Office of the Auditor General of Ontario

Value-for-Money Audit:

Ontario Power Generation: Management and Maintenance of Hydroelectric Generating Stations

November 2022

Ontario Power Generation

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1.0 Summary

Electricity is an essential part of Ontarians' daily lives and important to the economy. From heating and lighting our homes to running our fridges, vehicles and computers, electricity enhances our safety, quality of life and productivity.

Electricity can be produced from various sources, including nuclear, fossil fuels (such as coal and natural gas) and renewable energy (such as hydroelectric, wind, solar and bioenergy). To address growing concerns about climate change, Ontario has transitioned from its reliance on fossil fuels, which release large amounts of greenhouse gases that cause global warming, to using cleaner and renewable energy sources to generate electricity. In 2009, the Province enacted the *Green Energy Act*, which led to Ontario gradually closing all of its coal-fired power plants and building renewable and gas-fired resources.

More than half of the electricity generated in Ontario is produced by Ontario Power Generation (OPG). OPG is an Ontario-based corporation whose principal business is generating and selling electricity. It was established under the *Ontario Business Corporations Act* in 1999 and is wholly owned by the Province of Ontario. OPG produces electricity from its various energy sources, including hydroelectric, nuclear, gas and biomass.

As of March 31, 2022, OPG had approximately 14,700 megawatts (MW) of in-service generating capacity (the maximum capacity that a facility is designed to run at) across all of its generation facilities, excluding subsidiaries. Hydroelectric generation represents 7,500 MW (or 51%) of the total capacity at OPG. Nuclear is second with 4,850 MW (or 33%).

Hydroelectric (or hydro) power is Ontario's foundational electricity source, accounting for approximately 23% to 25% of Ontario's electricity supply since 2007. Hydro energy is considered a form of renewable energy because water flowing through a hydroelectric generating station is not consumed in the process of electricity generation and is typically returned to its waterway. Once the electricity is produced, it is sent along power lines to be used by consumers.

OPG owns and operates 66 hydroelectric generating stations, many of which have been operating for over 50 years, while some of the oldest ones have been operating for 100 or more years.

Over the last five years (2017–2021), annual revenue from OPG's hydroelectric generation has remained relatively stable in the $1.8 to $1.9 billion range, while annual operating costs have ranged from $950 million to $1.03 billion. In the same time frame, costs for capital projects to, for example, replace aging equipment have increased by 215%, from $208 million in 2017 to $656 million in 2021.

During our audit, we found that OPG's hydroelectric generating stations have not been effectively utilized over the last seven years because of having to curtail the production of electricity. In addition, OPG recorded over $700 million in revenue since 2015 for spilling (or releasing) water from its stations without generating any power due to Ontario's electricity supply exceeding demand.

We also noted that OPG incurred steadily increasing maintenance work orders in recent years partly due to the aging of stations and equipment. It also has experienced a continuous backlog of maintenance work orders since at least 2017. Although its generating units have typically been available for use (between 88% and 91% of the time), the number of forced (or unplanned) outages of these units increased between 2014 and 2019; since then, such outages have been slowly declining but are still higher than they were in 2014.

Given the forecasted increase in electricity demand and predicted future shortfall due to the potential closure of Pickering Nuclear Generating Station (which has an installed capacity of 3,100 MW of generation) in 2024/25, as well as the challenges of building new hydroelectric generating stations, it is important that OPG adequately maintain and manage its existing stations to allow for cost-effective and efficient electricity production. OPG estimates that there is unbuilt hydroelectric generation capacity of 3,000 to 4,000 MW in northern Ontario, and up to an additional 1,000 MW in unbuilt capacity in southern Ontario.

The following are some of our significant findings:

- **OPG has not been able to fully utilize its hydroelectric generating capacity over seven years.** We reviewed OPG's total installed generating capacity and compared it to the actual generation over the seven-year period from 2015 to 2021. We found that over this period, OPG was only using between 48% and 51% of the stations' total installed capacity. We also reviewed OPG's actual hydroelectric generation and compared it to what it could have produced, considering factors such as water availability, electricity demand and outages. We found that over the seven-year period from 2015 to 2021, OPG could have generated approximately 269 million megawatt hours (MWh) of electricity but only generated 226 million MWh, meaning about 43 million MWh of generating capacity went unused. In 2021 alone, OPG could have generated an additional 4.6 million MWh of electricity, or enough to power over 540,000 Ontario households for a year. We found that OPG has not conducted a detailed analysis of why there is a significant difference between installed capacity and actual generation, but informed us that this is due to multiple reasons. For example:
  - Ontario does not have the amount of water required to run all hydroelectric generating units at full capacity for 24 hours a day, seven days a week, and water availability and flow depend on seasonal factors that could also vary from year to year.
  - Some OPG generating stations were built as intermediate or peaking facilities, meaning that they were designed and constructed to generate only during periods of higher demand. There was no intention of having them generating consistently and it would not be possible based on water availability.
  - The installed capacity does not consider that units have to be taken down for maintenance and repairs, and could also be impacted by outages.
  - There are certain environmental and recreational water management considerations that OPG must adhere to.
- **OPG needs to strengthen its working relationship with the Independent Electricity System Operator (IESO) in exploring new hydroelectric opportunities to meet future electricity demands, given the challenges and uncertainties of building new stations**. While OPG is Ontario's largest power generator, the IESO is responsible for managing and planning for the province's electricity supply from various energy sources (including hydroelectric power) to meet future needs. Therefore, it is critical that OPG

and the IESO have a strong working relationship, especially when both parties are exploring additional hydroelectric opportunities in northern Ontario. In January 2022, the Ontario government asked OPG to examine opportunities for new hydroelectric development in northern Ontario, and also asked the IESO to identify the transmission infrastructure required and the associated costs. While unbuilt capacity (approximately 3,000 to 4,000 MW) in northern Ontario provides opportunities for building new stations, developing such capacity poses many challenges and uncertainties in terms of timing and costs. For example, OPG senior management informed us that it could take many years, in some cases over 10 years, to develop these stations, which includes conducting environmental assessments, consulting with Indigenous communities, constructing the stations and installing transmission lines. OPG also estimated that the costs of developing hydroelectric generation stations will be significant, ranging from $5 million to $22 million per MW of power for a potential station, depending on location and site conditions. Estimated costs will become even higher after considering additional transmission-related costs for stations.

- **OPG recorded approximately $730 million in revenue since 2015 for spilled water without generating any power due to excess power supply in Ontario**. When electricity supply exceeds demand in Ontario, OPG may be instructed by the Independent Electricity System Operator to decrease generation by spilling (or releasing) water when there are no practical options to store hydroelectric energy for future use. For 54 of OPG's 66 hydroelectric generating stations, OPG is compensated at a rate (currently $43.88 per megawatt hour [MWh]) that does not consider any forgone production due to spilling water under surplus electricity supply conditions. We found that the amount of surplus electricity lost as a result of spilled water in 2021 amounted to 1.9 million MWh, which is enough electricity to power approximately 220,000 households for a year. We also noted that since 2015, OPG spilled the equivalent of 25 million MWh of electricity and still recorded approximately $730 million in revenue related to the spilled water. The current compensation method (which takes both OPG's fixed costs and variable costs of operating these stations into account) does not appear to be fully achieving value for money for ratepayers. To illustrate, when OPG's hydroelectric stations are on spilling conditions without generating any power, OPG incurs limited variable costs of operating these stations. Therefore, the compensation method should consider fixed costs while variable costs should be limited.
- **Aging of hydroelectric stations and equipment has led to a continuous backlog of work orders, which could result in increased maintenance costs**. Between 2015 and 2021, the number of maintenance work orders for OPG's hydroelectric stations increased by 83% (from approximately 18,400 in 2015 to 33,800 in 2021). The related cost of these work orders increased by 48% (from $48.2 million to $71.2 million), although OPG informed us that part of the increase is a result of more accurately and consistently capturing costs in its work management system. We found that most of these work orders were for preventative maintenance, which is typically done to keep equipment in well-working order and avoid potential issues such as equipment failure that can lead to unplanned outages. We also found that OPG has had a continuous backlog of work orders over the last five years, and the backlog was approximately 9,500 work orders at the end of 2021.
- **Conditions of hydroelectric stations were not always assessed at regular intervals, with about 20% of stations not assessed in over 10 years**. One of the key tools OPG uses to assess and monitor the conditions of its hydroelectric generating stations is a Plant Condition Assessment (PCA), where an engineer(s) assesses the

condition of a station and its related equipment and processes. While OPG does not have a set time frame on how frequently PCAs must be completed, we noted that it would be prudent to conduct a PCA at least every 10 years to assess the completion status of recommended work because PCAs typically indicate specific work to be completed within a 10-year time frame. Our review of practices in other jurisdictions also identified that the United States Bureau of Reclamation (the second-largest producer of hydropower in the United States that operates 53 hydroelectric powerplants) indicates in its manuals that a comprehensive facility review of a station should be completed every six years. However, we found that OPG did not complete a PCA for approximately 20% (or 13) of its 66 hydroelectric generating stations within the last 10 years. We also found that the timing between PCAs was inconsistent across OPG's stations. For example, for both Sir Adam Beck I and Sir Adam Beck II Generating Stations (two of OPG's largest generating stations), 18 years passed between their most recent PCA and the prior one, but for Cameron Falls Generating Station, the gap was 10 years.

- **Insufficient planning has led to delays on some capital projects and cost overrun on one project**. We reviewed estimated and final costs for large hydroelectric capital projects completed over the last 15 years, and found that OPG experienced project delays and cost overrun on one project as a result of insufficient planning. For example, in OPG's Niagara Tunnel Project, sub-surface geotechnical investigations carried out prior to the project's commencement did not adequately note the rock conditions and work required. As a result, OPG later revised its project budget from the original $985 million to $1.6 billion, an increase of 62%. The project was originally scheduled to be completed by 2010 but was delayed to 2013 because of the changes in work. Given OPG's potential involvement in new hydroelectric generation projects in the future, it is critical for OPG to ensure its capital projects are effectively assessed, planned, overseen and executed to reduce the risk of significant project cost increases and delays.
- **OPG has not always addressed engineering recommendations for station maintenance on a timely basis**. As part of OPG's Plant Condition Assessment (PCA) process, contracted or staff engineers provide OPG with recommendations of what work is required to maintain its generating stations and address any issues found. We reviewed a sample of 10 PCAs and found that OPG did not always follow or address these recommendations on a timely basis. For example, for Abitibi Canyon Generating Station, the most recent PCA was completed in 2021 and the previous one was completed in 2016. Of the 37 major recommendations noted in the 2016 PCA, only three had been fully addressed, another three were in the process of being addressed, and 31 had either been scheduled only or not yet addressed at the time of the 2021 PCA.
- **Rate-setting process is not regulated for 12 OPG hydroelectric stations.** Of OPG's 66 hydroelectric stations, 12 stations are not subject to the Ontario Energy Board's rate regulation process. Instead, they contract with the IESO and thus negotiate their rates directly with the IESO. As such, their rates are significantly higher than those for rate-regulated stations. The rates for non-rate-regulated stations vary (from about $65 to about $250 per MWh), meaning they are at least 1.5 to almost six times higher than the rate for rate-regulated stations ($43.88 per MWh).
- **Public safety events remain high while dam safety events have gone down**. Based on our review of data on safety events that occurred at OPG's hydroelectric stations and dams over the last seven years, we found that

while events related to dam safety (involving the dam structure or station itself) have gone down (from 41 events in 2015 to 19 events in 2021), events related to public safety were high in recent years (145 events in 2021). We found that most of these public safety issues arose because the public either ignored or did not notice warning signs about trespassing on OPG property or waterways. We also confirmed that OPG took adequate steps to address issues such as contacting and sharing information with law enforcement and local authorities. However, it is important for OPG to continue to review and assess whether it has sufficient processes in place across all of its dams and generating stations, including those that are easily accessible by the public.

- **OPG's rate of return from its investment in its United States-based hydroelectric generation assets is lower than expected**. In addition to owning generating stations in Ontario, OPG has invested in generation assets in the United States through a series of subsidiaries operating as Eagle Creek. When OPG completed its acquisition of these subsidiaries, it had estimated that it would earn a certain return on its investment. However, a recent strategic review completed in 2022 found that the expected return had decreased by about 1.2%, primarily due to the COVID-19 pandemic.

This report contains 12 recommendations, consisting of 24 action items, to address our audit findings.

Overall Conclusion

Our audit found that opportunities for developing Ontario's future supply of hydroelectric power have not yet been fully explored to address the forecasted increase in electricity demand and predicted future shortfall due to the potential closure of Pickering Nuclear Generating Station in 2024/25. As the province's largest energy producer, OPG also plays a critical role in actively planning and exploring opportunities for expanding its hydroelectric operations in Ontario to help address those needs. Thus, it should work more effectively with its partners, especially the IESO, to better manage the projected supply challenges ahead. We noted that OPG's hydroelectric current generation capacity has remained underutilized, and can be more effectively used to meet the province's future electricity needs.

OPG has been a reliable provider of hydroelectric power to the province, but there is still opportunity to improve its incapability factor, which measures the percentage of time a generating unit is unavailable over a specific time frame for outages within OPG's control. Given the increasing age of many of OPG's hydroelectric generating stations, maintenance work orders have significantly increased over the last seven years, which in turn has resulted in a continuous backlog of work orders. Its increased focus on preventative maintenance has contributed to an improvement in its forced outage rate.

OPG has completed and is currently working on several major capital projects to maintain or develop greater generation capacity, but insufficient or inadequate upfront knowledge and planning have caused some significant project delays and additional costs. It could better follow and address engineering assessments, recommendations and any lessons learned on a timely basis to avoid future risks and increased costs.

While OPG has a strong dam safety program in place, it should continue to review its dam safety practices to prevent or reduce the high number of public safety events.

OVERALL RESPONSE FROM ONTARIO POWER GENERATION

As a learning organization, continuous improvement is fundamental to OPG's performance. The recommendations presented by the Auditor General create new opportunities for targeted improvements across OPG's Hydroelectric Operations and will further support the value these assets provide to Ontario ratepayers.

Hydroelectric power has served Ontario's electricity needs for well over a century and remains a critical contributor to the provincial energy mix.

Together with our predecessor companies, OPG has more than 115 years of experience as developers and stewards of hydroelectric power. We continue to do this job safely and with the greatest attention to delivering value for money for Ontario ratepayers.

OPG is committed to supporting Ontario's economic growth and its pathway to a clean energy future by:

- maintaining a productive and transparent relationship with market regulators in the operation of its facilities and in a manner that complies with market requirements within the province;
- exploring new hydroelectric development opportunities in partnership with Indigenous communities which serve the needs of Ontario;
- implementing enhanced engineering processes and tools to monitor, identify and document asset system health issues along with corrective actions and recommended timelines to minimize risk and improve fleet/station performance;
- appropriately monitoring, tracking and completing maintenance work on its hydroelectric generating assets to strengthen reliability and operational efficiency;
- identifying further opportunities to improve the reliability of OPG's hydroelectric facilities;
- managing its project portfolio and executing hydroelectric projects safely, on time, and on budget; and
- ensuring its existing and future assets provide the greatest value to Ontario taxpayers and ratepayers.

OPG's greatest priority is the safety of its employees and the public. Underpinning this commitment are strong safety systems, robust emergency plans and continuous efforts to keep the public informed of its many dam safety controls.

2.0 Background

2.1 Overview of Hydroelectric Generation

2.1.1 Hydroelectric Generating Stations

Hydroelectric generation is the process of using hydro (water) flow to produce electricity. Specifically, hydroelectric generating stations use flowing water to spin a turbine, which in turn spins a generator that produces electricity. The generated electricity is then sent along power lines to be used by consumers to power their houses, businesses, and vehicles, among other things.

Each station can house multiple turbines (or generating units) depending on the station design and if there is sufficient water to run multiple units at once. **Appendix 1** provides a layout of a typical hydroelectric generating station, including the pieces of equipment and components it comprises.

2.1.2 Hydroelectric Generation in Ontario's Energy Supply Mix

Hydroelectric energy (also known as waterpower), like solar and wind power, is considered a form of renewable energy because water flowing through a hydroelectric generating station is not consumed in the process of generating electricity and is typically returned to its waterway.

In 2009, the *Green Energy Act* was enacted with an aim to increase Ontario's use of renewable energy. Since then, renewable energy sources (including hydro, wind, solar and biofuel) along with nuclear and gas-fired resources have replaced Ontario's coal-fired power plants for electricity generation, with the last one in Thunder Bay shut down in 2014. **Figure 1** shows the change in Ontario's energy supply mix from 2007 to 2022 in five-year intervals. Hydroelectric power accounted for about 23% to 25% of Ontario's energy supply mix over that period.

Figure 2 provides a jurisdictional comparison of the energy supply mix of selected provinces in Canada.

Ontario has a more diversified energy supply mix than other provinces, with no one resource type comprising more than 35% of Ontario's total installed capacity, which is the maximum amount of electricity that can be produced by generators.

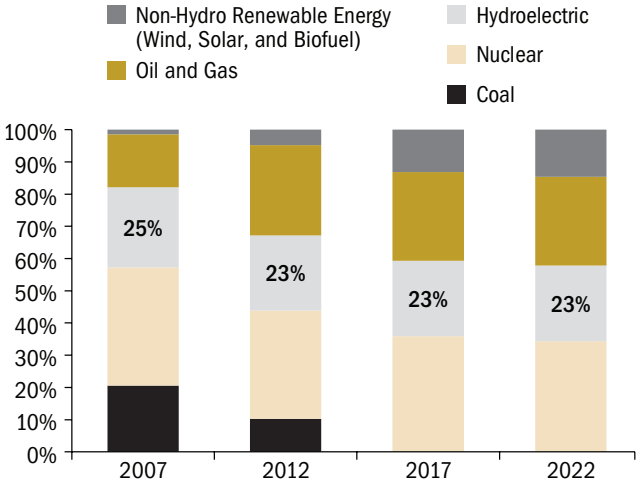
Ontario, and Canada in general, has seen a continued push toward using both nuclear and renewable energy sources to reduce reliance on fossil fuels, oil and gas in order to decrease carbon emissions. While hydroelectric power is considered as a form of renewable energy, the construction of generating stations and dams still produce carbon emissions and impact local wildlife species that rely on the waterways. Thus, such construction is subject to environmental assessments by various parties like the Ministry of Environment and the Ministry of Natural Resources and Forestry.

In April 2022, Ontario released its Low-Carbon Hydrogen Strategy, which aims to use electricity from low-carbon sources (such as hydroelectric and nuclear energy) to generate hydrogen gas for transportation, industrial, commercial and residential purposes. As such, an increasing demand for renewable energy, including hydroelectric generation, is expected to continue into the future. The future of hydroelectric generation is discussed in **Section 4.1**.

