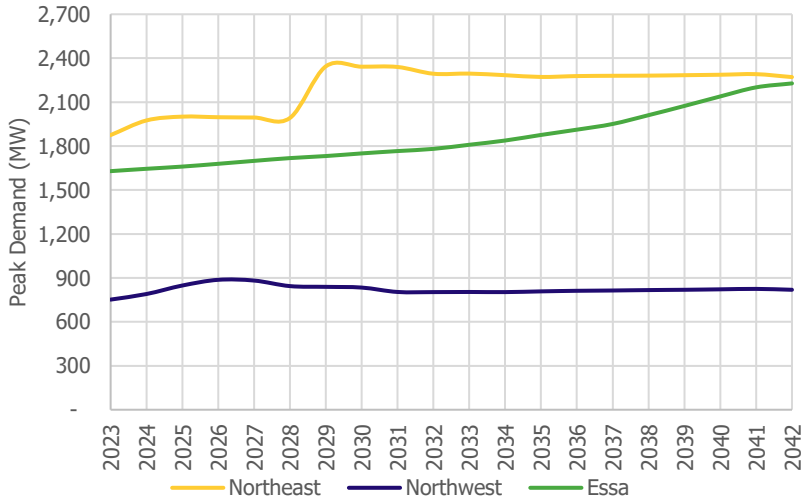
1. To enable decarbonization efforts, it is expected that existing gas plants in the GTA will be decommissioned. These gas plants were strategically located to help supply demand during peak hours as well as provide critical voltage support and, hence, decommissioning them will trigger the need for transmission reinforcements to the GTA.

[4] This option included designing the double circuit 230 kV line to a 500 kV standard, to provide sufficient capacity to connect four SMR units and flexibility to operate at 500 kV over the longer-term. Operation at 500 kV would require extending the line past Clarington TS to connect to the 500 kV system at either Cherrywood TS or stations further west. This also necessitates the expansion of Bowmanville SS to serve as a connection point for the SMR project to the 500 kV system.

2. A recent planned reinforcement to the Flow East Towards Toronto (FETT) interface, expected in-service in 2026, will facilitate higher flows across the interface to enable generation connections in the west to meet near- to medium-term resource adequacy needs. However, the transfer limit on this interface can still be limiting when there are outages that involve 500 kV circuits coming out of Bruce NGS, as well as when there are high flows on the Queenston Flow West (QFW) interface. In order to meet long-term needs, further transmission expansion to increase flow into the GTA beyond the recent FETT upgrade is likely required.

3. The demand in Northern Ontario is forecast to increase over the next 20 years. This can be seen in Figure 2, which shows the increase in the forecast peak demand in the Northeast, Northwest and Essa zones. This forecast increase will potentially reduce the amount of available resources to supply Southern Ontario through the Flow South (FS) interface. However, in the POG report, the government requested the IESO explore transmission enhancements to enable more renewable generation in Northern Ontario and, so, this could potentially balance the demand increase.

Figure 1 | Peak Demand Forecast for Northeast, Northwest and Essa zones



4. The IESO is presently executing a request for proposals (LT1 RFP) for capacity resources to meet the province's need for generation capacity and we are seeing the potential for a large number of generation projects to be located in the Eastern Ontario electrical zone (east of Bowmanville). A summary of the Deliverability Test results completed for LT1 can be found in Appendix 1. A large portion of these projects are not going to be deliverable because of limitations along the Bowmanville to Cherrywood corridor.

5. The IESO and Hydro-Québec have set out their intention to negotiate a new Capacity Sharing Agreement that will provide ratepayer value and enhance reliability for both provinces. The deal will see the IESO provide 600 MW to Hydro-Québec in the winter and Hydro-Québec provide 600 MW to the IESO in the summer. Ontario will also have the opportunity to bank any amount of the 600 MW of summer capacity provided each year for use in any future summer period during the agreement, allowing the province to save capacity until it is required.

Considering the facts mentioned above, along with existing limitations on the Bowmanville to Cherrywood corridor under outage conditions (currently managed using the GTA East RAS), there is a

need to reinforce the Bowmanville to Cherrywood corridor with additional 500 kV transmission circuits to meet future system needs. Given the proximity of the in-service date for the first SMR unit, the provincial need for the new capacity and energy the project will provide, and the typical timelines for developing large transmission infrastructure, there is a need to commit to the connection arrangement for the first SMR before the design and construction of the expansion of Bowmanville SS begins and before the bulk system studies are completed.

4. Recommendations

While reinforcement of the Bowmanville to Cherrywood corridor is required to meet future system needs, further bulk system studies must be completed to confirm the final scope and timing of the work required. In the interim, it is recommended to proceed with a phased approach to connect the four OPG SMRs at the 500 kV voltage level to Bowmanville SS.

