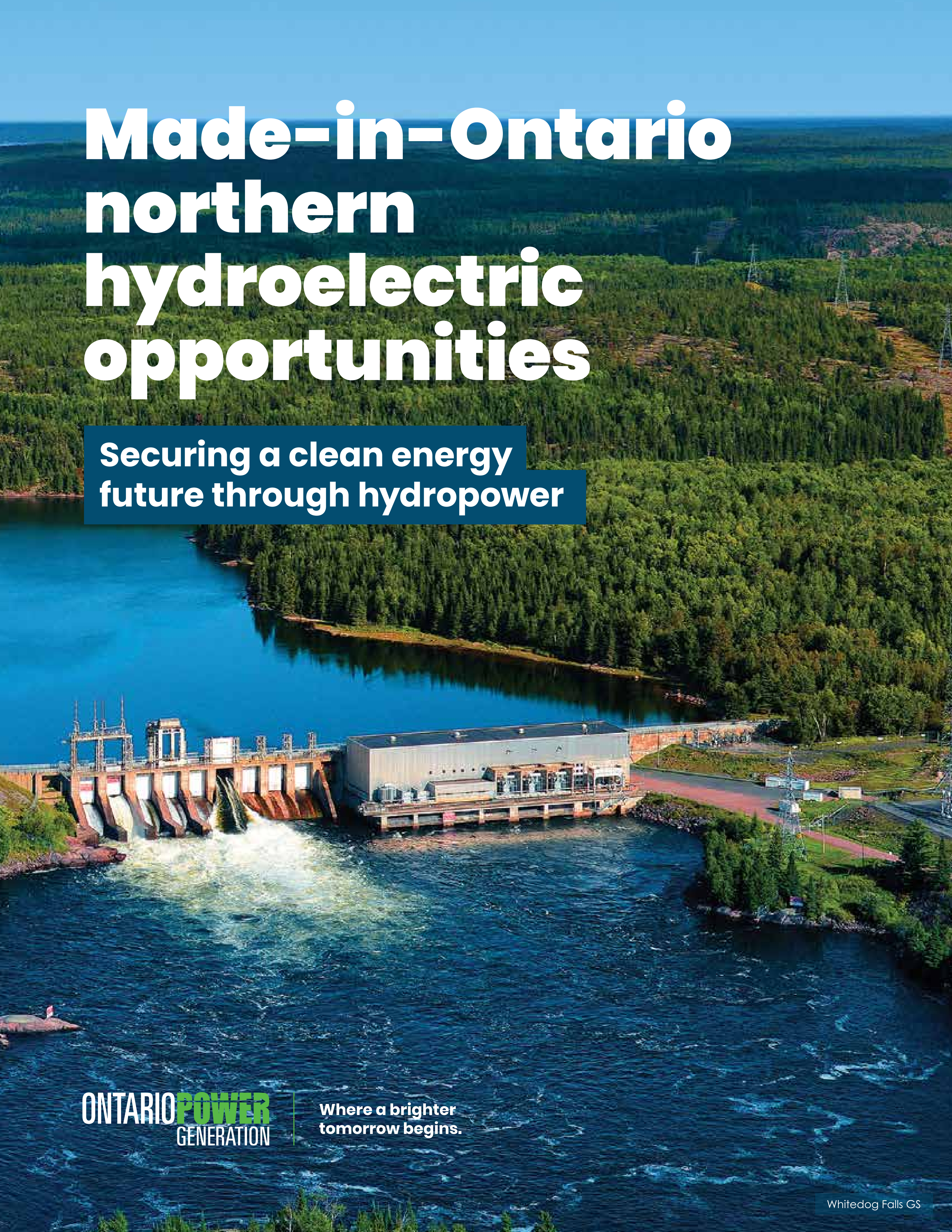
Made-in-Ontario northern hydroelectric opportunities

Securing a clean energy future through hydropower



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ONTARIO POWER GENERATION

Where a brighter tomorrow begins.