Furthermore, the future electrification of Ontario's transportation sector—which OPG estimates accounted for approximately 30% of carbon emissions in the province in 2021—will increase Ontario's demand for

Figure 1: Ontario's Energy Supply Mix by Fuel Type, 2007, 2012, 2017 and 2022

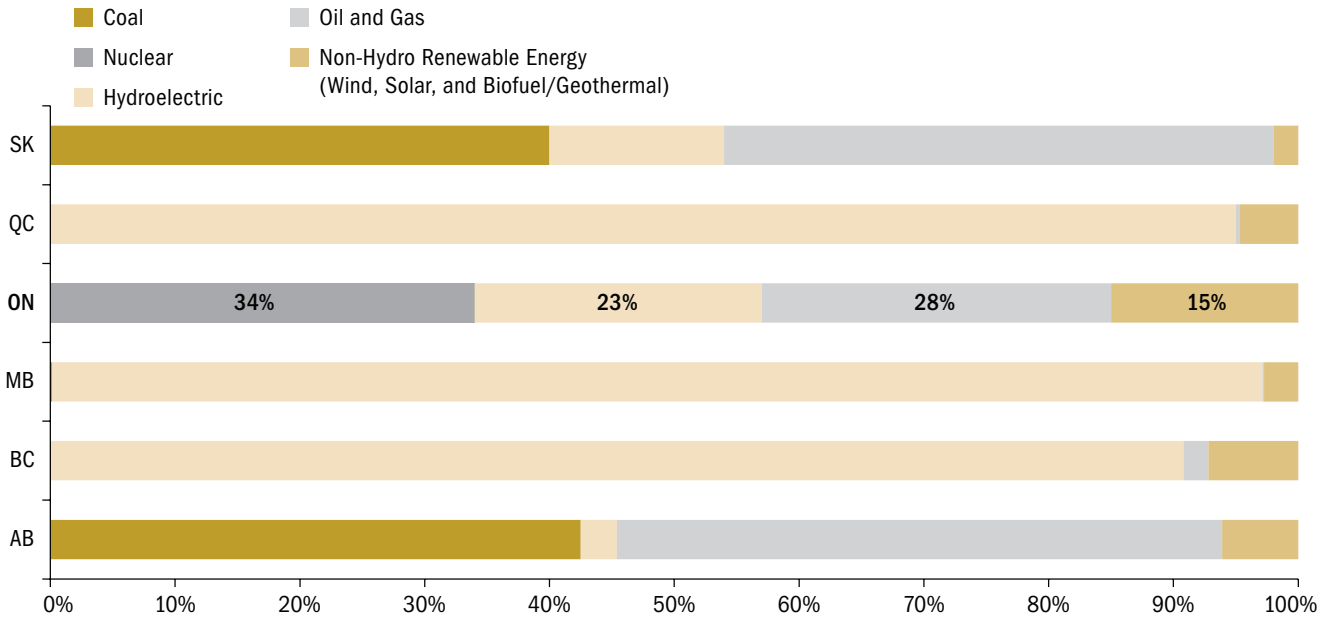
Source of data: Independent Electricity System Operator



Note: The percentages were calculated based on installed capacity, which is the maximum amount of electricity that can be produced by generators. The data was reported based on calendar year.

Figure 2: Energy Supply Mix of Selected Provinces in Canada by Fuel Type, 2022

Prepared by the Office of the Auditor General of Ontario



Note: The percentages were calculated based on installed capacity, which is the maximum amount of electricity that can be produced by generators. The data was reported based on calendar year.

electricity. As such, more electricity will be needed to support the province's increasing transition from fossil-fuelled vehicles to electric vehicles.

2.2 Overview of Ontario Power Generation (OPG)

2.2.1 OPG's Role and Organizational Structure

Ontario Power Generation (OPG) is an Ontario-based corporation whose principal business is to generate and sell electricity. OPG was established under the *Ontario Business Corporations Act* in 1999 and is wholly owned by the Province of Ontario.

OPG produces more than half the electricity in Ontario from its various energy sources, including hydro, nuclear, gas and biofuel. OPG defines its purpose as providing low-cost power in a safe, clean, reliable and sustainable manner for the benefit of its customers and sole shareholder (the Province of Ontario). **Appendix 2** provides OPG's organizational chart. As of December 31, 2021, OPG had approximately 8,800 employees with about 1,250 (or 14%) of them involved with OPG's hydroelectric operations, many of them being tradespeople and operators.

2.2.2 OPG's Generation Facilities

Figure 3 provides a breakdown of OPG's generation facilities and generating capacity (or installed capacity), which is the maximum amount of electricity that can be produced by a generating station if it was running 100% of the time at its maximum ability. As of March 31, 2022, OPG had a total of approximately 14,700 megawatts (MW) of in-service capacity across all of its generation facilities, excluding subsidiaries. Hydroelectric generation represents the largest installed capacity at almost 7,500 MW (or 51%) of OPG's total capacity, and nuclear is second at 4,850 MW (or 33%), as shown in **Figure 3.**

Most of OPG's 66 hydroelectric generating stations have been operating for a number of years; many have operated for over 50 years, while some of the oldest ones have operated for 100 or more years. These stations vary significantly in size and generating capacity. **Appendix 3** provides additional details related to each generating station.

Figure 4 provides a breakdown of OPG's actual generation of electricity by energy source from 2017 to 2021. In 2021, OPG generated approximately 78 million megawatt hours (MWh) of electricity in

Figure 3: OPG's Generation Facilities and Capacity by Energy Source, as of March 31, 2022

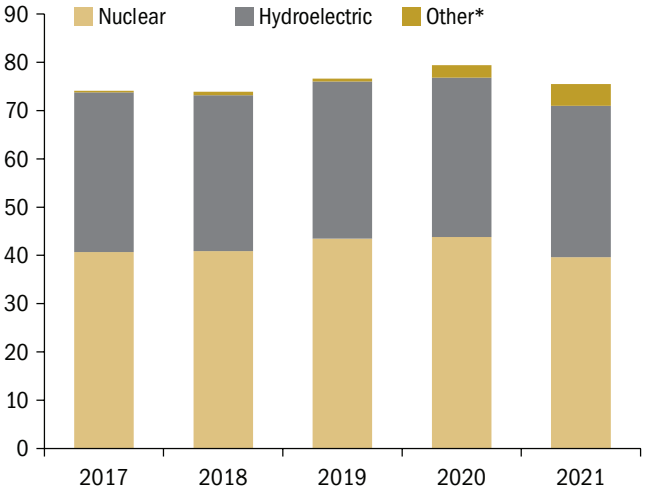
Source of data: Ontario Power Generation

Energy Source	Number of Stations	Installed Generating Capacity in Megawatts (MW)[1]	% of Total
Hydroelectric	**66**	**7,483**[2]	**51**
Nuclear	2	4,850	33
Gas	1	2,100	14
Biomass	1	205	1
Solar	1	44	<1
Total	**71**	**14,682**	**100**

1. Installed capacity is the maximum amount of electricity that can be produced by generators when they are all in service.
2. See **Appendix 3** for a breakdown of installed capacity by hydroelectric generating station.

Figure 4: OPG's Annual Electricity Generation by Energy Source, 2017–2021 (millions of megawatt hours)

Source of data: Ontario Power Generation



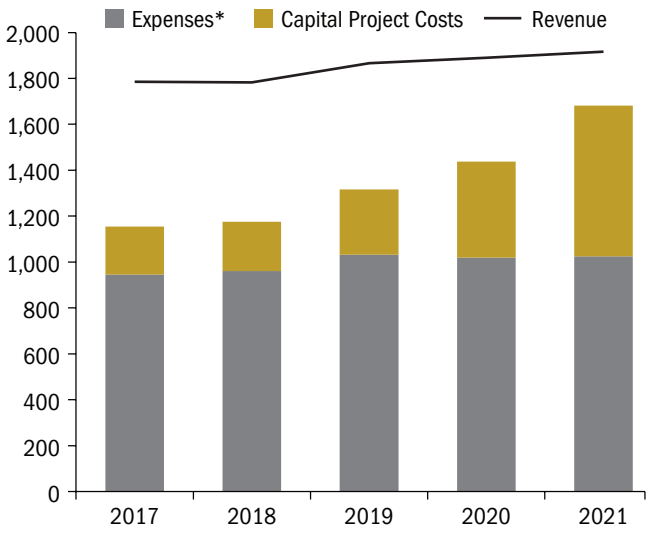
* Other generation includes thermal and solar.

Ontario. Nuclear accounted for the largest amount of OPG's actual generation, approximately 51% (or almost 40 million MWh), while hydroelectric accounted for 37% (or about 31 million MWh). The breakdown between nuclear and hydroelectric generation has been relatively consistent each year.

While hydroelectric has the largest production capacity at OPG, nuclear accounts for a higher amount of OPG's actual generation (see **Figure 4**) because OPG's nuclear reactors are designed to operate consistently at full power and are not suitable for reacting to rapid or frequent changes in demand. As such, they provide a base level of electricity to the province while other sources (like hydro) are used to alter production depending on demand. Hydroelectric generation is one of the most flexible forms of generation because it can use available water to meet varying system needs, and can be ramped up or down fairly quickly relative to most other forms of generation, typically within minutes.

Figure 5: OPG's Hydroelectric Generation Revenue and Expenditures, 2017–2021 ($ million)

Source of data: Ontario Power Generation



* Hydroelectric generation expenses include fuel expenses and charges, operations, maintenance and administration costs, and depreciation expenses. Income taxes and interest are excluded.

2.3 OPG's Revenue and Expenditures for Hydroelectric Generation

Figure 5 shows OPG's revenue and expenditures related to its hydroelectric operations over the last five years. OPG earns most of its revenue from ratepayers (electricity consumers) in Ontario, mainly based on rates approved by the Ontario Energy Board (OEB) or prices specified in its long-term energy contracts with the Independent Electricity System Operator (IESO). Between 2017 and 2022, OPG's annual hydroelectric revenue has been fairly stable in the $1.8 to $1.9 billion-dollar range.

Annual hydroelectric expenses have also remained relatively consistent in the $950 million to $1.03 billion-dollar range over that period. However, OPG's capital costs related to its hydroelectric operations have increased by 215%, totalling $656 million in 2021. Capital costs accounted for about 39% of OPG's total hydroelectric expenditures (excluding interest expenses and income taxes) in 2021, an increase from 18% in 2017. Major contributors to capital costs in 2021 were:

- $215 million for an ongoing dam safety project at the Little Long reservoir dam, which is located in the same area as Little Long Generating Station (north of Kapuskasing), to increase the amount of water that can be released;
- $53 million at Sir Adam Beck I Generating Station (in the Niagara region) for an ongoing project to overhaul and replace generating units that are near their end of life; and
- $59 million to redevelop Calabogie Generating Station (in Greater Madawaska) that will more than double the capacity of generation from the original station, which was significantly damaged in 2018 due to a tornado in the region.

Maintenance work orders and capital projects are discussed further in **Section 4.3** and **Section 4.6**, respectively.

Appendix 4 contains a glossary of terms related to OPG and hydroelectric generation.

3.0 Audit Objective and Scope

Our audit objective was to assess whether Ontario Power Generation (OPG) has effective systems and procedures in place to:

- plan hydroelectric asset management and maintenance processes in an efficient, cost-effective and timely manner;
- execute and manage hydroelectric assets, maintenance projects, and dam and public safety programs in accordance with applicable policies, standards, regulatory requirements and best practices; and
- monitor, measure and report on the performance and effectiveness of hydroelectric operations and activities.

In planning our work, we identified the audit criteria (see **Appendix 5**) we would use to address our audit objective. These criteria were established based on a review of applicable legislation, policies and procedures, internal and external studies, and best practices. OPG senior management reviewed and agreed with the suitability of our objectives and associated criteria.

We conducted our audit from January 2022 to October 2022, and obtained written representation from OPG management that, effective November 21, 2022, they have provided us with all the information they were aware of that could significantly affect the findings or the conclusion of this report.

We performed procedures at OPG including but not limited to the following:

- interviewing senior management responsible for overseeing hydroelectric asset management and maintenance processes;
- interviewing operations staff and engineers responsible for managing and completing ongoing maintenance and capital projects;
- reviewing applicable policies, guidelines, legislation and regulations related to hydroelectric operations in Ontario;
- reviewing OPG Board of Director meeting minutes and packages;
- analyzing hydroelectric generation, outage, capacity and spilling data;
- analyzing maintenance and operation work order data;
- reviewing a sample of inspection and assessment reports related to generating stations and dams, including reports on recently completed and ongoing capital projects; and
- reviewing strategic plans, annual reports, and internal and external performance measure targets and results.

We also conducted site visits at seven hydroelectric generating stations in Ontario (as specified in **Appendix 3**), where we toured the stations and nearby dams and interviewed management, operations staff and station engineers. The sites we selected include those that have recently undergone or are undergoing capital projects, generate a significant amount of hydroelectric power, and are spread across different regions and waterways of the province.

As well, we met with various stakeholders that OPG regularly works with, including:

- the Ontario Energy Board (OEB) to discuss rate applications and revenue mechanisms for regulated hydroelectric generating stations;
- the Independent Electricity System Operator (IESO) to discuss non-regulated hydroelectric rate-setting processes and to review provincial electricity grid supply and demand forecasts;
- the Ministry of Energy to discuss hydroelectric strategy and opportunities; and
- the Ministry of Natural Resources and Forestry to discuss dam safety.

In addition, we met with and reviewed information from various individuals and stakeholders involved or familiar with hydroelectric operations in Ontario, including:

- The Ontario Waterpower Association, a not-for-profit member-based organization that promotes

the sustainable development of waterpower resources in Ontario. Membership includes generators (including OPG), engineering firms, environmental consultants and other organizations that share the interest of advancing waterpower in Ontario.

- Hatch Limited, a global multidisciplinary management, engineering and development consultancy. Hatch supplies engineering, project and construction management, business consulting and operational services in the energy, mining and infrastructure sectors.
- Former OPG and IESO staff.

We reviewed relevant research, studies and reports in other jurisdictions to identify risk areas, performance benchmarking, best practices, and opportunities in the areas of hydroelectric asset management and maintenance. Reports include those published by utility-based organizations such as Electricity Canada (formerly the Canadian Electricity Association), the Electric Utility Cost Group, and the Centre for Energy Advancement through Technological Innovation.

We conducted our work and reported on the results of our examination in accordance with the applicable Canadian Standards on Assurance Engagements—Direct Engagements issued by the Auditing and Assurance Standards Board of the Chartered Professional Accountants of Canada. This included obtaining a reasonable level of assurance.

The Office of the Auditor General of Ontario applies the Canadian Standards of Quality Control and, as a result, maintains a comprehensive quality control system that includes documented policies and procedures with respect to compliance with rules of professional conduct, professional standards and applicable legal and regulatory requirements.

We have complied with the independence and other ethical requirements of the Code of Professional Conduct of the Chartered Professional Accountants of Ontario, which are founded on fundamental principles of integrity, objectivity, professional competence and due care, confidentiality and professional behaviour.

4.0 Detailed Audit Observations

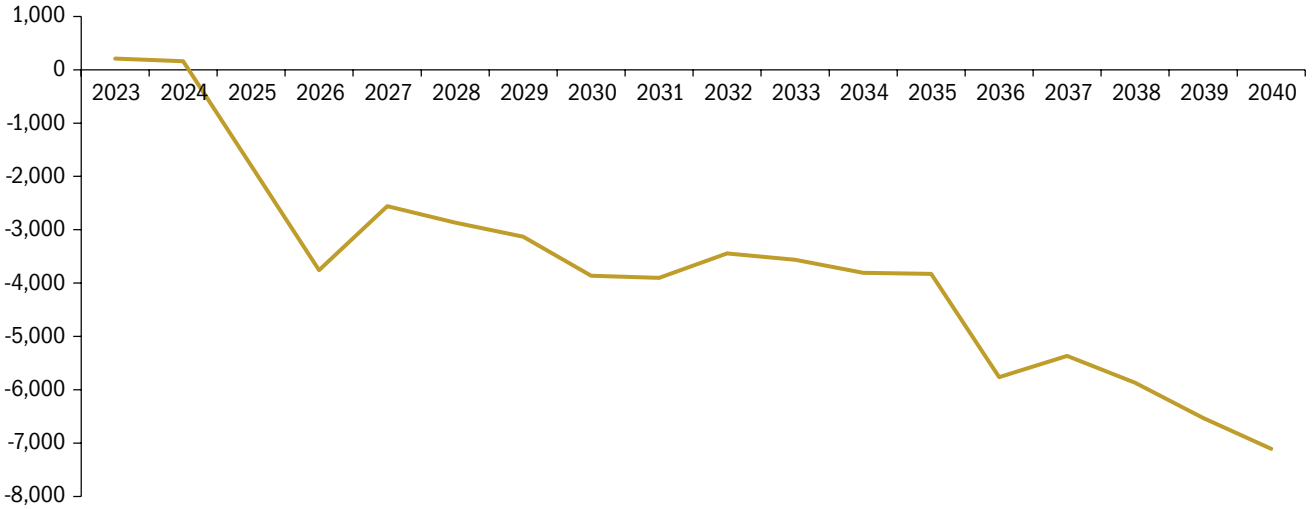
4.1 OPG Has Not Fully Utilized Its Hydroelectric Generating Capacity

In Ontario, demand for electricity, including hydroelectric power, is expected to increase in the future for various reasons, including:

- **Growing reliance on renewable energy sources—**Ontario has been moving toward using more renewable energy generation, which is sustainable and environmentally friendly. Besides wind and solar power, hydroelectric power is also considered as a form of renewable energy.
- **Increasing usage of electricity instead of fossil fuels—**This is generally referred to as the process of electrification, whereby technologies that use fossil fuels (such as coal, oil and natural gas) are replaced with technologies that run on electricity. For example, the automobile industry has been developing and producing electric vehicles that rely on electricity instead of gasoline.
- **The closure of a major nuclear station—**One of the province's major nuclear stations, Pickering Nuclear Generating Station, is scheduled to be shut down in 2024/25, although in September 2022 the province announced it would seek approval from the Canadian Nuclear Safety Commission to extend that to 2026. As well, Ontario might consider refurbishing this station, which could allow the station to remain in service for an additional 30 years. This station has a generating capacity of approximately 3,100 megawatts (MW) and if it is shut down, that lost supply will have to be made up by other stations and energy sources, including hydroelectric generation.
- **Population growth—**Ontario's population is projected to grow by almost 5.6 million people (or 37.7%) by 2046. An increase in population will lead to an increase in demand for electricity.

Figure 6: Forecasted Electricity Generating Capacity, 2023–2040 (megawatts)

Source of data: Independent Electricity System Operator



Note: This figure shows capacity surplus or shortfall, which is assessed based on demand forecast, supply and transmission outlook. Positive means surplus and negative means shortfall. The capacity shortfall represents the total amount of generating capacity that will not be sufficient to meet energy requirements, in which case Ontario will require new resources and/or imports to meet demand.

In December 2021, the Independent Electricity System Operator (IESO) released its annual report which includes a forecast of electricity supply and demand. As seen in **Figure 6**, the IESO predicts that Ontario, which historically has had surplus electricity, will experience a shortfall beginning in 2025 and continuing until at least 2040, meaning Ontario will have to fill the gap through various sources such as importing power from other jurisdictions, utilizing unused capacity from existing generating stations, and/or building new generating stations.

4.1.1 OPG Has Not Fully Utilized Its Hydroelectric Generating Capacity Over Seven Years

Each hydroelectric generating station has an installed generating capacity, which represents the maximum capacity at which a station is designed to generate. However, the actual electricity production of each generating station depends on numerous factors including water availability and flow, demand for electricity, and planned and unplanned outages (that is, generating stations are out of service for a period of time).

We reviewed OPG's total installed generating capacity and compared it to the actual generation over the seven-year period from 2015 to 2021. The results of this analysis are shown in **Figure 7**. We found that over this period, OPG was only using between 48% and 51% of the stations' total installed capacity.