Hydro One has indicated that, in order to incorporate new 500 kV connections (network lines and connecting the SMRs) at Bowmanville, a new 500 kV switching station will be required. However, this new switching station will not be ready before the first SMR unit's grid connection timeline of 2027. For that reason, a temporary connection method utilizing the 500 kV Lennox to Bowmanville circuits should be pursued by Hydro One for the first SMR as part of the Bowmanville SS network expansion to enable provincial decarbonization efforts. This is to ensure the needed provincial energy and capacity the first SMR provides will be available as planned. Hydro One will confirm the preferred connection circuits for the first SMR unit, balancing cost, complexity and ensuring the temporary connection mitigates any negative reliability impacts.

Temporarily connecting the first SMR allows the unit to connect on schedule. While the first SMR unit proceeds with the temporary connection, the IESO will undertake the South and Central Ontario Bulk Study. The study will evaluate options to expand the 500 kV network in the east GTA, including the previously contemplated 500 kV line from Bowmanville SS to Cherrywood TS (or further west), via Clarington, and will also confirm the scope of the expanded switching station at Bowmanville SS.

Timelines for plan development and implementation will be aligned with connection of the remaining SMR units and the needs of the bulk transmission system. The IESO will communicate the timing and scope of the required bulk system study through the Schedule of Planning Activities included in the 2023 APO.

The IESO is aware that, based on the connection arrangement planned in 2021 for the new SMRs, Hydro One and OPG proceeded with early development work on a 230 kV line from the Darlington SMR NGS to Clarington TS, along with the associated expansion of the 230 kV yard at Clarington TS to accommodate the new circuits.[5] Given the new plan to connect at 500 kV, the Southern and Central Ontario Bulk Study will consider this previous line development work, west of Bowmanville SS towards Cherrywood, when carrying out options analysis. As indicated earlier, the Bulk Study will

[5] The line was designed as a 500 kV line with bundled conductors, operated at 230 kV, to allow for sufficient capacity to connect the four SMR units along with providing future flexibility to connect the facility to the 500 kV system.

evaluate and confirm the exact scope of network expansion required on the 500 kV Bowmanville to Cherrywood corridor.

5. Conclusion & Next Steps

The recently publish POG report outlined a number of actions required to decarbonize the economy. In consideration of existing system limitations, actions outlined in the POG report, recent experience from ongoing resource procurements, and studies of alternative connection arrangements, the SMR project planned for the Darlington NGS site should be connected to the 500 kV system via an expansion of Bowmanville SS.

In order to ensure the planned in-service dates for the SMR units can be maintained, the following phased approach is required.

- A temporary connection of the first SMR using two of the existing Bowmanville to Lennox 500 kV circuits, enabling the targeted 2027 grid connection date for the SMR;
- Continue with development work for the expansion of the 500 kV Bowmanville SS; and
- Subsequent connection of the remaining planned SMR units to the new 500 kV Bowmanville SS expansion by 2035.

While the above work is underway, the IESO will carry out a bulk system study and publish a report in June 2025 to confirm the scope of the 500 kV reinforcement needed. This study work will proceed as part of the Southern and Central Ontario Bulk Study, which will begin in early 2024. The scope of this study and information on study timelines will be available in the IESO's 2023 Annual Planning Outlook.

The IESO requests that Hydro One provide regular updates to the IESO as work progresses, including updates on costs, the proposed layout of the new Bowmanville SS, any updates to stated in-service dates, and confirmation of connection details, including preferred connection circuits and impacts on reliability.

Appendix 1 – Deliverability Test Results for LT1

Summary

The IESO carried out Deliverability Tests for the LT1 RFP on a total of 388 projects. These included capacity values totalling 1,842 MW for proposed Eligible Expansion projects and 65,941 MW for proposed New Build projects.[6] Due to these high levels of interest, no project was assessed as "Deliverable". All of the projects that passed the tests received a "Deliverable but Competing" result.

Projects that received a "Not Deliverable" result will not be eligible in the LT1 RFP. However, the capacity values of projects that received "Deliverable but Competing" results still total 1,003 MW for proposed Eligible Expansion projects and 43,914 MW for proposed New Build projects.

The aggregated test results by Zone are shown below.

Most projects in the West Zone did not pass the tests, particularly west of London, where most of the available connection room was taken up by the successful contracts from the Expedited Long-Term RFP.

Zones	**Applications**		**Deliverable but Competing**	
	Total MW applied	# of projects	Total MW passed	# of projects passed
BRUCE	1,250	3	1,050	3
EAST	23,200	104	20,036	93
ESSA	9,496	48	4,947	34
NIAGARA	378	6	259	6
NORTH-EAST	563	12	430	11
OTTAWA	1,535	17	939	12
SOUTH-WEST	14,620	67	12,347	65
TORONTO	4,835	28	4,270	24
WEST	11,905	103	640	17
Total	67,783	388	44,917	265

[6] For this calculation, the variation with the largest capacity (MW) for a given project was used.

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