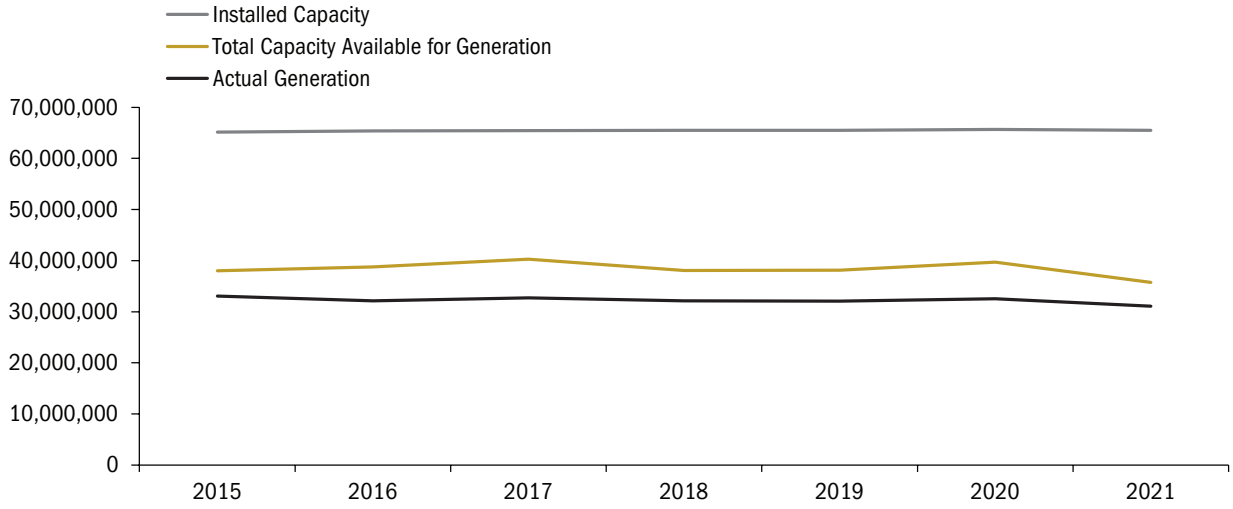
We also reviewed OPG's total hydroelectric generation and compared it to what OPG estimated it could have produced considering factors such as water levels and outages. We found that over the seven-year period from 2015 to 2021, OPG could have generated approximately 269 million MWh of electricity. However, OPG only generated 226 million MWh of electricity, meaning that about 43 million MWh of generating capacity went unused over the last seven years (see **Figure 7**). In 2021 alone, OPG could have generated an additional 4.6 million MWh of electricity, or enough to power over 540,000 Ontario households for a year.

We found that OPG has not conducted a detailed analysis of why there is a significant difference between installed capacity and actual generation. However, OPG informed us that there are multiple reasons for why actual generation is lower than the installed capacity. For example:

- Ontario does not have the amount of water required to run all hydroelectric generating units at full capacity for 24 hours a day, seven days a

Figure 7: Utilization of OPG's Hydroelectric Generating Capacity, 2015–2021 (megawatt hours)

Source of data: Ontario Power Generation



week, and water availability and flow depend on seasonal factors that could also vary from year to year.

- Some OPG generating stations were built as intermediate or peaking facilities, meaning that they were designed and constructed to generate only during periods of higher demand. There was no intention of having them generating consistently and it would not be possible based on water availability, as discussed above.
- The installed capacity does not consider that units have to be taken down for maintenance and repairs, discussed further in **Section 4.3**, and could also be impacted by outages, as discussed in **Section 4.5**.
- There are certain environmental and recreational water management considerations that OPG must adhere to. For example, at its large Sir Adam Beck stations in Niagara region, OPG is required to ensure hydroelectric generation does not impact the ability of ferries to operate during summer months.

OPG also informed us that one of the key reasons for underutilizing its hydroelectric generating capacity is low demand. The Independent Electricity System Operator (IESO) is responsible for determining how much electricity is needed across the province as well as which generators should increase and decrease production, and the IESO would have directed OPG to limit production over the years mainly due to low demand for electricity in the province.

We asked OPG to estimate the breakdown of how its installed capacity of 7,500 megawatts (MW) was used (see **Figure 8**). OPG noted that about 40% of its installed capacity (or about 3,000 MW) could not be utilized due to insufficient water availability. Another 9% (or 695 MW) could not be utilized due to surplus power conditions or other system constraints that resulted in the spilling of water, and about 2% (140 MW) was not used due to outages.

Figure 8: Utilization of OPG's Installed Capacity of Hydroelectric Generation, Average of 2015–2021

Source of data: Ontario Power Generation

	Megawatts*	%
Actual generation	3,700	49
Not able to generate due to insufficient water availability	3,000	40
Not able to generate due to spilling of water in response to surplus power conditions or other system constraints	695	9
Not able to generate due to outages	140	2
Total installed capacity	**7,535**	**100**

* Numbers are approximate and rounded.

While generating stations cannot practically operate at 100%, due to planned and unplanned outages, water availability and fluctuations in demand for electricity in the province, OPG still has a significant amount of unused capacity each year. As such, OPG's hydroelectric generating stations can be more effectively utilized to some extent to help meet future electricity demand, which is expected to increase for various reasons including the potential closure of Pickering Nuclear Generating Station (responsible for approximately 3,100 MW of generation) in 2024/25.

RECOMMENDATION 1

To maximize the use of current hydroelectric generating stations and prepare for increased energy demands in the future, we recommend that Ontario Power Generation work with the Ministry of Energy and the Independent Electricity System Operator to develop both a short-term and long-term strategy to utilize the unused production capacity that exists within its current hydroelectric generating stations while also pursuing new hydroelectric opportunities.

RESPONSE FROM ONTARIO POWER GENERATION

Ontario Power Generation (OPG) remains committed to delivering value for money for Ontario ratepayers, and as such, will continue to ensure the safe and efficient operation of its hydroelectric stations.

As a market participant, OPG is required to offer into the market all of the electricity it can produce, which is impacted by factors such as water availability, safety and regulatory requirements, proper maintenance, and station capacity. While OPG strives to ensure its units are available to be offered into the market, it is only one of a number of generators in the province, and it is the Independent Electricity System Operator (IESO), as the market/system operator, that ultimately decides which generation is used by the electricity system based on its dispatch methodology and regulations. Should the IESO undertake any future review of the unused production capacity that exists within OPGs hydroelectric generating stations, OPG would participate in such a review.

OPG will continue to seek opportunities to improve and maintain the reliability of its hydroelectric stations to ensure its units are available to meet Ontario's rising demand for renewable energy.

As a steward of the province's hydroelectric generating stations, OPG understands the long-lasting benefits this technology can deliver for local communities and economies, for Indigenous partners, for the environment, and for ratepayers. OPG agrees with the Auditor General that there is a need to examine new hydroelectric development opportunities in the province and is committed to working with industry partners and Indigenous communities in this regard.

4.1.2 OPG Needs to Strengthen Its Working Relationship with the IESO in Exploring Ways to Meet Future Electricity Shortfalls, Given the Challenges and Uncertainties of Building New Stations

While OPG is Ontario's largest power generator, the Independent Electricity System Operator (IESO) is responsible for managing and planning for the province's electricity supply from various energy sources (including hydroelectric power) to meet future needs. Therefore, it is critical that OPG and the IESO have a strong working relationship, especially when both parties are exploring additional hydroelectric opportunities in northern Ontario as directed by the Ontario government.

In response to the forecasted shortfall in electricity mentioned in **Section 4.1.1**, in January 2022, the Ontario government asked OPG to examine opportunities for new hydroelectric development in northern Ontario and to share that information with the Ministry of Energy as well as the IESO. The Ontario government also asked the IESO to identify the transmission infrastructure and costs associated with

enabling these new hydroelectric stations along with the value of these to the system.

OPG estimates there is unbuilt hydroelectric generation capacity of 3,000 to 4,000 megawatts (MW) in northern Ontario. OPG also noted there is up to an additional 1,000 MW in unbuilt capacity in southern Ontario. While unbuilt hydroelectric capacity exists in Ontario, developing such capacity is challenging and also involves many uncertainties in terms of timing and cost. Specifically:

- Developing new stations will take many years because of the significant amount of work involved, which includes preparing environmental assessments and designs, consulting with Indigenous communities, constructing stations and related infrastructure such as dams, and installing transmission lines to connect the generating stations to the provincial electricity grid. For example, one of the projects OPG recommends for consideration would only provide approximately 80 MW of daily peaking power, but it would likely take over five years to put the station in service. As a result, this project would only be a small step toward addressing the predicted power shortfall in Ontario. Other, larger projects offering over 1,000 MW of daily peaking power could take 10 or more years to complete.
- Developing hydroelectric generation in northern Ontario will be costly. OPG estimated that such costs can vary significantly, from $5 million to $22 million per MW of power from a potential station, depending on location and site conditions. Estimated costs will become even higher after considering additional transmission-related costs for stations.
- Working on multiple projects simultaneously is challenging because the sector has limited vendors for OPG to choose from.

With recent government direction for OPG to collaborate with the IESO on hydroelectric opportunities in northern Ontario, it is critical for OPG and the IESO to have open two-way communication to avoid repeating an incident where a lack of co-ordination between these two parties resulted in wasted ratepayer money.

We found that in 2015, OPG was looking to develop a small (5.8 MW) hydroelectric generating station south of Timmins. This project was part of the IESO's renewable procurement program, which allowed generators to bid for project funding through an open process. However, OPG's bid for the project was subsequently rejected by the IESO, who cited a lack of transmission capability in the region as the reason. Based on our review of OPG's Board of Director minutes, it appears that both OPG management and its Board of Directors were surprised by the IESO's decision and related rationale. As a result of the bid rejection, OPG had to write off approximately $6.2 million in costs associated with putting together the bid, including engineering and architectural assessments.

RECOMMENDATION 2

To economically and efficiently pursue new hydroelectric energy projects in the future, we recommend that Ontario Power Generation:

- work with the Independent Electricity System Operator (IESO) to develop a strategy to allow for open communication during the selection of new development projects; and
- consult all potential partners, including Hydro One, the IESO and third-party vendors, regularly to assess the ongoing viability of project development.

RESPONSE FROM ONTARIO POWER GENERATION

Ontario Power Generation (OPG) agrees with the Auditor General that open communication is essential to support the Province during the selection of any new hydroelectric development projects.

OPG is committed to working with Indigenous communities and industry partners in the development process. OPG has engaged with the Province and the Independent Electricity System Operator (IESO) regarding the development of new hydroelectric projects and will support the development of strategies that will serve the needs of Ontario during this period of energy transition. OPG will

also further engage with industry partners including Hydro One to support the development of a bulk transmission network strategy to enable new generation.

Consistent with the values and priorities outlined in its Reconciliation Action Plan, OPG believes that any strategies to procure new hydroelectric energy must consider how hydroelectric developments can contribute to broader provincial objectives related to Indigenous reconciliation. It must also align with provincial planning as it pertains to Northern Ontario development and Ontario's Critical Mineral Strategy. OPG is committed to sharing information and collaborating with Indigenous communities, the Province and industry partners to work towards securing Ontario's clean energy future through hydroelectric development opportunities.

4.2 OPG Recorded Approximately $730 Million in Revenue Since 2015 for Spilled Water without Generating Any Electricity Due to Excess Power Supply in Ontario

During periods when the province has low electricity demand and a surplus of electricity supply, OPG may be instructed by the Independent Electricity System Operator (IESO) to reduce hydroelectric generation by spilling water (allowing water to bypass a station without generating any electricity) as there were no remaining options to store hydroelectric energy for future use.

Since at least 2013, Ontario has been experiencing surplus baseload generation (SBG) conditions. These conditions occur when the amount of electricity that could be produced by baseload facilities (which are typically designed to run at a steady output 24 hours a day to meet the minimum demand for electricity) exceeds the demand for electricity, resulting in surplus electricity supply. The amount of SBG related to OPG's hydroelectric generation in 2013 was approximately 1.7 million megawatt hours (MWh); this increased steadily to 5.9 million MWh in 2017, before decreasing to 1.9 million MWh in 2021. Ontario's hydroelectric baseload facilities include five of OPG's hydroelectric generating stations, including Sir Adam Beck II and RH Saunders which are two of OPG's largest hydroelectric stations.

The IESO manages SBG conditions mainly by instructing some baseload facilities, such as OPG's hydroelectric generating stations, to reduce (curtail) production by spilling water or to completely shut down. Reducing hydroelectric generation is typically used as the first option to respond to SBG conditions in Ontario, as hydroelectric generation facilities can respond quickly, typically within minutes, to meet varying demand (as noted in **Section 2.2.2**).

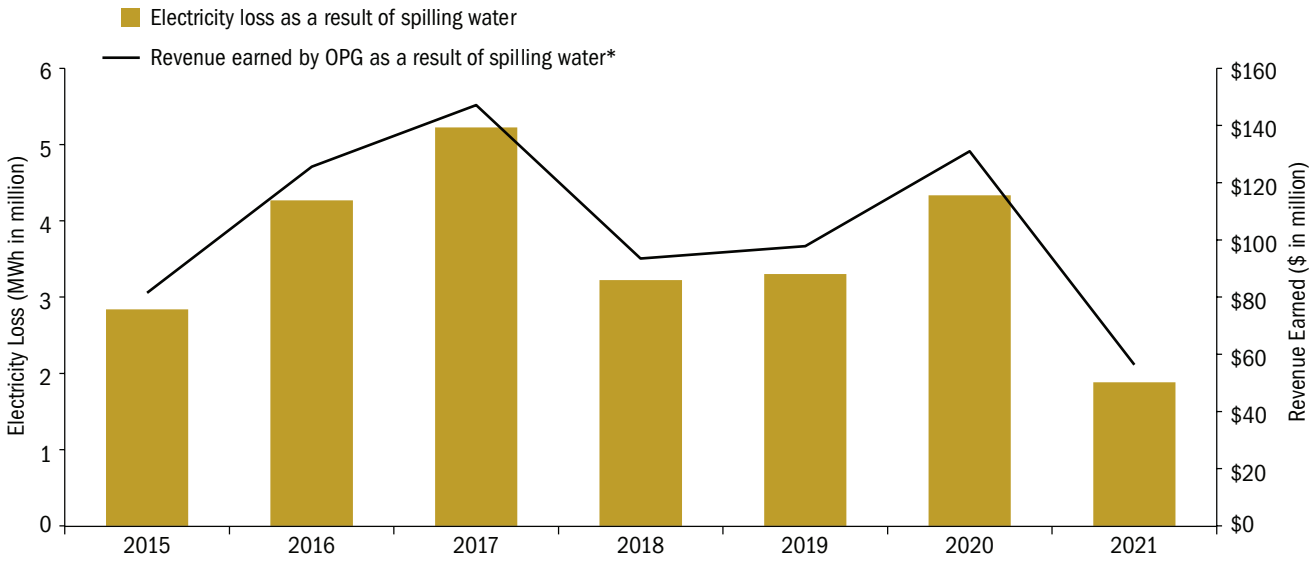
As discussed in **Section 4.7**, of the 66 hydroelectric stations operated by OPG, 54 of them are subject to rate regulation by the Ontario Energy Board (OEB) and are compensated at a rate that is set based on a forecast of the amount of electricity generation, not considering any potential reductions due to SBG. This means that OPG receives a fixed rate (currently $43.88 per megawatt hour [MWh]) for the forecasted amount of electricity it expects to generate in the year. When OPG has to spill water to reduce or stop its production of hydroelectric generation due to SBG conditions, it still receives the rate for forgone production as compensation because the need to spill water is out of its control.

We reviewed the amount of surplus electricity lost as a result of spilled water at OPG's regulated stations and the amount of related SBG spill revenue earned by OPG for the seven-year period from 2015 to 2021 (see **Figure 9**). We found that over this time frame, the amount of water spilled by OPG could have been used to generate 25 million MWh of electricity. OPG still recorded approximately $730 million in revenue related to the spilled water as a result of SBG conditions.

While the amount of surplus electricity lost as a result of spilling water has dropped in 2021 due to increasing demand, from the highest of about 5.2 million MWh in 2017, the amount of electricity lost in 2021 still amounted to 1.9 million MWh, which is enough to provide electricity to approximately 220,000 households for a year.

Figure 9: Electricity Loss and Revenue Earned by OPG Related to Spilled Water, 2015–2021

Prepared by the Office of the Auditor General of Ontario



* Revenue for spilled water is only applicable for OPG's 54 regulated hydroelectric generating stations (see **Section 4.2**) and is net of the gross revenue charge (a set of taxes and charges paid by the organization on gross revenue).

We reviewed rate applications submitted by OPG to OEB as well as documentation related to compensation for spilling water. When OPG submits cost and production forecasts to OEB, it does so on a cost-recovery basis plus a marginal rate of return. That is, OPG estimates both the costs (fixed and variable) of running its regulated hydroelectric stations and the amount of electricity expected to be generated, and then requests the revenue required to cover those costs plus a return on equity (ROE) rate of approximately 9% on its capital investments. The OEB-approved revenue requirement is divided by the forecasted production to establish a per MWh rate. However, there is no separate mechanism that adjusts the revenue rate when water is being spilled to reduce or stop hydroelectric generation.

Therefore, the current compensation method does not appear to be fully achieving value for money for ratepayers. When OPG's hydroelectric stations are on spilling conditions without generating any power, OPG incurs limited variable costs of operating and running its stations. Therefore, it is reasonable that the compensation should consider fixed costs, and there should be a continued examination of limiting variable costs. The built-in approximate ROE rate of 9% for OPG should also be reviewed to see if it is practical to exclude this when OPG is spilling water. This is especially important given that OPG has consistently been in spilling conditions since at least 2015.

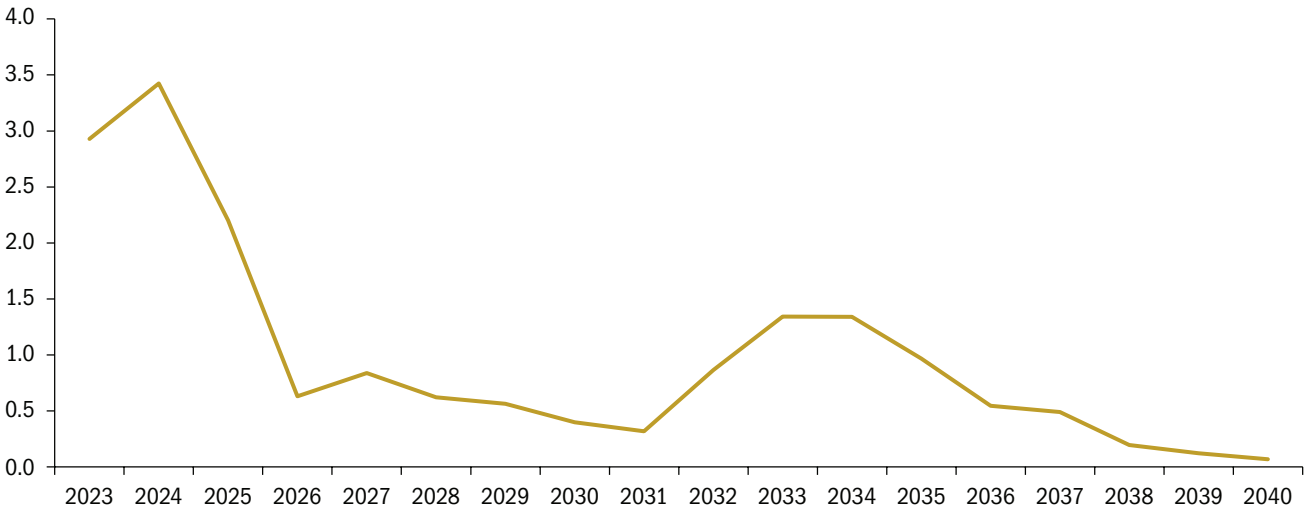
While the IESO expects the amount of SBG to drop in the future, it estimates that the province will continue to experience SBG conditions until 2040 (see **Figure 10**). These conditions may lead to OPG continuing to reduce hydroelectric generation and spill water in instances where the water cannot be stored. Therefore, it is important to review and reassess the current reimbursement or compensation method related to SBG to ensure ratepayers are receiving value for money.

RECOMMENDATION 3

To protect the interests of Ontario ratepayers, we recommend that Ontario Power Generation collaborate with the Independent Electricity System Operator and the Ontario Energy Board to assess options for more cost-effective ways to be compensated for surplus baseload generation conditions, such as covering only fixed costs when hydroelectric generating stations are requested to spill water in order to curtail production.

Figure 10: Forecasted Surplus Baseload Generation, 2023–2040 (millions of megawatt hours)

Source of data: Independent Electricity System Operator



Note: Surplus baseload generation (SBG) occurs when electricity supply from baseload generating stations (including nuclear stations and certain hydroelectric stations) exceeds demand.

RESPONSE FROM ONTARIO POWER GENERATION

The Ontario Energy Board (OEB) has reviewed and approved the cost-effectiveness and ratepayer value of the methodology used to compensate OPG for its spill as a result of the actions taken by the Independent Electricity System Operator (IESO) in response to Surplus Baseload Generation (SBG) conditions. Should the OEB undertake any future review of the compensation methodology, OPG would participate in any such review. Currently, the compensation OPG receives when it reduces output to help address SBG excludes OPG's variable cost, a water rental charge, which applies only when OPG generates electricity.

SBG is a system condition that is managed by the IESO. When SBG conditions occur, OPG responds to IESO instructions to provide the IESO with flexibility, including instances when OPG hydroelectric facilities reduce output to assist the IESO in managing SBG. By reducing output at its hydroelectric facilities, OPG helps the IESO avoid more inefficient and costly responses to SBG.

4.3 Aging of Hydroelectric Stations and Equipment Has Led to a Continuous Backlog of Work Orders Which Could Result in Increased Maintenance Costs

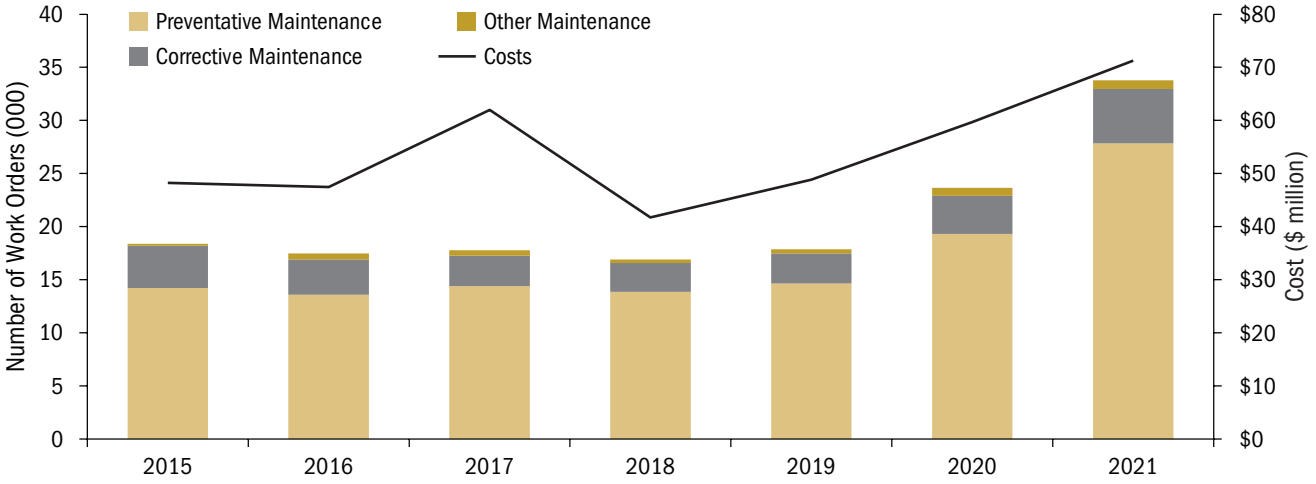
As shown in **Appendix 3**, the majority of OPG's hydroelectric generating stations (86%) have been in service for over 50 years, and in some cases for over 100 years. While a generating station's structure can have an indefinite life, there is an ongoing need to conduct adequate and timely maintenance work on the station's equipment and physical structure to ensure the station can be operated continuously in an economic, efficient and safe manner.

Increase in Maintenance Work Orders and Costs

Maintenance work orders and related costs have increased, which in turn has contributed to a continuous backlog of work orders. OPG uses various data systems and software to track and report on maintenance work, including systems that allow OPG to track work orders and related costs. We obtained and analyzed data related to OPG's hydroelectric generation work orders for the last seven years (2015–2021), which include requests for such work as preventative

Figure 11: Total Hydroelectric Generation Maintenance Work Orders and Costs, 2015–2021

Source of data: Ontario Power Generation



Note: This figure shows data related to Ontario Power Generation's (OPG's) hydroelectric generation work orders that were started in each year based on a report generated through OPG's work order system. This figure includes all types of work orders, including but not limited to preventative maintenance, corrective maintenance, project, and expedited work orders.

and corrective maintenance. Work orders can be initiated by different parties within OPG, including but not limited to its engineers, maintenance staff and/or operations staff.

As seen in **Figure 11**, we found that the number of maintenance work orders increased by 83% over the last seven years (from approximately 18,400 work orders in 2015 to about 33,800 in 2021). The related cost of these work orders increased by 48% (from a total of $48.2 million to $71.2 million), although OPG informed us that part of the increase is a result of more accurately and consistently capturing costs in its work management system.

We reviewed the major contributors to these increases and noted that the number and cost of preventative maintenance work orders in particular significantly grew from 2015 to 2021. As seen in **Figure 12**, the number of these work orders increased by over 95% (from about 14,230 to 27,850), with the related cost increasing by 160% (from approximately $13 million to almost $34 million), in that period.

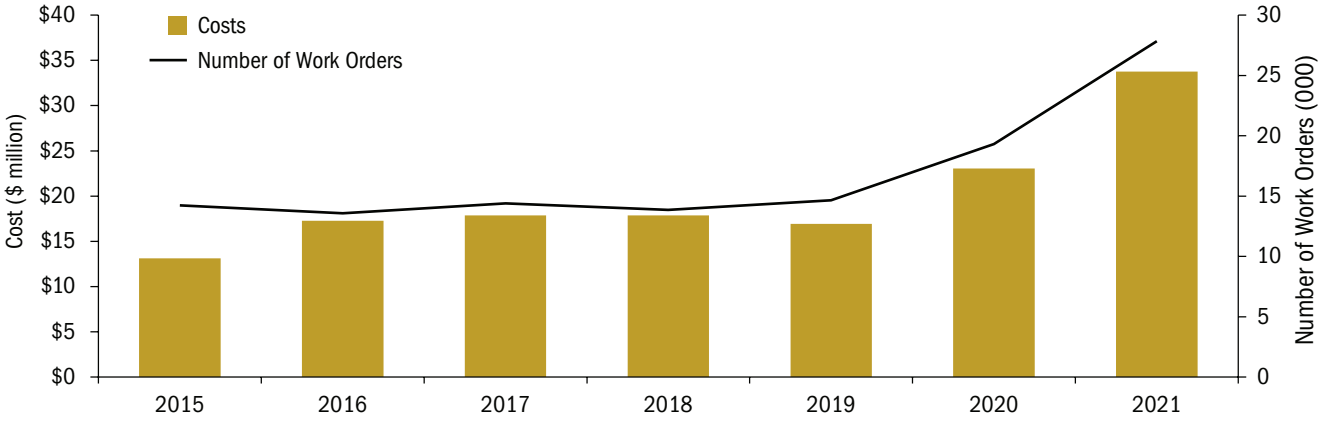
Preventative maintenance work orders are typically created to either prevent or detect equipment problems, or meet prescribed regulatory requirements. Some areas with a high number of work orders in 2021 included:

- work to maintain systems related to sluiceways (sliding gates or other devices for controlling the flow of water), spillways, control dams and water level instrumentation;
- work to inspect and maintain powerhouse buildings as well as station ancillary buildings and sites; and
- work to manage mobile equipment such as vehicles, trucks, tractors, trailers and mobile lifting devices.

Through discussion with OPG maintenance and engineering staff, we found that the significant increase in preventative work orders in 2020 and 2021 was due to a combination of factors, including an increased use of work orders to identify equipment deficiencies as well as increased corrective work due to the aging of various systems and equipment. As noted above, 86% of OPG's hydroelectric generating stations have been in service for over 50 years. As such, OPG expects to complete several major overhaul projects to maintain its hydroelectric stations in the coming years, including projects related to some of its large stations such as Sir Adam Beck II in Niagara and RH Saunders in Cornwall. These overhauls will involve replacing and refurbishing major components (for example, turbines and generators) as well as addressing other worn

Figure 12: Preventative Maintenance Work Orders and Costs, 2015–2021

Source of data: Ontario Power Generation



Note: This figure shows data related to Ontario Power Generation's (OPG's) hydroelectric generation work orders that were started in each year based on a report generated through OPG's work order system.

components. OPG expects to continue conducting preventative and corrective maintenance work leading up to these major overhauls.

We also noted that beginning in 2016, OPG undertook a major redesign of spillway gates as a result of changes in Ontario's energy markets. More specifically, we found that to help manage Ontario's surplus electricity supply (discussed further in **Section 4.2**), OPG has been instructed to spill water (allow water to bypass a station without generating any electricity) more frequently, which involves frequent operation of sluice gates (which are used to control water levels and flows). This, along with aging, has reduced the life expectancy of components and contributed to issues that have impacted their reliability, thereby prompting OPG to improve its design of sluice gates to prevent further maintenance costs due to increased frequency of gate operation.

Continuous Backlog of Maintenance Work Orders

We found that OPG has also incurred a significant backlog of maintenance work orders over the past five years, but does not have policies and procedures for ensuring all work orders are assigned due dates and for addressing overdue work orders.

OPG's system for tracking and reporting maintenance work allows for the capture of due dates for completing work orders. However, we found that the due date field is not consistently used by OPG staff when creating work orders. For example, of the approximately 34,000 work orders started in 2021, about 5,000 (or 15%) of them did not have an assigned due date in the system.

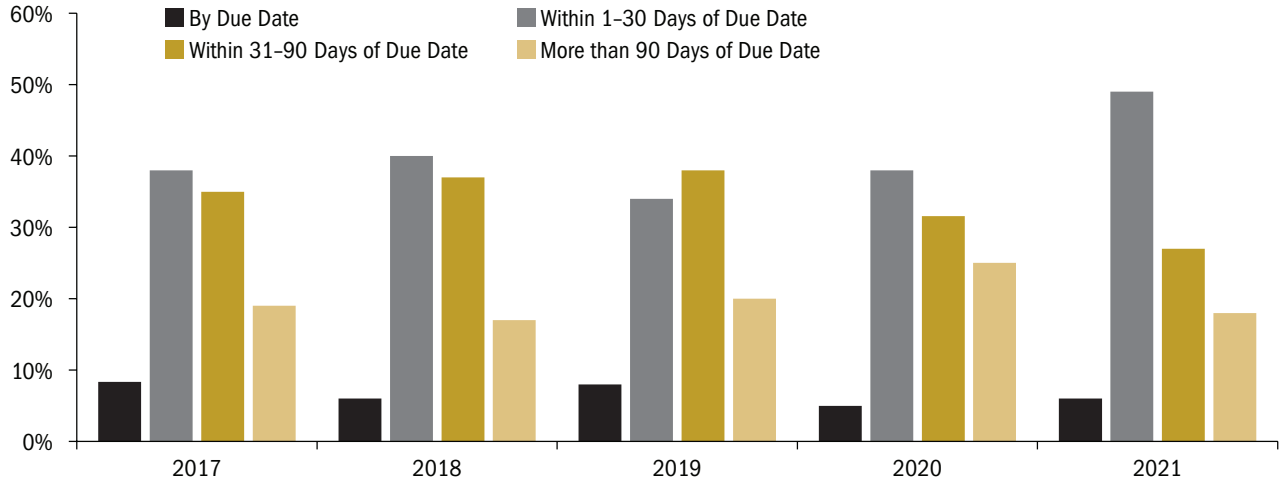
We noted that OPG does not have a documented policy or guideline on when or if a due date should be entered. OPG informed us that the use of the due date field is not mandatory for all types of work orders, although staff can still choose to use it when entering work orders into the system.

We analyzed data for work orders that did include a due date over the last five years (2017–2021), and found that between 2017 and 2021, while the majority (75% to 83%) of work orders were completed within 90 days (or approximately three months) of their respective due dates, roughly 17% (or about 2,500) to 25% (or about 5,300) of work orders were completed over 90 days later than their due date each year, as seen in **Figure 13**. OPG informed us that work orders that progress to a closed status within its work management system within 90 days of the due date are considered to have been completed on time, although this information could not be verified across all work orders as the system does not adequately indicate when the work order was actually completed.

We also noted that OPG tracks and reports on its backlog of work orders annually. We reviewed these reports over the last five years and found there has been a continuous backlog during that period, although OPG made progress on clearing some of it

Figure 13: Work Order Completion Date, 2017–2021

Prepared by the Office of the Auditor General of Ontario



Note: OPG informed us that work orders that have closed within 90 days of the due date within the work management system are considered to have been completed on time, but the work management system does not adequately indicate the actual work order completion date. As such, the data included in this figure uses the due date as presented within the work management system.

in 2021 (as shown in **Figure 14**). The number of work orders in this backlog has remained high, ranging from a low of approximately 9,500 (2021) to over 17,000 (2020). When reviewed together with increasing work orders and costs, the existing backlog, if not addressed on a timely basis, could continue to grow and become more difficult and expensive to clear. Furthermore, delays in maintenance activities increase the risk of a decline in the reliability of OPG's hydroelectric generating stations (as discussed in **Section 4.5.1**).

RECOMMENDATION 4

To better monitor, track and complete maintenance work on its hydroelectric generation fleet, we recommend that Ontario Power Generation:

- establish procedures requiring staff to include due dates for work orders;
- measure and oversee all work orders against due dates to identify whether work orders are being completed on a timely basis and implement corrective action when needed; and
- develop a strategy with a risk-based work prioritization methodology to address increasing maintenance work orders and the work order backlog.

RESPONSE FROM ONTARIO POWER GENERATION

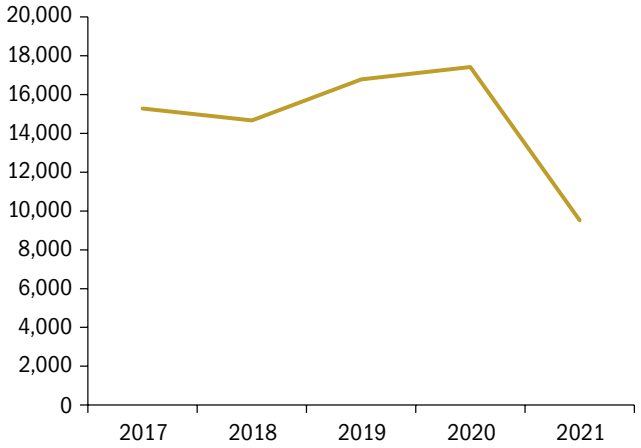
Ontario Power Generation (OPG) agrees with the Auditor General's recommendation. Appropriate work prioritization and completion are integral to the safe and efficient operation of OPG's hydroelectric generating stations, ancillary equipment, and control dams.

OPG strives to continually improve the work management program and practices through enhancements to procedures, development of computer-based tools, and use of performance indicators. OPG will:

- review applicable procedures to clarify guidance on due dates for preventative work orders;
- continue to improve work prioritization for preventative work orders in alignment with equipment criticality;
- identify the performance indicators and oversight requirements for preventative work order due dates; and
- continue to improve work prioritization for corrective work orders in a manner that promotes issue identification and timely resolution.

Figure 14: Work Order Backlog, as of December 2017–December 2021

Source of data: Ontario Power Generation



OPG remains focused on the safe and reliable operation of its assets for the people of Ontario and will continue to identify opportunities to improve its work management performance in alignment with the Auditor General's recommendation.

4.4 OPG Did Not Always Assess the Conditions of Its Hydroelectric Stations and Address Engineering Recommendations on a Timely Basis

To ensure that its stations can be operated continuously in an economic, efficient and safe manner, OPG has tools in place and hires engineers to assess the conditions of its hydroelectric generating stations (separate from OPG's dam safety reviews and inspections, which are discussed in **Section 4.8**). However, we noted that OPG did not always perform these assessments or implement the recommendations given by the engineers in a timely manner.

4.4.1 Conditions of Hydroelectric Stations Were Not Always Assessed at Regular Intervals, with About 20% of Stations Not Assessed in Over 10 Years

OPG uses a number of assessment tools and techniques to monitor the physical and mechanical conditions of its hydroelectric generating stations, and to determine what work is necessary to maintain the reliability of the stations. One of the key tools used is a Plant Condition Assessment (PCA), a document completed by OPG engineers or an engineering consulting firm, which includes the following information:

- a technical, engineering-based assessment of the current physical condition of a hydroelectric station, as well as its related equipment and processes;
- a high-level estimate of the life of major components of the generating station, along with investments deemed necessary to maintain the viability of the generating station for up to 30 years; and
- a forward-looking assessment of longer-term factors for a hydroelectric station, such as the aging of equipment, major component replacements, and refurbishment options.

OPG does not have a set time frame for how frequently its engineers (or engineer consultants) should complete PCAs. Instead, we were informed that OPG schedules PCAs on a risk-informed basis, considering factors such as the date of a station's last PCA, the size of the station, and any risks identified through an annual risk assessment program. We reviewed practices in other jurisdictions and noted that timelines and types of assessments can vary. For example, the United States Bureau of Reclamation (the second largest producer of hydropower in the United States that operates 53 hydroelectric powerplants) indicates in its manuals that a comprehensive facility review—a review of the management, operations, mechanical and electrical maintenance of a station—should be completed every six years.

We also noted that many PCAs included recommended work and necessary investments that should be completed within a 10-year time frame. As such, it would be prudent to conduct a PCA at least every 10 years to adequately monitor and manage station conditions and assess the completion status of any recommended work.

However, we reviewed the completion dates of the PCAs for all 66 of OPG's hydroelectric generating stations and found that approximately 20% (or

13 stations) did not have a PCA completed in the last 10 years.

We also reviewed time gaps between the two most recent PCAs for a sample of generating stations and again noticed an inconsistency of timing between PCAs. For example:

- For both Sir Adam Beck I and Sir Adam Beck II Generating Stations (two of OPG's largest generating stations), their most recent PCA was conducted 18 years after the prior one.
- For Abitibi Canyon Generating Station, there was a gap of five years between its most recent PCA issued in 2021 and the previous one in 2016.
- For Cameron Falls Generating Station, its most recent PCA was completed in 2022 while the prior one was completed in 2012, 10 years earlier.

We spoke with OPG staff and noted that OPG is currently revising its PCA process and looking to improve how station conditions are assessed. We were informed that under an updated process, station or equipment conditions would be monitored using a "real-time" process to provide a view of condition at any time rather than a periodic snapshot as per the current PCA process. Action would then be taken on an as-needed basis when a known condition has changed and requires action. However, the revised process has not yet been implemented so the effectiveness of the change cannot be assessed.

RECOMMENDATION 5

To comprehensively monitor hydroelectric generating station conditions as part of its updated assessment process, we recommend that Ontario Power Generation:

- develop and document criteria on how often assessments must be completed and include any rationale for situations where stations are subject to different timelines based on risk factors, if applicable; and
- include a comprehensive assessment aspect that allows senior management to periodically assess the conditions and risks of the stations in a more fulsome and timely manner.

RESPONSE FROM ONTARIO POWER GENERATION

Ontario Power Generation (OPG) agrees with the Auditor General's recommendations. OPG is committed to comprehensive monitoring and ongoing assessment of its hydroelectric assets. To date, this has been achieved through periodic Plant Condition Assessments (PCAs) to determine asset condition and required investments. OPG also undertakes an annual Engineering Risk Assessment Program review to assess changes in condition and identify mitigating measures to support plant performance.

In response to the Auditor General's recommendation, and as part of OPG's commitment to continually improving the monitoring and assessment of its assets, OPG will:

- develop a Health Monitoring and Reporting (System Health) process that documents the criteria and timelines for ongoing station assessment, including software-based tools to capture data from various sources and assess asset health and condition;
- implement standard meetings with a cross-functional team to collaboratively review the data gathered; and
- implement a process to enhance senior management's ability to periodically assess station conditions and risks and ensure mitigation plans have been identified as necessary.

4.4.2 OPG Has Not Always Addressed Engineering Recommendations for Station Maintenance on a Timely Basis

As discussed in **Section 4.4.1**, engineers hired by OPG conduct Plant Condition Assessments (PCAs) of hydroelectric generating stations and provide recommendations of work required to maintain the reliability of those stations. The amount of work and cost required are typically reflective of the age of the station and its equipment.

We reviewed a sample of 10 PCAs and found that OPG did not always address these engineering recommendations on a timely basis. For example:

- For Sir Adam Beck I, one of OPG's oldest and largest stations, the most recent PCA was issued in 2020, while the previous one was issued 18 years prior, in 2002. In our review, we found that OPG had addressed 11 of the 29 major recommendations from the 2002 PCA, but the remaining 18 (such as those related to turbine overhauls and generator conversions) were still either in progress or scheduled for a future start date. Furthermore, the PCA in 2002 recommended $165 million of work over the next 30 years (up to 2032), whereas the most recent PCA in 2020 recommended a total of $768 million in expenditures over the next 30 years, almost five times higher than the amount recommended in 2002. Most of the major recommendations made in the 2020 PCA had also been made in the 2002 PCA.
- For Abitibi Canyon, a mid-sized generating station, the most recent PCA was issued in 2021, while the previous one was issued in 2016. We noted that of the 37 major recommendations in the 2016 PCA, only three had been fully addressed, three were in the process of being addressed, and 31 had either been scheduled only or not yet addressed. Apart from these major recommendations, the 2016 PCA also identified six additional items related to civil, mechanical and electrical assessments, but we noted that OPG had not taken any action to address these items by the time of the 2021 PCA. With regards to costs, the 2016 PCA recommended approximately $148 million of work over the next 30 years (up to 2046). The 2021 PCA recommended a total of $323 million in work over the next 30 years, over two times higher than the amount recommended in the 2016 PCA. The increase was primarily attributed to higher cost estimates for work that was already identified in the 2016 PCA. Most of the major recommendations made in the 2016 PCA were made again in the 2021 PCA.
- For RH Saunders, a large generating station, the most recent PCA was conducted in 2012, while the previous one was completed in 2005. The 2012 PCA did not provide specific updates on major recommendations made in the 2005 PCA (which was based on visual inspections, historical records and staff knowledge), because providing such updates was not a mandatory requirement at the time. While OPG has completed other assessments as needed since 2012, it has not conducted a PCA for this station over the last 10 years subsequent to the 2012 PCA, which recommended $236 million in expenditures over the next 30 years.

Through discussion with OPG staff and engineers, we were informed that managing a station's maintenance program and project portfolio sometimes involves shifting priorities, and requires that processes are in place (e.g., the Engineering Risk Assessment Program, business planning) to determine what work is urgent or critical versus what can be delayed safely to accommodate other required work. However, since OPG has no documentation that outlines how and when these discussions between engineers and operations staff happened, who made the decisions and why, and whether engineering recommendations were followed, we were unable to determine the specific reasons for delaying the work outlined within the above-noted PCAs.

In the absence of documentation, no information is currently available to assess whether any significant increases in cost estimates or work required in the most recent PCAs are a consequence of delaying work that past PCAs recommended.

RECOMMENDATION 6

To efficiently address required work as per engineering recommendations made during its hydroelectric generating station inspections and assessments, we recommend that Ontario Power Generation:

- develop timelines for follow-up on the completion of recommendations made;
- document the rationale and approvals for recommended work that is delayed or not completed by expected timelines; and
- investigate and document the rationale for why cost estimates have increased significantly from previous assessments and regularly report that information to its Board of Directors.

RESPONSE FROM ONTARIO POWER GENERATION

Ontario Power Generation (OPG) agrees with the Auditor General's recommendation. OPG is committed to the reliable operation of its facilities across Ontario by performing the right work at the right time and planning and executing work in accordance with its established asset management programs.

In response to the Auditor General's recommendation, and as part of its focus on continuous improvement OPG will:

- implement enhanced system health monitoring processes and tools to identify and document system health issues along with corrective actions and recommended timelines for implementation;
- establish collaborative meetings with Engineering and Operations leadership to review asset health recommendations and document task prioritization across the fleet; and
- utilize a defined level of accuracy for asset investment estimates and report on significant deviations as part of the established business plan submission to the Board of Directors.

4.5 OPG Can Further Improve the Reliability and Performance of Its Hydroelectric Generating Stations

The reliability of OPG's hydroelectric generating stations has been fluctuating over the last 10 years (2012–2021), with declining reliability from 2012 to 2019 as evidenced by the increase in the total duration of outages occurring at its stations and reduced availability, and then showing improvement in 2020 and 2021. While OPG's generating units have generally been performing at an average compared to peers in Canada, there is still room for improvement.

4.5.1 Fluctuating Reliability of OPG's Hydroelectric Generating Stations Poses Risks for Future When Electricity Demand Is Expected to Increase

OPG uses various measures to assess the performance of its hydroelectric stations. Some key measures relate to the reliability of a station's hydroelectric generating unit(s), a critical set of equipment containing a turbine that spins to produce electricity. A single OPG generating station can have anywhere from one to 16 generating units.

OPG produces a monthly reliability report that shows the performance of its stations' hydroelectric generating units. We reviewed the reliability reports produced over the last 10 years (2012–2022), focusing on the four key performance measures: (1) generating unit availability rate; (2) forced outage factor; (3) scheduled outage factor; and (4) incapability factor.

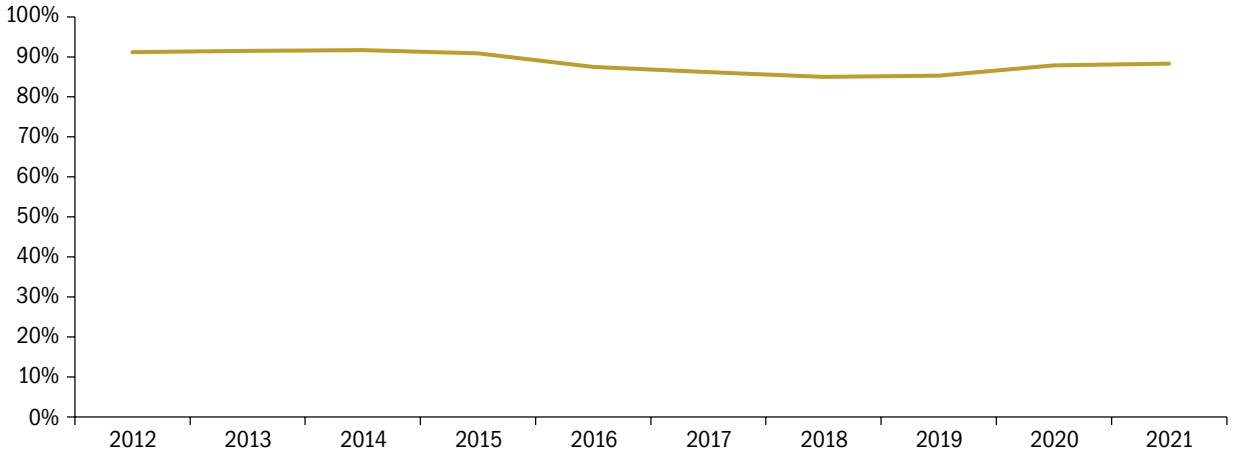
We found that the generating unit availability rate—the amount of time a generating unit is available for service divided by the total unit calendar hours in the period—has remained high over those 10 years (see **Figure 15**). This shows that OPG's hydroelectric generating stations have generally been a reliable source of electricity in the province.

However, the other three performance measures have fluctuated over the last few years when compared to the period between 2012 and 2014 (see **Figure 16**). Specifically:

- OPG's forced outage factor—the percentage of operating time a unit is unavailable due to forced outages within OPG's control (excludes external factors such as an outage across third-party transmission lines)—increased from 2% in 2012 to over 6% in 2019 and 2020. While the rate dropped to 3% in 2021, it was still slightly higher

Figure 15: Hydroelectric Generating Unit Availability Rate, 2012–2021

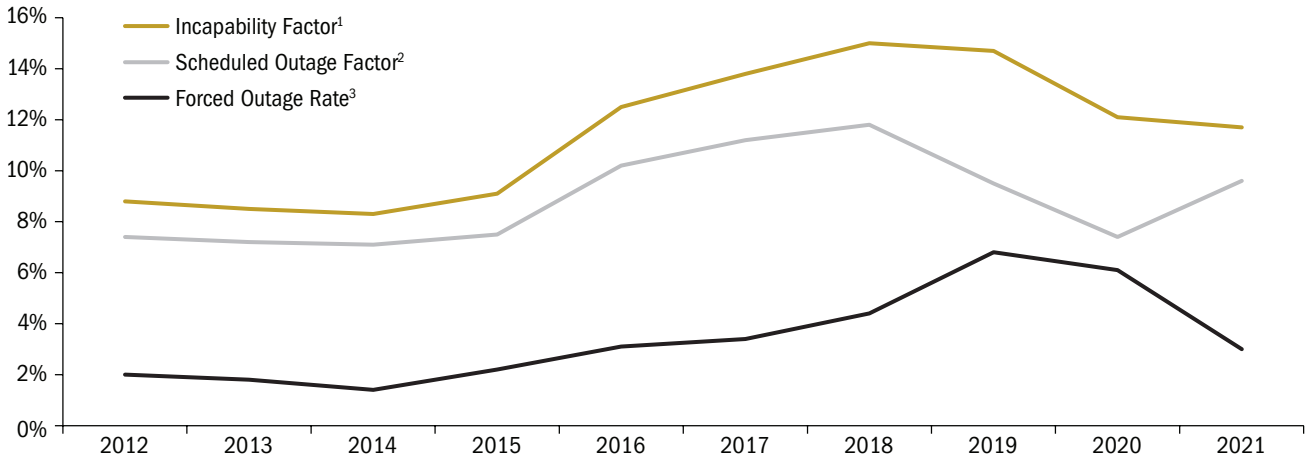
Source of data: Ontario Power Generation



Note: Generating unit availabilty rate is the amount of time a generating unit is available for service divided by the total calendar hours in the year that the unit was installed.

Figure 16: Hydroelectric Outage and Incapability Factor Results, 2012–2021

Source of data: Ontario Power Generation



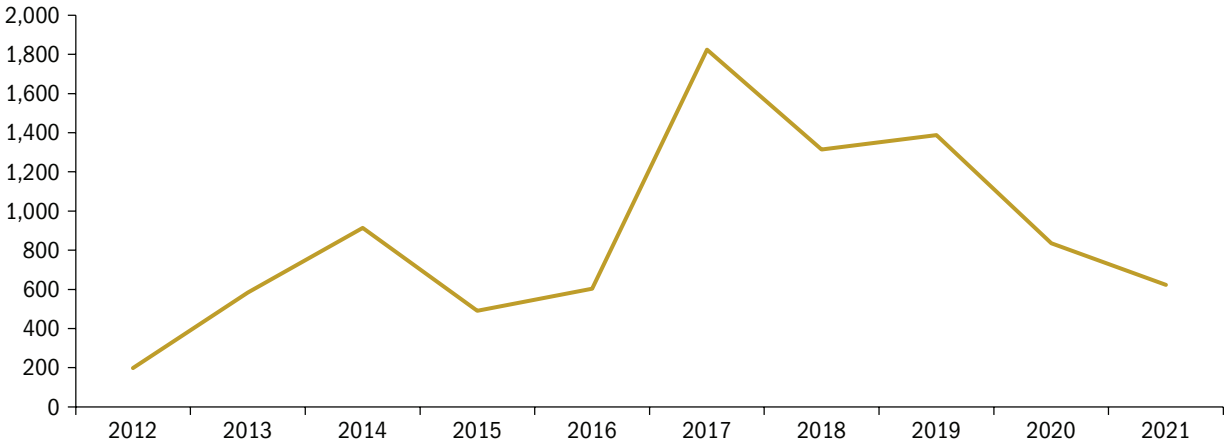
1. Incapability factor: the total percentage of time a unit is unavailable (planned and forced) over a specific time frame for outages within OPG's control.
2. Scheduled outage factor: the percentage of time a unit is unavailable due to planned downtime (for example, for preventative maintenance).
3. Forced outage rate: the percentage of operating time a unit is unavailable due to forced outages within OPG's control (excludes external factors such as an outage across third-party transmission lines).

than the rate in 2012. When forced outages are high, it limits OPG's ability to generate electricity.

- OPG's scheduled outage factor—the percentage of time a unit is unavailable due to planned downtime (for example, for preventative maintenance)—showed a smaller but noticeable increase, from 7.4% in 2012 to around 12% in 2018 and 9.6% in 2021. Scheduled outages are typically expected with aging equipment but, like forced outages, can have a negative impact on OPG's ability to generate electricity.
- OPG's incapability factor—the total percentage of time a unit is unavailable (planned and forced) over a specific time frame—increased from 8.8% in 2012 to 15% in 2018, before decreasing to 11.7% in 2021.

Figure 17: Estimated Electricity Loss Due to Planned and Forced Outages, 2012–2021 (thousands of megawatt hours)

Source of data: Ontario Power Generation



We also reviewed the approximate amount of energy production that was lost due to both planned and forced outages and found that energy production loss generally increased up to 2019, then decreased in 2020 and 2021 (as seen in **Figure 17**). However, the electricity lost in 2021 due to outages amounted to 623,000 megawatt hours (MWh), which was enough to power approximately 73,000 Ontario households for a year.

In order to identify the root causes of forced outages, we reviewed materials prepared by OPG's Engineering Risk Assessment Program (ERAP), which is a risk management program that aims to identify hazards and assess/treat risks related to OPG's equipment, systems or structures. As discussed in **Section 4.3**, we found that the aging of hydroelectric stations and equipment has led to a significant increase in maintenance costs and a continuous backlog of work orders, which in turn could lead to forced outages based on our review of the ERAP's 2020 annual presentation. In particular, the ERAP's 2020 annual presentation identified that:

- There was evidence indicating that maintenance on OPG's hydroelectric stations was not being completed.
- Regarding the reliability of turbines or generators, components are coming to the end of their useful life, resulting in an increase of OPG's equipment failure rate.
- For small hydro plants, equipment continues to age, and forced outages and breakdown maintenance have continued until re-development. Examples of recent failures include Meyersburg and Eugenia hydroelectric generating stations.

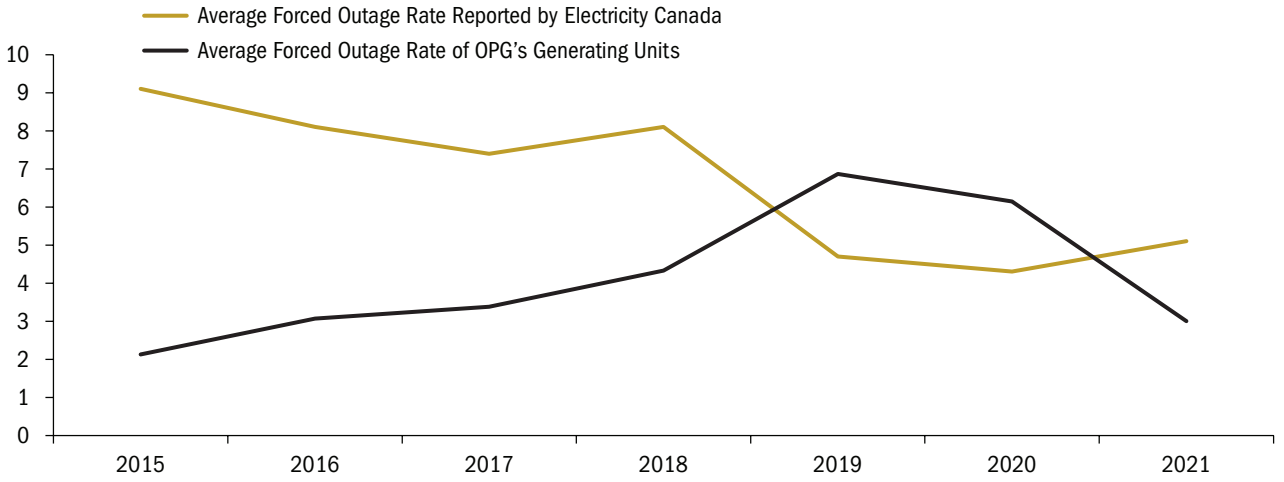
4.5.2 OPG's Performance in Hydroelectric Generation Has Room for Improvement in Comparison with Its Peers in Other Jurisdictions

We reviewed industry reports to compare OPG's performance in hydroelectric generation against similar organizations in other provinces. One of these industry reports, developed by Electricity Canada (formerly the Canadian Electricity Association), allows for reliability benchmarking of participating hydroelectric generation operators including OPG, Manitoba Hydro, SaskPower, BC Hydro and others.

As noted in **Section 2.1.1**, each hydroelectric station can house multiple generating units depending on the station design. One of the measures Electricity Canada reports on is the equivalent forced outage rate, which represents the percentage of time a generating unit is forced unavailable. We reviewed and analyzed OPG's generating units and compared it to the average

Figure 18: Equivalent Forced Outage Rate (%), 2015–2021

Prepared by Office of the Auditor General of Ontario



Note: Equivalent forced outage rate represents the percentage of time a generating unit is forced to be unavailable.

outage rate reported by Electricity Canada for each of the last seven years (see **Figure 18**). Overall, we found that the average of OPG's generating units was better than the Electricity Canada average in some years but worse in others. For example, in 2020, OPG's average forced outage rate among its units was approximately 6% while the average for operators reporting into Electricity Canada was closer to 4%.

Annual measures reported by Electricity Canada also include the following three performance measures, which are used to rank the top 10 best-performing generating units at hydroelectric stations in Canada:

- **Incapability factor—**the percentage of time a unit is unavailable due to total outages (planned and forced), calculated by dividing the total outage time of a unit (within the operator's control, excluding external factors) by the total unit hours in the period.
- **Operating factor—**the operation time of a unit, calculated by dividing the total operating time of the unit by the total unit hours in the period.
- **Availability factor—**the availability of a unit to operate, calculated by dividing the total hours the unit was available for service by the total unit hours in the period.

We found that while OPG's hydroelectric generating units were ranked as having a top 10 performance on occasion, it was not as often as some peer organizations in other provinces.

RECOMMENDATION 7

To further improve and maximize the reliability of its generating stations, we recommend that Ontario Power Generation:

- review why various reliability metrics, such as availability and outage factors, have shown fluctuating results; and
- identify learning opportunities and adopt best practices for improving the reliability of generating stations through, for example, its participation in various peer groups.

RESPONSE FROM ONTARIO POWER GENERATION

Ontario Power Generation (OPG) agrees with the Auditor General's recommendation. OPG is committed to operational excellence and will continue to identify opportunities to improve its operational performance through enhanced data collection

methods and the application of more advanced analytical techniques like machine learning.

In response to the Auditor General's recommendation, OPG will:

- utilize its Monitoring and Diagnostic Centre to proactively identify degradations in equipment performance;
- evaluate equipment failures that impact station reliability metrics to determine the root cause and identify actions to mitigate the risk of repeat failures; and
- continue to collaborate with industry peer groups and partners to share learnings and contribute best practices for improving asset reliability.

4.6 OPG Does Not Always Complete Capital Projects and Assessments in a Cost-Effective and Timely Manner

As discussed in **Section 2.3**, OPG incurs high capital costs as part of its hydroelectric operations. Capital expenses include refurbishing generating stations and replacing equipment as well as building new stations and related infrastructure such as dams and tunnels. Given that major projects typically include significant uncertainties, such as geotechnical conditions that impact construction, conducting an extensive risk analysis prior to project initiation and periodical reviews during the project are critical to reducing the risk of cost overruns or project delays.

We reviewed details related to a sample of five large capital projects that were completed over the last 15 years to assess OPG's performance in managing its capital projects in a cost-effective and timely manner. We found that insufficient planning by OPG has led to significant costs and delays on some of these projects. We also found that OPG did not always close out projects and complete post-project reviews on a timely basis to ensure lessons learned are applied to ongoing and future projects.

4.6.1 OPG Has Experienced Delays on Some Large Capital Projects with Cost Overrun on One Project Due to Insufficient Assessment and Planning

We reviewed estimated and final costs for a sample of large hydroelectric capital projects completed over the last 15 years (see **Figure 19**), and found that OPG experienced project delays on some projects and cost overrun on one progect as a result of insufficient assessment and planning.

Of the five projects shown in **Figure 20**, OPG was able to complete four under budget. However, we noted that as a result of work-order changes, the final costs of some of these projects were higher than what they could have been with more planning and project management processes in place. Furthermore, two of those projects faced significant delays that resulted in their completion three years later than originally expected. Examples of these projects are illustrated below.

Lower Mattagami River Redevelopment Project

We noted that OPG's original budget for the Lower Mattagami River Redevelopment Project was $2.56 billion, which included a $425 million project contingency fund (representing over 15% of the total budget) to account for any uncertainties and risk exposure such as geotechnical conditions and weather.

During the project, there were two cases where generating station site conditions (specifically, the state of the underground foundation) were significantly different from what OPG had originally noted in their preliminary assessments. This resulted in significant change orders and additional work at a cost of approximately $92 million, which was allocated from the project's $425 million contingency fund. It is possible that some of this additional work and related cost could have been reduced or avoided altogether with additional upfront planning.

Niagara Tunnel Project

Over several years before starting the Niagara Tunnel Project, OPG carried out substantial geotechnical

Figure 19: Sample of Completed Hydroelectric Projects, 2007–2022

Prepared by the Office of the Auditor General of Ontario

Project Name*	Project Description	Original Budget ($ million)
Lower Mattagami River Redevelopment Project	This project is located on the Mattagami River, approximately 70 kilometres northeast of Kapuskasing, Ontario. The project involved adding a third generating unit to three existing hydroelectric generating stations (Little Long, Harmon, and Kipling) and constructing a new three-unit generating station adjacent to another station (Smoky Falls) that was decommissioned.	2,560
Niagara Tunnel Project	This project involved building a new 10-kilometre-long water tunnel that allowed Ontario Power Generation to use additional water from the Niagara River for generation.	985
Upper Mattagami–Hound Chute Redevelopment Project	This project involved redeveloping three generating stations (Wawaitin, Sandy Falls, and Lower Sturgeon) on the Upper Mattagami River and the Hound Chute station on the Montreal River.	298
Sir Adam Beck Pump Generating Station Reservoir Refurbishment Project	This project involved refurbishing the Sir Adam Beck Pump Generating Station Reservoir to improve the safety of the reservoir.	58
Sir Adam Beck I G7 Frequency Conversion Project	This project involved installing a new generator and other equipment including a transformer, runner and an upgrade to a turbine.	35

* See **Figure 20** for details on the cost and timeline of each of these projects.

Figure 20: Costs and Timelines of a Sample of Completed Hydroelectric Projects, 2007–2022

Prepared by the Office of the Auditor General of Ontario

Project *	Original Budget ($ million)	Final Cost ($ million)	Surplus (Deficit) ($ million)	Estimated Completion Year	Actual Completion Year
Lower Mattagami River Redevelopment Project	2,560	2,520	40	2015	2014
Niagara Tunnel Project	985	1,460	(475)	2010	2013
Upper Mattagami–Hound Chute Redevelopment Project	298	285	13	2011	2010
Sir Adam Beck Pump Generating Station Reservoir Refurbishment Project	58	52	6	2017	2017
Sir Adam Beck I G7 Frequency Conversion Project	35	32	3	2009	2012

* See **Figure 19** for a description of each of these projects.

investigations to assess the sub-surface conditions of the site and inform the project design. However, within the first year of tunnel mining, OPG encountered unexpected adverse rock conditions, which resulted in significantly more money, work and time spent to excavate the tunnel than was originally expected. Specifically, OPG had to re-plan the project and revised the project budget from $985 million to $1.6 billion, an increase of over 62% (or $615 million). The project was originally scheduled to be completed by 2010, but

was delayed by about three years. The project was completed in March 2013 at a cost of $1.46 billion. Again, some of these cost increases and delays could have been avoided with additional upfront planning and project management processes.

Sir Adam Beck I G7 Frequency Conversion Project

OPG had expected the Sir Adam Beck I G7 Frequency Conversion Project, which involved installing a new generator, to be completed and fully operational in 2009. However, the new generator was operated in a derated (decreased capacity) state until 2011 and the project was subsequently completed in 2012.

We noted that this was primarily due to warranty work being needed to address deficiencies caused by a vendor. These deficiencies related to problems with a turbine that resulted in excessive vibration of the generating unit and pressure on the unit's cover, as well as limited operation of the wicket gate (which helps control the flow of water to the generator). These problems became apparent only after the generating unit was put back into service. While some of the work was covered under the warranty as part of the project scope, an additional $2.9 million in costs was incurred for turbine disassembly and reassembly as this was not covered by the warranty. Although the overall cost of the project was under the original project budget, OPG could have realized further savings had there not been deficiencies caused by the vendor and if the warranty had covered all related costs.

In reviewing OPG's risk register—which identifies, documents and retains information related to risks—we noted one identified risk was that poor workmanship and engineering by external vendors would have a significant financial impact on OPG's renewable generation projects. The risk register also indicated that recent experiences with poor design, workmanship or installation had resulted in equipment damage and/or delays to project schedules. In reviewing the OPG's Board of Director meeting minutes, we also found that the Board raised similar concerns about vendors not meeting OPG's expectations.

Other Ongoing Capital Projects

Besides reviewing the aforementioned capital projects that were completed over the last 15 years, we also reviewed OPG's ongoing capital projects and noted that delays and higher-than-expected costs are also being experienced in these projects. Through discussion with OPG and a review of these projects' details, we noted that the COVID-19 pandemic has also generally contributed to an increase in costs for construction supplies and equipment as well as project delays due to global manufacturing shutdowns, the closure of ports, and transportation delays.

Given that OPG will be involved with new hydroelectric generation projects, it is critical for OPG to ensure its capital projects are sufficiently planned, overseen and executed as well as continuously assessed for timeliness and cost-efficiency.

RECOMMENDATION 8

To plan and complete capital projects efficiently and cost-effectively, we recommend that Ontario Power Generation (OPG):

- work with potential vendors to conduct more thorough pre-project assessments to identify and reduce the risk of possible issues arising that could result in cost increases or project delays;
- oversee and monitor project work more closely on a regular basis to identify and correct any potential delays as soon as reasonably possible; and
- review its contract terms (such as warranty conditions) to ensure they protect OPG in the event of issues caused by vendors.

RESPONSE FROM ONTARIO POWER GENERATION

Ontario Power Generation (OPG) agrees with the Auditor General that capital projects should be planned and executed in an efficient and cost-effective manner.

OPG will continue to implement its enterprise-wide Project Excellence initiative to strengthen project management and controls, assess and incorporate industry best practices, and facilitate continuous improvement for capital projects including:

- engaging potential vendors as part of front-end engineering design planning, in order to improve early understanding of constructability and site conditions;
- further improving vendor oversight and communication through the Construction Centre of Excellence (CCoE) initiative and enhanced project management proficiency training; and
- reviewing contract template language to ensure OPG is appropriately protected in the event of vendor-related issues.

4.6.2 OPG Did Not Complete Post-Project Reviews in a Timely or Comprehensive Enough Manner

As part of the close-out of a capital project, OPG's policy is to conduct a review to document the effectiveness of the project, including whether it was completed on time and within budget. The level of detail contained in this post-project review is typically aligned with the cost and complexity of a project. A simple equipment replacement project generally has a short post-project review, while a post-project review for building a new generating station is more complex and includes details of how the project progressed and changed over time compared to the original proposal.

We found that OPG did not always close out projects and complete post-project reviews on a timely basis. For example:

- Although the Lower Mattagami River Redevelopment Project was completed in 2014, OPG did not complete the post-project review until 2020, six years later. OPG had originally estimated it would take one year to complete the review but subsequently noted it had underestimated the magnitude of the project close-out scope.
- For the Niagara Tunnel Project, which was completed by 2013, OPG did not complete the post-project review until three years later in 2016. Similar to the reasoning above, OPG had underestimated the project close-out scope based on the amount of work that had to be done.
- The Upper Mattagami–Hound Chute Redevelopment Project was completed by the end of 2010, but OPG did not complete the post-project review until the end of 2012. While OPG noted that a two-year close-out period could be expected for a project of this size, it also noted that poor record-keeping by the contractor resulted in more time spent to complete the post-project review.

We also identified an example where OPG did not conduct a comprehensive post-project review for a large project, specifically the building of Peter Sutherland Sr. Generating Station which involved a large capital cost of approximately $300 million. The project was completed ahead of schedule (2017 instead of 2018) and slightly under budget (by about $6 million), but OPG did not conduct a comprehensive post-project review as it had for other large projects we reviewed. Such a review for a successfully completed project of this size would help OPG to identify any best practices and/or lessons learned that could be applied to ongoing and future projects.

Post-project reviews help OPG and its senior management team learn from past projects so that future risks can be better managed. When OPG does not complete these reviews on a timely basis, it faces the increased risk of similar issues going unnoticed until they result in additional costs and project delays.

RECOMMENDATION 9

To evaluate capital projects and apply lessons learned to ongoing and future projects in a timely manner, we recommend that Ontario Power Generation:

- complete post-project reviews within one to two years after a project has been substantially

completed using techniques such as monitoring ongoing record-keeping and/or completing project close-outs in steps throughout the project; and
- conduct comprehensive post-project reviews on all large projects to identify lessons learned and/or best practices, and then apply them to ongoing and future projects accordingly.

RESPONSE FROM ONTARIO POWER GENERATION

Ontario Power Generation (OPG) agrees with the Auditor General's recommendation. OPG will continue to incorporate post-implementation and lessons learned reviews from ongoing and past projects into future work, in order to realize opportunities to execute projects more efficiently. Throughout all phases of the project lifecycle, OPG engages both internal and external stakeholders to identify opportunities to capitalize on successes and to seek opportunities for continuous improvement. Digital tools are utilized to facilitate the identification and retrieval of past lessons as part of project planning.

OPG is committed to further improving post-implementation review (PIR) practices and timeliness, and will:
- establish standard PIR governance to ensure all projects are reviewed at a level commensurate with their complexity and cost, and lessons learned are identified for application to future projects;
- implement target completion timelines and requirements for ongoing tracking and monitoring of PIR completion status; and
- develop digital tools and leverage existing sources of project information to improve PIR timeliness and streamline documentation management.

As recommended by the Auditor General, OPG will continue strengthening its post-project review processes and tools to identify additional opportunities for project improvements.

4.7 Rate-Setting Process Is Not Regulated for 12 OPG Hydroelectric Generating Stations

Of OPG's 66 hydroelectric generating stations, 54 are rate-regulated by the Ontario Energy Board (OEB) pursuant to the *Ontario Energy Board Act* (Act), meaning OPG submits cost projections for operating these stations to the OEB, which then assesses the reasonableness of the projections as part of its rate approval process. The other 12 stations are not prescribed under the Act and do not have their rates regulated by the OEB. Instead, they contract directly with the Independent Electricity System Operator (IESO) and thus negotiate their rates with the IESO. We found that their rates are higher than those for rate-regulated stations.

The process whereby OPG applies for rates for the 54 generating stations subject to the OEB's rate-regulation process is a transparent one. The OEB has a panel of commissioners, who are responsible for making independent decisions on applications and other hearing matters that come before the OEB. The OEB adjudicates rate applications through a quasi-judicial process, which is similar to a court-like process that involves an oral, written or electronic hearing, providing interested parties from the public an opportunity to comment on the rate applications. Members of the public may want to contribute such input as higher rates for generating stations could mean higher electricity rates for consumers. The OEB also shares the final decisions and rates publicly.

However, the remaining 12 stations that are non-rate-regulated go through a private process with the IESO, which contracts with those stations directly. While the IESO also reviews the reasonableness of cost projections, the commercial terms of the contracts between the IESO and these 12 stations are not made known to the public, similar to contracts between IESO and private sector hydroelectric generators. This means the public is not given any opportunity to provide input, nor are the final rates transparent to the public.

As part of our audit, we reviewed the rates for OPG's non-rate-regulated stations and found they are significantly higher than the rate-regulated stations' rates

which, since January 2021, have been approximately $43.88 per megawatt hour of electricity produced. As shown in **Figure 21**, the rates for non-rate-regulated stations vary, ranging from about $65 per MWh to about $250 per MWh, meaning they are at least 1.5 times to almost six times higher than the rate for rate-regulated stations. We also noted a wide range of rates for private sector (non-OPG) hydroelectric generators who contract directly with the IESO. Rates for these private sector generators ranged from approximately $70 per MWh to $154 per MWh.

We noted that the difference in rates between rate-regulated and non-rate-regulated stations is partly impacted by capital expenditures. Specifically, while both processes take into consideration the capital expenditures spent on hydroelectric generating stations, many non-rate-regulated stations are relatively newer and have incurred higher recent capital expenditures, typically contributing to a higher rate.

RECOMMENDATION 10

To consistently and fairly set rates for hydroelectric generation, we recommend that Ontario Power Generation work with the Ontario Energy Board, the Independent Electricity System Operator and the Ministry of Energy to complete a fulsome review of the rate-setting processes for rate-regulated stations and non-rate-regulated stations, and determine whether the current methods of rate-setting are appropriate and in the interests of ratepayers.

RESPONSE FROM ONTARIO POWER GENERATION

Ontario Power Generation (OPG) is committed to providing low-cost power in a safe, clean, and reliable manner, however, OPG does not have the authority to establish the form of payments for its generation assets.

The Ministry of Energy (Ministry) has determined which of OPG's facilities will be regulated and which of OPG's facilities will be contracted. Pursuant to section 78.1 of the *Ontario Energy Board Act, 1998* and O. Reg. 53/05, the Ontario Energy Board (OEB) is solely responsible for developing methods by which OPG is paid for the output of its regulated hydroelectric facilities and the amount OPG is paid. The Independent Electricity System Operator (IESO) has sole responsibility for developing procurement contracts for generation pursuant to sections 25.31 and 25.32 of the *Electricity Act, 1998*.

OPG's opportunity for input into the form of OEB regulation or IESO procurement contracts occurs solely in the context of public consultations convened by these two bodies. Aside from public consultations initiated by the OEB and IESO, OPG has no ability to work with the OEB and IESO on the form of payments for its hydroelectric generation.

Should the Ministry undertake a review of which stations are regulated or contracted, or should the IESO or OEB undertake a review of the compensation methodologies for OPG's hydroelectric assets, OPG would support any such review.

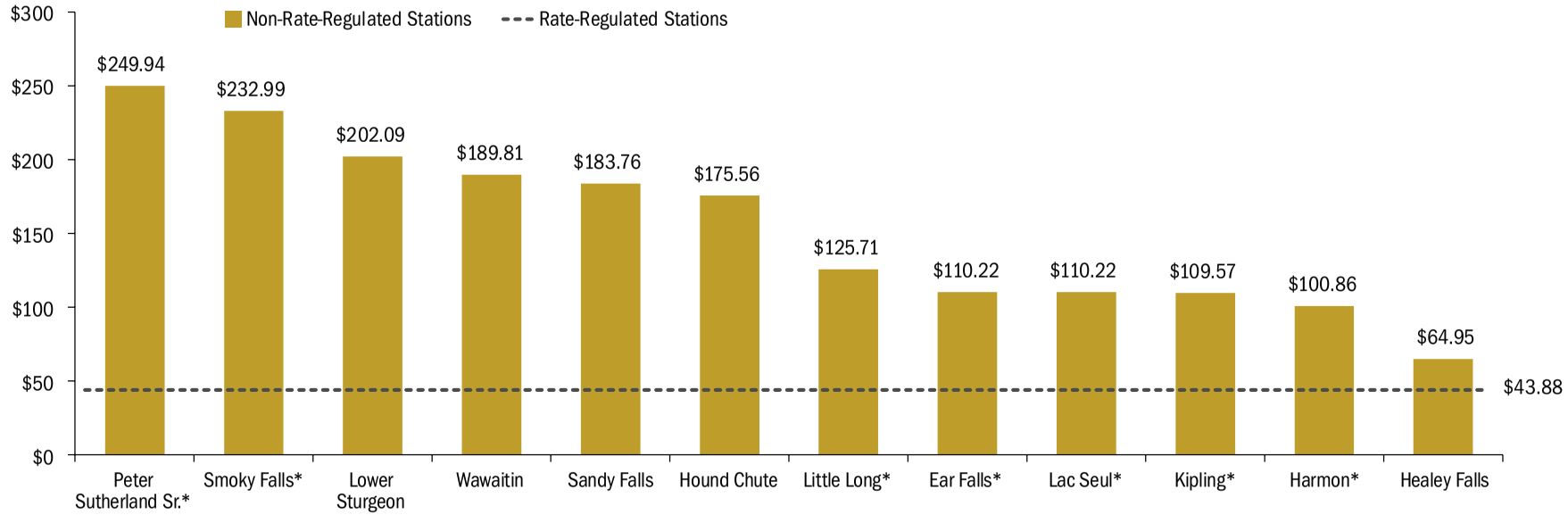
4.8 OPG Has Followed Dam Safety Best Practices, but Should Continue Working to Reduce Public Safety Events

An important part of hydroelectric generation is the use of dams. A dam is a structure or barrier that is constructed across a watercourse to control water levels and flow. In some instances, dams can store water in reservoirs for future use in hydroelectric generation. However, dams also pose a risk if they fail. For example, a dam failure can result in water spills that affect local animal and wildlife populations and, in some situations, can also impact nearby communities with issues such as flooding.

OPG owns and maintains 241 dams in Ontario. While OPG has never had a dam failure, having a strong dam safety program that constantly assesses the dam structure itself and other related aspects such as public safety is crucial in operating and managing hydroelectric stations.

Figure 21: Rates for OPG's Non-Rate-Regulated Stations and Rate-Regulated Stations, 2021 ($ per megawatt hour)

Prepared by the Office of the Auditor General of Ontario



	Peter Sutherland Sr.*	Smoky Falls*	Lower Sturgeon	Wawaitin	Sandy Falls	Hound Chute	Little Long*	Ear Falls*	Lac Seul*	Kipling*	Harmon*	Healey Falls
Original Date Unit Was Put in Service	2017	1931 (rebuilt 2014)	1923 (rebuilt 2010)	1912 (rebuilt 2010)	1911 (rebuilt 2010)	1910 (rebuilt 2010)	1963–2014	1930–1948	2009	1966–2014	1965–2014	1913-2010
2021 Installed capacity (MWh)	245,280	2,338,920	119,136	134,904	49,056	77,088	1,822,080	255,266		2,014,800	2,049,840	159,169
2021 Actual Generation (MWh)	93,386	515,179	40,735	50,111	29,823	40,192	394,846	94,521		451,303	445,851	82,239

Note: The per megawatt hour rates for non-rate-regulated stations were calculated by dividing the 2021 generation revenue by 2021 actual generation in megawatt hours. These rates do not include ancillary service revenue.

* Of OPG's 12 non-rate-regulated stations, these seven stations (Peter Sutherland Sr., Smoky Falls, Little Long, Ear Falls, Lac Seul, Kipling and Harmon) involve First Nations partnerships and ownership.

4.8.1 OPG Dam Safety Program Has Followed Industry Guidelines, but Dam Safety Reviews Were Not Completed on a Timely Basis

Based on our discussion with OPG senior management responsible for dam safety and our review of dam safety governance, we learned that OPG's policy is to operate its facilities in a safe, secure and reliable manner and ensure its dams comply with applicable dam safety legislation and requirements. In managing dam safety, OPG follows industry practices such as those recommended in the guidelines published by the Canadian Dam Association (CDA).

The CDA is an industry association comprised of individuals and organizational members including consulting engineers, dam owners, and regulators. The CDA provides a forum for the exchange of ideas and experiences in the field of dam safety. The CDA also has a Dam Safety Committee with a mandate to provide stewardship for technical publications including dam safety guidelines. Committee members are volunteers acting in their professional capacity and come from various organizations across the country, including OPG, BC Hydro, Hydro-Québec and others.

Through a review of publicly available information and discussion with various organizations and engineers, including dam safety professionals, we noted that the guidelines developed by the CDA are recognized as representing good industry practice in the area of dam safety. OPG's dam safety program is aligned with the CDA's guidelines, for example, by ensuring regular and timely inspections and reviews of all OPG's dams to maintain good functioning and safety.

As part of its dam safety program, OPG conducts two key types of inspection and review:

- **Dam safety general inspection (inspection)—** This is a regular inspection done by OPG's professional engineering staff for all 241 dams OPG owns and maintains. The inspections are scheduled every one to two years based on dam classification. An inspection involves performing detailed observations of the structure to ensure that components of the dam are functioning as designed, monitoring previously identified issues, and identifying emergent issues that may require monitoring or corrective action.
- **Dam safety review (review)—**This is a more comprehensive review completed by an independent third-party (typically an engineering consulting firm). A review involves confirming the dam's classification based on risks and compliance with current regulations and industry guidance as well as verifying the results of OPG's own dam inspections and assessments such as the above-mentioned dam safety general inspection. The frequency of reviews depends on the risk level of the dam. For example, OPG's policy is that a review should be completed every 10 years for dams that are classified as high-risk (typically meaning where a dam failure could result in a loss of life), while dams that are classified as low-risk (with no risk of loss of life and limited property and environmental impacts) should undergo a review approximately every 15 years.

To determine whether OPG completed dam safety general inspections on a timely basis, we reviewed a sample of 30 reports from these inspections (representing 12% of OPG's 241 dams). We found that OPG was generally completing these inspections on a timely basis. For all 30 dams we reviewed, an inspection was completed within the last two years (2020 or 2021) as scheduled.

We also reviewed a sample of 30 dam safety review reports and noted that while such reviews were comprehensive and reported on areas such as river flow levels, equipment testing and seismic movements that impacted or could impact dams, they were not being completed on a timely basis. For example, of OPG's 241 dams, only 102 (or 42%) were reviewed within the 10- to 15-year period after the last review. While the COVID-19 pandemic did result in a short-term deferral for some dam safety reviews, many had already passed the 10- to 15-year period. For example, 79 (or 33%) of OPG's dam safety reviews were or are in the process of being completed at least five years later than what is required per OPG's policy.

We also reviewed the results of inspections and reviews to determine what kind of issues or concerns were identified. We found that these were mainly related to regular maintenance work required to fix the structure or equipment of the dams (as discussed in **Section 4.3**) or corrections required to avoid reportable public safety events (as discussed further in **Section 4.8.2**).

4.8.2 Public Safety Events Remain High While Dam Safety Events Have Gone Down

OPG's practice is to track and report dam and public safety events. These are regularly reviewed by senior management and reported to OPG's Board of Directors. These events involve risks or issues related to the dams, generating stations, and controls put in place to maintain public safety. Events are categorized by severity, where Categories I, II and III indicate high, moderate and low severity, respectively (see **Figure 22** for more detailed definitions of these event categories).

We reviewed details of the events that occurred over the last seven years and found that while events for dam safety (involving the dam structure and/or station itself) have gone down, from 41 events in 2015 to 19 in 2021 (see **Figure 23**), events related to public safety have fluctuated from year to year but have increased and remained high in recent years, with 145 events occurring in 2021 (see **Figure 24**). OPG informed us that the increase in public safety events could be due to its improvement in monitoring practices, for example by using video cameras to more thoroughly capture public safety events.

We also reviewed details of these events to identify if OPG has taken timely and appropriate actions to address the issues (detailed in **Figure 25**). We found that:

- With regards to dam safety events (as shown in **Figure 23**), OPG did not experience any significant (or Category I) events. Rather, most of the Category II and III events observed were manageable and OPG took adequate steps to correct issues when they were identified.

Figure 22: Classifications of Dam Safety and Public Safety Events

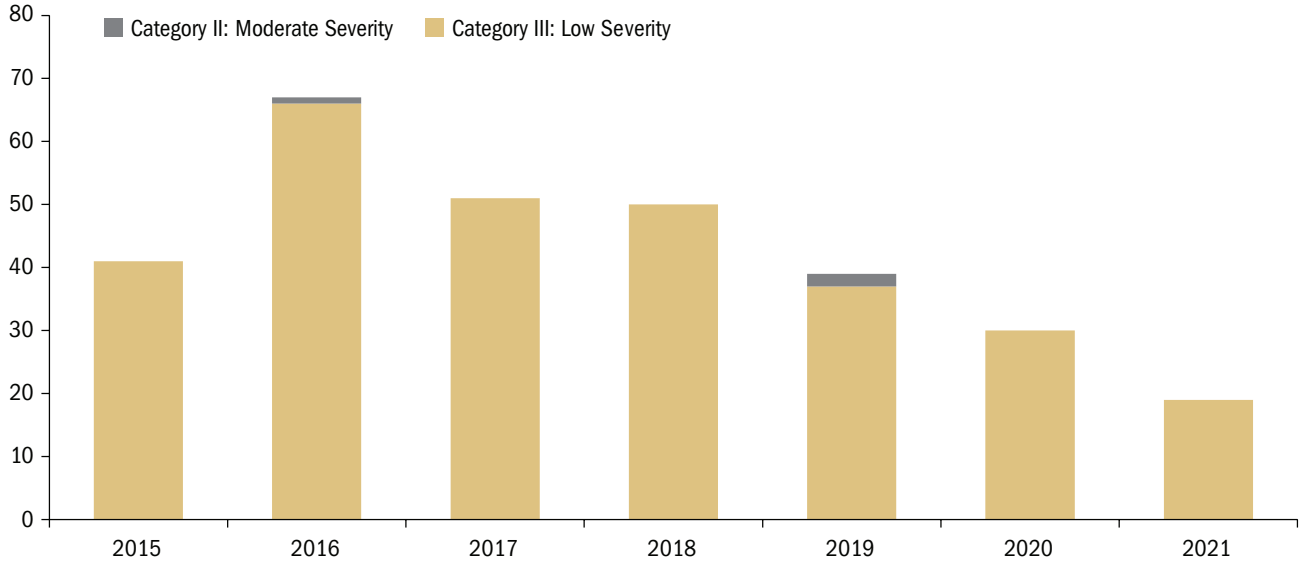
Prepared by the Office of the Auditor General of Ontario

Category	Severity	Dam Safety Event	Public Safety Event
Category I	High	A dam failure, including events created by a dam leading to a community activating an emergency plan for the purpose of evacuation.	An incident involving a dam or its operation that results in a rescue by a first responder, a fatality, or a serious injury.
Category II	Moderate	An event created by a dam that results in downstream communities and other stakeholders being notified to raise their level of awareness in preparing their response, or being given a notice to comply with a legislative dam safety requirement (e.g., a notice of trespassing to prohibit individuals from entering certain areas surrounding a dam).	An incident involving trespassing where there is a significant risk of exposure to potentially dangerous conditions associated with a dam or its operation that could result in a fatality or serious injury.
Category III	Low	Structural deficiencies of a dam that require interim measures to enhance monitoring and response (e.g., increasing seepage), or a spillway gate or other device failing to operate as designed.	An event involving trespassing where there is a risk of exposure to potentially dangerous conditions or the failure of a public safety control measure (e.g., a broken safety boom, which is a barrier that blocks access to certain areas surrounding a dam).

Note: See **Figure 25** for examples of dam safety and public safety events that have occurred at Ontario Power Generation.

Figure 23: Number of Dam Safety Events, 2015–2021

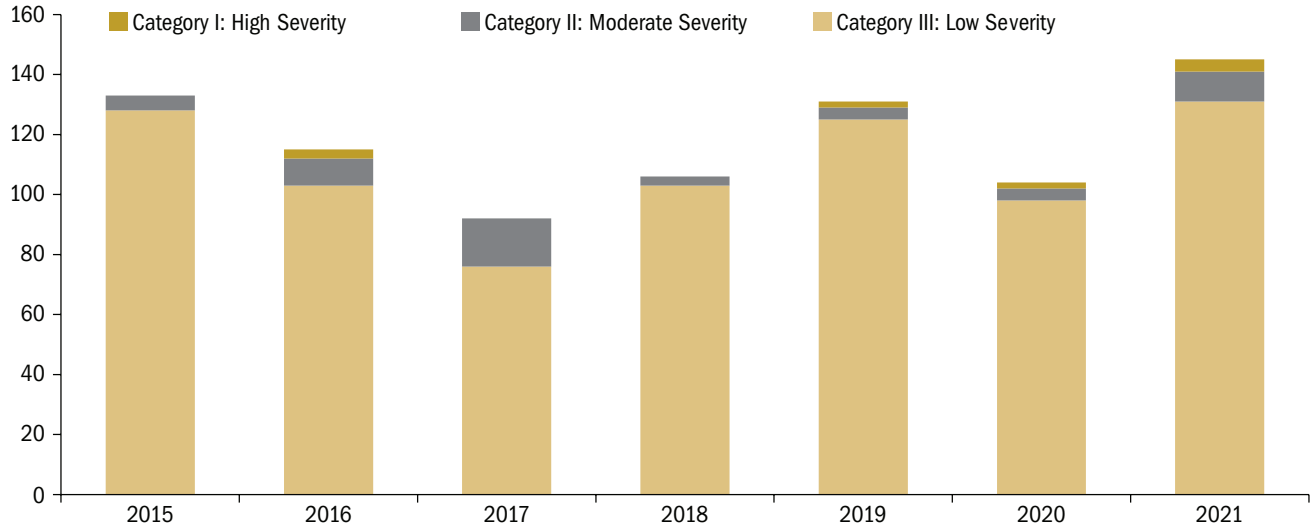
Prepared by the Office of the Auditor General of Ontario



Note: See **Figure 22** for more detailed definitions of event categories. No Category I dam safety events occurred between 2015 and 2021.

Figure 24: Number of Public Safety Events, 2015–2021

Prepared by the Office of the Auditor General of Ontario



Note: See **Figure 22** for more detailed definitions of event categories.

- With regards to public safety events (as shown in **Figure 24**), in most cases the issues arose because the public either ignored or did not notice warning signs about trespassing on OPG property or waterways (for example, when a kayaker was paddling in the waterway of a dam). In these cases, OPG generally took adequate steps to address issues, such as contacting and sharing information with law enforcement and local authorities.

While OPG may not have complete control over some aspects of public safety (such as the public ignoring signage or barriers and getting too close to a dam or generating station), it is important that OPG continue to remain diligent in taking steps to avoid such issues from occurring.

Figure 25: Examples of Dam Safety and Public Safety Events

Prepared by the Office of the Auditor General of Ontario

Type of Event	Category of Event*	Event Details and Response Taken by Ontario Power Generation (OPG)
Dam Safety	II	A sluicegate (a gate that can be opened and closed to control water flow) failed to open while attempting to let water pass. Staff found faulty electrical components and replaced them.
Dam Safety	II	A transmission line faulted, resulting in a generating station going offline. The backup generator overloaded and multiple staff were assigned to get the backup generator up and running.
Dam Safety	III	A headpond boom (floating barrier) was found broken at a dam during winter when ice had covered the water. Given the low risk of boating due to ice, repairs were put on hold and made later prior to boating season.
Dam Safety	III	After significant rainfall, erosion was noticed on the upstream side of a dam. Jersey barriers (barriers similar to those seen on roads during construction) were temporarily placed on nearby roads and a geotechnical engineering firm was contacted to determine a path forward.
Public Safety	I	An individual in a kayak was observed paddling in the waterway of a dam. The fire department was contacted to remove the kayaker and the kayaker was charged for entering a restricted area.
Public Safety	II	OPG security noticed a fishing vessel inside a risk area of a dam tailrace (the area immediately below the exit side of a dam) and contacted additional security to remove the vessel. OPG shared information with the local police service to identify the owner of the vessel to issue a notice of trespassing.
Public Safety	III	During a security patrol, security noticed a cut in a fence that was restricting access to OPG property. Security remained on-site until site services repaired the cut.

* See **Figure 22** for definitions of event categories.

While safety practices vary by dam based on site-specific risk assessments, and not every dam and generating station (such as those in very remote areas) requires measures such as a buoy and/or alarm system, it is important for OPG to continue to review and assess whether it has sufficient processes in place across all its dams and generating stations, including those that are easily accessible by the public.

RECOMMENDATION 11

To protect its hydroelectric generating stations, dams and the public, we recommend that Ontario Power Generation:

- complete all dam inspections and reviews on a timely basis in accordance with policies and best practices to assess the safety and operations of its dams; and
- continue to review safety processes across its hydroelectric assets to raise public awareness and identify opportunities to implement additional safety measures, such as buoys or alarm systems, where necessary and feasible.

RESPONSE FROM ONTARIO POWER GENERATION

Ontario Power Generation (OPG) agrees with the Auditor General on the importance of maintaining a robust dam safety program.

Public safety remains OPG's greatest priority which includes the safe operation of its dams and hydroelectric stations. OPG adheres to all applicable dam safety regulations and actively participates in forums which seek to improve dam safety.

OPG will further streamline its dam safety review process to ensure timely completion of the reports and maintain its ongoing assessments of the control measures in place to protect the public from water-related hazards.

OPG will also further work with local authorities, law enforcement and community stakeholders to raise awareness and build public acceptance of the hazards associated with dams and hydroelectric stations to further strengthen public safety in the province. OPG will also continue its multi-platform water safety campaigns, which change seasonally, and target water recreationists and anglers.

4.9 OPG Needs to Continue to Monitor and Report on Its Foreign Acquisition and Investment Activities

In addition to its own generating stations and operations in Ontario, OPG owns generation assets in the United States through a series of subsidiaries operating as Eagle Creek. In November 2018, OPG first acquired Eagle Creek for an equity value of $298 million US. In October 2019, OPG acquired Cube Hydro Partners LLC and Helix Partners PF for $1.12 billion US. The latter two organizations, along with Eagle Creek, are all under joint management as Eagle Creek.

OPG consolidates the operations and assets of Eagle Creek into its financial statements. Eagle Creek operates exclusively in the United States (with no presence in Ontario or Canada) with its own Board of Directors. Eagle Creek's current Board of Directors is comprised of four members, two of whom are executives from OPG.

Eagle Creek is considered a smaller hydroelectric operator when compared to OPG. Although Eagle Creek owns 87 hydroelectric generating stations in the United States, compared to OPG's 66 stations in Ontario, Eagle Creek's stations have a total installed capacity of 688 megawatts, almost 12 times less than the installed capacity of approximately 7,500 megawatts at OPG's 66 stations.

We spoke with senior management at OPG and noted that the investment in Eagle Creek was a strategic decision meant to act as a platform for long-term sustainable growth in United States markets. OPG's decision to look outside of Ontario for investment opportunities was due to limited growth opportunities available in Ontario at the time. Because the potential closure of Pickering Nuclear Generating Station in 2024/25 will result in a loss of nuclear generation, which in turn will create a gap in OPG's revenue, the investment in Eagle Creek was also made to provide a revenue source for OPG to partially fill this future revenue gap.

4.9.1 OPG and the Ministry of Energy Did Not Have an Acquisition Framework in 2018 When Acquiring Eagle Creek

We reviewed documents on the decision-making process of OPG's investment in Eagle Creek, and found that OPG and the Ministry of Energy (Ministry) did not have a formal acquisition framework or process in place to assess the potential acquisition of Eagle Creek in November 2018.

OPG has a mandate to pursue business opportunities both within and outside of Ontario. The 2015 Memorandum of Agreement between OPG and the Province of Ontario stipulates that "OPG shall leverage its assets and expertise to generate new revenues on a commercially sound basis, including the making of strategic investments and acquisitions in the electricity sector, as well as in related business opportunities inside and outside of Ontario, on its own or in partnership as appropriate, for the benefit of the Corporate and the Shareholder [the Province]."

We noted that OPG included only general details on its intent to look for investment opportunities outside of Ontario in its 2018–2021 business plan that was submitted to the Ministry. OPG noted that "… growth opportunities in Ontario's electricity sector remain limited due to uncertain future electricity demand levels, and OPG's current asset portfolio continues to be heavily weighted on Ontario-centric regulated nuclear and hydroelectric generation." Furthermore, OPG indicated its strategy would be to expand its business portfolio through "non-organic" investments, referring

to investments outside of Ontario. The business plan only mentioned that such investments would depend on market opportunities and the Province's expectations without specifying in what and where OPG was going to invest.

In April 2018, the then-Minister of Energy sent a response to OPG's business plan submission, acknowledging that "… the eventual shutdown of Pickering [Nuclear Generating Station] in 2024 will require changes to ensure OPG is financially and operationally strong, and positioned for future growth opportunities." The letter went on to say that "I [Minister of Energy] encourage OPG to continue to explore new business opportunities, including developments and acquisitions of projects. I expect OPG to keep the Province informed of its business development projects and to seek Shareholder [the Province's] concurrence on the material initiatives it plans to undertake."

We spoke with Ministry staff and found that while the Ministry was aware and kept informed of the acquisition process of Eagle Creek in 2018, formal Ministry approval was not required and the Ministry was not directly involved in the acquisition as direct taxpayer funds were not being used for the acquisition (OPG used its corporate public debt program and other available credit facilities to fund the acquisition). We also noted that OPG and the Ministry did not have an acquisition framework in place before making these multi-million-dollar foreign investment decisions.

It was not until 2021, about two years after OPG's acquisition of Eagle Creek, that the Ministry and OPG finalized an acquisition framework to evaluate any future investment opportunities. This acquisition framework described the steps OPG would take to ensure it was adequately assessing, prioritizing and valuating investment opportunities. For example, the framework indicates that OPG should consider the following:

- The time frame for a positive contribution to OPG's net income.
- How the investment would be part of a transition to a cleaner economy from an environmental perspective.
- How the investment would create long-term savings for Ontarians and stimulate economic development and/or employment in Ontario.

The acquisition framework also requires OPG to regularly monitor the performance of its investment and conduct a periodic (three to five year) strategic review, which is to be shared with OPG's Board of Directors as well as the Province as its shareholder. Additional details related to a recently completed strategic review are included in **Section 4.9.2**.

4.9.2 OPG's Rate of Return from Its Investment in Eagle Creek Is Lower Than Expected

As discussed in **Section 4.9.1**, Eagle Creek owns and operates hydroelectric generating stations to provide a return to its investor, namely OPG. OPG originally estimated that it would earn a certain return on its investment in Eagle Creek. However, in 2022, OPG completed a strategic review of its investment in Eagle Creek and lowered its expected rate of return by about 1.2%.

We reviewed OPG's analysis and surrounding details and noted there were multiple reasons for the reduced rate of return, including the COVID-19 pandemic which began in March 2020 and reduced electricity demand due to lockdowns in the United States. Eagle Creek also provides returns by investing in other hydroelectric organizations, but the COVID-19 pandemic has resulted in limited investment opportunities being brought to the United States market for Eagle Creek to expand its business. This in turn has also impacted the expected rate of return on investment for OPG.

It is important that OPG and the Ministry continuously monitor the status of this investment to ensure Eagle Creek provides a positive rate of return.

We also reviewed the revenue earned from Eagle Creek and noted that it was significantly lower than the revenue gap that would exist if Pickering Nuclear Generating Station (Pickering Station) was shut down. For example, in 2021, the revenue from Eagle Creek was approximately $140 million while Pickering Station's revenue was about $2 billion.

RECOMMENDATION 12

To protect the Province and by extension Ontario taxpayers and ratepayers, we recommend that Ontario Power Generation:

- complete an annual strategic review of its foreign investments and potential investment opportunities in Ontario and provide this information to both its Board of Directors and the Province; and
- regularly assess its acquisition framework, including a forward-looking risk analysis and potential investments (in both Ontario and other jurisdictions), and report those results to the Province.

RESPONSE FROM ONTARIO POWER GENERATION

Ontario Power Generation (OPG) agrees with the Auditor General's recommendation and is focused on growing in ways that support a sustainable future and provide the greatest value to Ontario taxpayers and ratepayers.

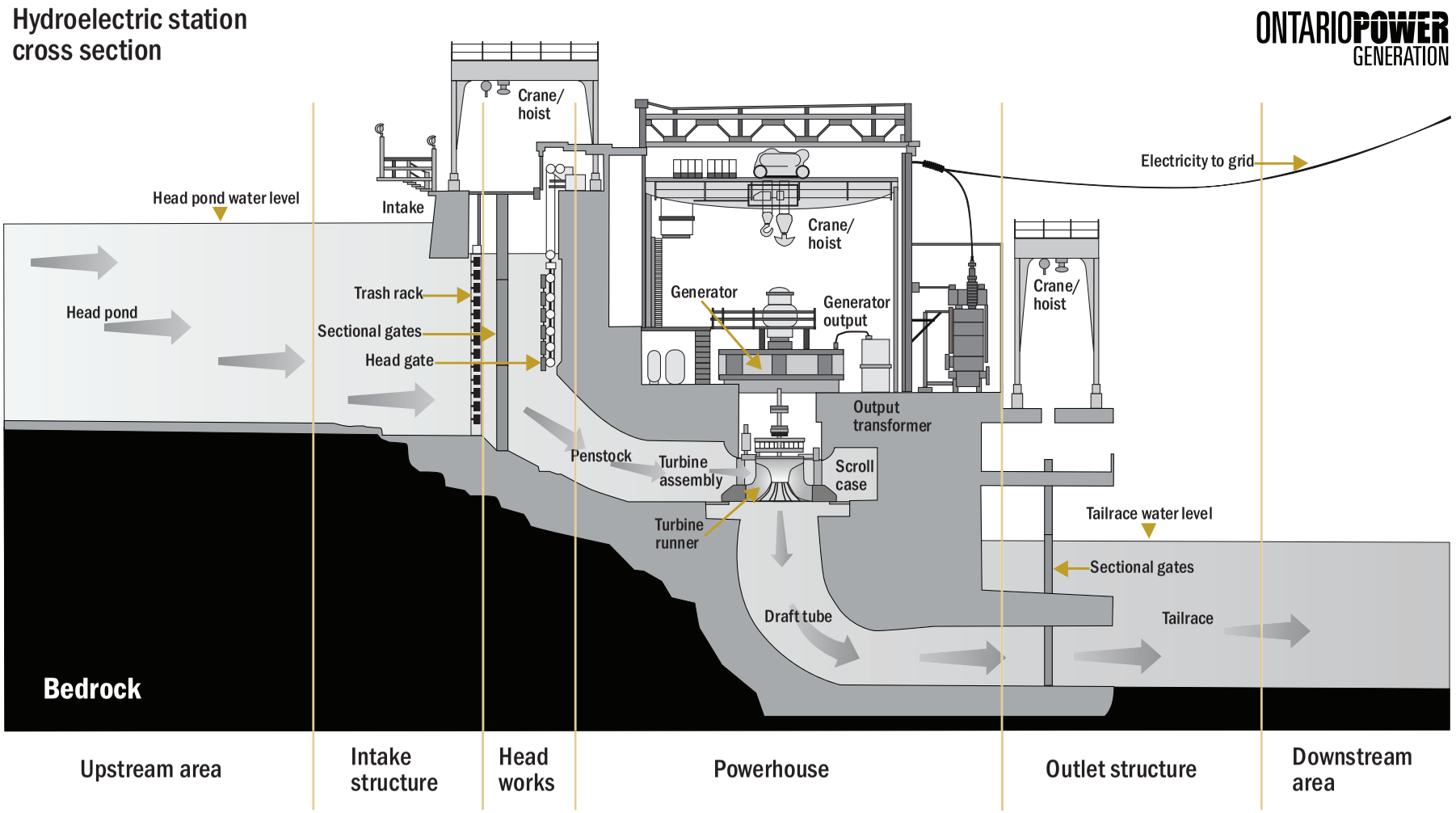
As part of OPG's commitment to its Board of Directors, it has established an Acquisition Performance Monitoring Framework, inclusive of annual performance updates. OPG will continue to report to its Board of Directors on this information on an annual basis and will provide the same information to the Province.

OPG's Acquisition Performance Monitoring Framework includes a periodic strategic review, as the Auditor General has recommended. As market conditions dictate, OPG intends to adjust the frequency of this strategic review to ensure its Board of Directors and the Province is aware of any substantial changes.

While the Acquisition Framework between OPG and the Province does not contain a formal assessment process, it does include a requirement for ongoing meetings which occur approximately once per month. The intent of this forum is to discuss potential investments. As part of this process, OPG commits to assessing the Acquisition Framework annually with the Province to ensure it remains effective and is structured to serve the best interest of Ontario taxpayers and ratepayers.

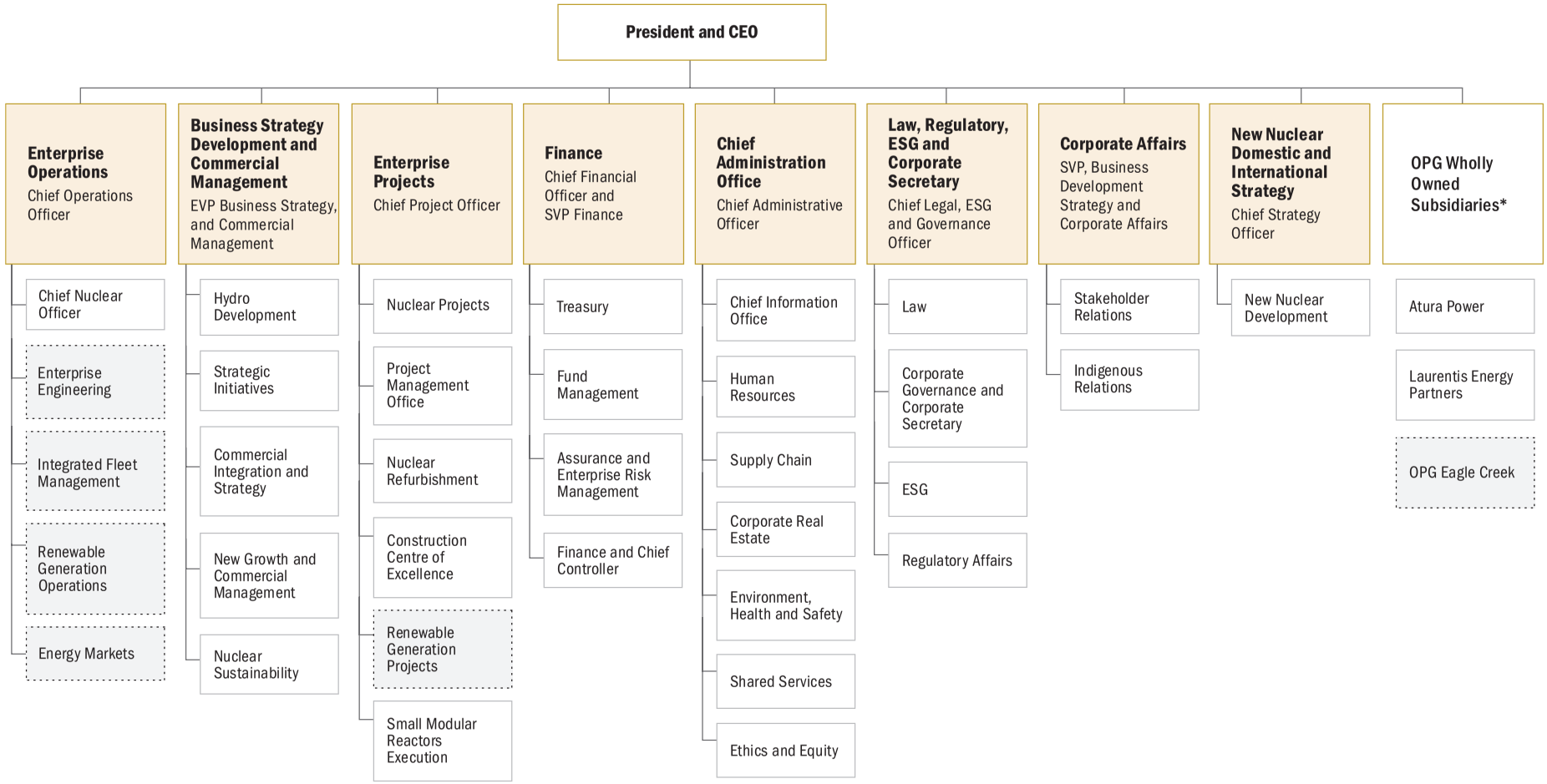
Appendix 1: Hydroelectric Generating Station

Source: Ontario Power Generation



Appendix 2: OPG Organizational Chart

Prepared by the Office of the Auditor General of Ontario



Our audit focuses on these divisions

* Not a comprehensive list

Legend: EVP – Executive Vice President
SVP – Senior Vice President
ESG – Environmental, Social and Governance

Appendix 3: OPG's Hydroelectric Generating Stations

Prepared by the Office of the Auditor General of Ontario

Region	Hydroelectric Generating Station	Original Date Unit Was Put in Service	2021 Installed Capacity (megawatts)	2021 Actual Generation (megawatt hours)	Age (# of years)[1]
Eastern (32 Stations)	Abitibi Canyon[2]	1933–1959	345	858,043	62–88
	Arnprior	1976–1977	82	133,976	44–45
	Barrett Chute	1942–1968	176	295,749	53–79
	Bingham Chute	1923–1924	1	2,619	97–98
	Calabogie[3]	1917	0	–	104
	Chats Falls	1931–1932	96	502,995	89–90
	Chenaux	1950–1951	144	645,841	70–71
	Chute	1923–1924	3	10,447	97–98
	Coniston	1905–1915	3	11,946	106–116
	Crystal Falls	1921	8	38,459	100
	Des Joachims	1950–1951	429	1,968,348	70–71
	Elliot Chute	1929	2	4,194	92
	Harmon[4]	1965–2014	234	445,851	7–56
	Healey Falls[4]	1913–2010	18	82,239	11–108
	Hound Chute[4]	1910 (rebuilt 2010)	9	40,192	11
	Kipling[4]	1966–2014	230	451,303	7–55
	Little Long[2,4]	1963–2014	208	394,846	7–58
	Lower Notch	1971	274	293,710	50
	Lower Sturgeon[4]	1923 (rebuilt 2010)	14	40,735	11
	Matabitchuan	1910	10	34,274	111
	McVittie	1912	3	14,273	109
	Mountain Chute	1967	170	299,174	54
	Nipissing[5]	1909	0	–	112
	Otter Rapids	1961–1963	182	431,051	58–60
	Otto Holden	1952–1953	243	911,963	68–69
	Peter Sutherland Sr.[2,4]	2017	28	93,386	4
	RH Saunders[2]	1958–1959	1,045	7,211,104	62–63
	Sandy Falls[4]	1911 (rebuilt 2010)	6	29,823	11
	Smoky Falls[2,4]	1931 (rebuilt 2014)	267	515,179	7
	Stewartville	1948-1969	182	295,430	52–73
	Stinson	1925	5	20,760	96
	Wawaitin[4]	1912 (rebuilt 2010)	15	50,111	11
Western (29 Stations)	Aguasabon	1948	47	100,355	73
	Alexander	1930–1958	69	338,815	63–91
	Auburn	1911–1912	2	9,364	109–110
	Big Chute[6]	1909–1919 (rebuilt 1993)	10	–	28
	Big Eddy	1941	8	44,138	80
	Cameron Falls	1920–1958	92	404,906	63–101

Region	Hydroelectric Generating Station	Original Date Unit Was Put in Service	2021 Installed Capacity (megawatts)	2021 Actual Generation (megawatt hours)	Age (# of years)[1]
	Caribou Falls	1958	91	299,440	63
	Ear Falls[4]	1930–1948	17	94,521	73–91
	Lac Seul[4]	2009	12		12
	Eugenia Falls	1915–1920	6	21,502	101–106
	Frankford	1913	3	10,047	108
	Hagues Reach	1925	4	19,279	96
	High Falls	1920	3	14,127	101
	Kakabeka Falls	1906–1914	25	92,260	107–115
	Lakefield	1928	2	7,454	93
	Manitou Falls	1956–1958	73	230,120	63–65
	Merrickville	1915–1919	2	2,826	102–106
	Meyersberg	1924	5	20,510	97
	Pine Portage	1950–1954	145	420,437	67–71
	Ragged Rapids	1938	8	43,446	83
	Ranney Falls	1922–1926	10	63,340	95–99
	Seymour	1909	6	29,040	112
	Sidney	1911	4	21,019	110
	Sills Island	1900	2	9,263	121
	Silver Falls[7]	1959	48	–	62
	South Falls	1916–1925	6	46,443	96–105
	Trethewey Falls	1929	2		92
	Hanna Chute	1926	1		95
	Whitedog Falls	1958	68	159,093	63
Niagara (5 Stations)	DeCew Falls I	1898	23	1,213,971	123
	DeCew Falls II	1948	144		73
	Sir Adam Beck I[2]	1922–1930	438	11,355,484	91–99
	Sir Adam Beck II[2]	1954–1958	1,499		63–67
	Sir Adam Beck Pump Generating Station	1957–1958	174		63–64
Total	**66**		**7,481 (rounded)**	**31,199,221**	

1. The age of some stations is presented as a range, because each generating station can have multiple generating units which may have started operating in different years.
2. Generating stations we visited during our audit.
3. Calabogie Generating Station was critically damaged by a tornado in September 2018 and will be out of service until the completion of a redevelopment project scheduled in 2022.
4. Contracted (non-rate-regulated) generating stations.
5. Nipissing Generating Station no longer generates electricity following the decision to not refurbish leaking penstocks.
6. Big Chute Generating Station is currently offline for repair work (that is, a forced outage).
7. Silver Falls Generating Station is currently in a planned outage (that is, an overhaul).

Appendix 4: Glossary of Terms

Prepared by the Office of the Auditor General of Ontario

Term	Definition
Baseload generators/ generating stations	Generating stations that produce a constant, steady supply of electricity 24 hours a day, seven days a week.
Canadian Dam Association (CDA)	A group of owners, operators, regulators, consultants and suppliers interested in dams and reservoirs. CDA provides a forum for the exchange of ideas and experience in the field of dam safety, public safety and protection of the environment.
Dam failure	An uncontrolled release of water through a dam as a result of structural failures or deficiencies in the dam.
Electricity Canada	An association (formerly called the Canadian Electricity Association) that provides a forum for the evolving and innovative electricity business in Canada. It supports, through its advocacy efforts, the regional, national and international success of its members.
Electrification	The process of replacing technologies that use fossil fuels (coal, oil, and natural gas) with technologies that use electricity as a source of energy.
Forced outage	The shutdown of a generating unit for emergency reasons or due to an unanticipated breakdown of a unit.
Generating unit availability rate	The amount of time a hydroelectric generating unit is able to produce electricity over a certain period divided by the amount of time in the period.
Hydroelectric energy (waterpower)	A form of renewable energy that uses the power of moving water (waterflow) to generate electricity.
Hydroelectric generating station	A station that converts the energy of moving or flowing water into electricity.
Incapability factor	The total percentage of time a unit is unavailable for outages (planned and forced) within OPG's control.
Independent Electricity System Operator (IESO)	The co-ordinator, integrator, and planner of Ontario's electricity system. The IESO monitors the energy needs of the province in real time (24 hours a day, seven days a week), balances supply and demand, directs the flow of electricity across Ontario's transmission lines, and performs electricity system planning.
In-service capacity	The portion of installed capacity that can be depended upon to produce electricity.
Installed capacity	The maximum amount of electricity that can be produced by a generator (or generating station or generating unit).
Megawatts (MW)	A unit of measurement to determine electricity generation/consumption, equal to one million watts.
Megawatt hour (MWh)	A unit of energy equal to outputting one million watts for one hour.
Ontario Energy Board (OEB)	The regulator of the province's electricity and natural gas sectors to protect the public interest, including setting payment rates for OPG production at its regulated generating stations.
Ontario Waterpower Association	A not-for-profit, member-based organization that promotes the sustainable development of waterpower resources in Ontario.
Plant Condition Assessment (PCA)	A forward-looking tool used to assess long-term factors related to a generating station such as aging, major component replacements, rehabilitation options, etc.
Post-implementation review	A documented review conducted to analyze the effectiveness of completed capital projects.

Term	Definition
Ratepayer	An Ontarian or business that pays for electricity.
Renewable energy	Energy derived from natural processes that are replenished at a rate that is generally equal to or faster than the rate at which they are consumed. Examples of renewable energy sources include hydro (or water), wind, solar and biomass.
Return on equity (ROE)	A measure of financial performance/profitability.
Risk register	A database that identifies, documents and retains information on risks related to capital projects, including (but not limited to) the description, cause and potential impact of the risk.
Scheduled outage	The shutdown of a generating unit for a planned inspection, maintenance or other work.
Sluiceways	A sliding gate or other device for controlling the flow of water.
Spillways	A structure within a dam that provides a safe path for excess water to flow to a downstream area.
Surplus baseload generation (SBG)	A situation when electricity production from baseload facilities (generators) is greater than electricity demand.
Work order	A document (either in electronic or paper format) that describes maintenance work that has been approved for completion.

Appendix 5: Audit Criteria

Prepared by the Office of the Auditor General of Ontario

1.	Asset planning and investment processes are in place to identify hydroelectric assets for maintenance, replacement and refurbishment based on a sound documented rationale such as a rating system, and to justify the rationale and need for investment in new capital projects.
2.	Hydroelectric assets are routinely assessed based on accurate, complete and timely data to appropriately prioritize and complete needed preventative maintenance activities in order to maintain the reliability of hydroelectric stations and prevent potential outages of or damages to stations.
3.	Revenues and resource allocation (for example, human resources) for hydroelectric generation are based on timely, reliable and reasonable information, taking into consideration costs and assumptions of risk with due regard for economy and efficiency.
4.	Assets (including equipment and supplies) for hydroelectric capital and maintenance projects are acquired through competitive and transparent procurement procedures to achieve value for money and meet the quality standards.
5.	Hydroelectric capital and maintenance projects are properly managed, maintained and renewed cost-effectively, efficiently and timely in accordance with relevant policies, capital plans, and asset management practices.
6.	The impacts of hydroelectric stations to the environment and public safety, which can be caused by operational issues and incidents such as dam failures and flooding, are minimized and/or prevented by implementing appropriate and effective measures as well as monitoring on a regular basis.
7.	Roles and responsibilities of all parties involved in hydroelectric operations are clearly defined and accountability requirements are established to ensure effective service delivery, co-ordination and oversight.
8.	Appropriate and relevant performance measures and targets for hydroelectric capital and maintenance projects are established and continuously monitored and reported on against actual results to ensure that intended outcomes are being achieved and that corrective actions are being taken when issues are identified.

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