Made-in-Ontario northern hydroelectric opportunities

Securing a clean energy future through hydropower

The Honourable Todd Smith
Ontario Minister of Energy

Dear Minister Smith,

In response to your letter of January 20, 2022, I'm pleased to provide you with this report titled: **Made-in-Ontario northern hydroelectric opportunities: *Securing a clean energy future through hydropower***. The report should help to inform plans to meet Ontario's emerging energy demands, as you work to ensure economic growth and progress on decarbonization progress for the critical decades ahead.

Rightly noted in your request, hydroelectric power has been a stalwart, serving Ontario's electricity needs for well over a century, and continuing to this day. It helped a growing province expand its industrial base, shaped local economies from Kenora to Cornwall, and created jobs everywhere in between. Today, hydro and nuclear power produce more than 85% of Ontario's total energy and remain the backbone of its grid – one of the cleanest in the world.

Ontario is indeed fortunate to have thousands of megawatts of untapped hydroelectric potential, as well as realistic options for achieving this potential. While economies around the world face pressure to decarbonize, few have this enviable advantage. Meeting the projected demand growth, and decarbonizing other sectors through widespread electrification, will require mobilizing reliable, clean power sources like hydro.

New northern hydroelectric development would also be a boon to other economic priorities like the Ring of Fire, which in turn helps advance *Ontario's Critical Mineral Strategy*. And as noted in the *Driving Prosperity Automotive Plan*, the province has "*an incredible opportunity to connect and vertically integrate our northern and southern economies to build a made-in-Ontario supply chain for innovative technologies like electric vehicles and battery storage.*"

Investments in hydro development would also directly benefit our economy with at least 75% of capital expenditures and 90% of lifetime operational expenditures spent in Ontario. Our durable, century-old hydroelectric stations also remain the lowest-cost sources of power in the province. Provided the assets are maintained, hydroelectricity is also the only generating technology that is renewable, long-lasting and readily available.

As we've learned through OPG's ground-breaking hydro partnerships with Indigenous communities, these potential developments could bring about lasting economic and social benefits to Indigenous communities and enable other significant regional economic benefits by supplying clean energy to communities and local mines.

Though every community has unique needs and perspectives on specific projects, all of the Indigenous communities OPG had initial conversations with were generally supportive of hydroelectric development, provided it is done responsibly, there is meaningful, early participation, and community benefits that further economic and social progress. In turn, the development plans will also benefit from the connection that Indigenous partners have to the lands and rivers where these sites are located.

Finally, new hydroelectricity can be a source of pride and confidence for Ontarians in knowing their economic future is significantly powered by a secure, domestic source of electricity. Once developed, these facilities become multi-generational, perpetual assets that provide renewable energy for generations to come.

To make the most of this natural energy advantage in ways that are sustainable and inclusive of Indigenous and northern community needs, OPG recommends beginning planning and strategic work now. This includes working with the Independent Electricity System Operator (IESO) to inform their *Pathways to Decarbonization Study*, as well as the Government's future long-term energy planning framework to explore a future role for new hydro. It also includes accelerating advanced projects where progress has been made on Indigenous community commercial partnerships and environmental assessments, as well as initiating co-planning discussions with First Nations on hydroelectric development in the Moose River Basin. New hydroelectricity, similar to nuclear, can take a decade plus to develop. There is a clear need to start now, ensuring we build out our clean energy grid for future generations. The full list of recommendations can be found in the Taking Action section of the report.

Minister, we thank you for the opportunity to carry out this important examination and we look forward to engaging in next steps, with all partners including the IESO, the Ontario Waterpower Association (OWA), Indigenous communities, appropriate ministries, and northern stakeholders, to analyze, plan and initiate further development of northern Ontario's hydroelectric potential.

Sincerely,

Ken Hartwick

Ken Hartwick

President and Chief Executive Officer
Ontario Power Generation

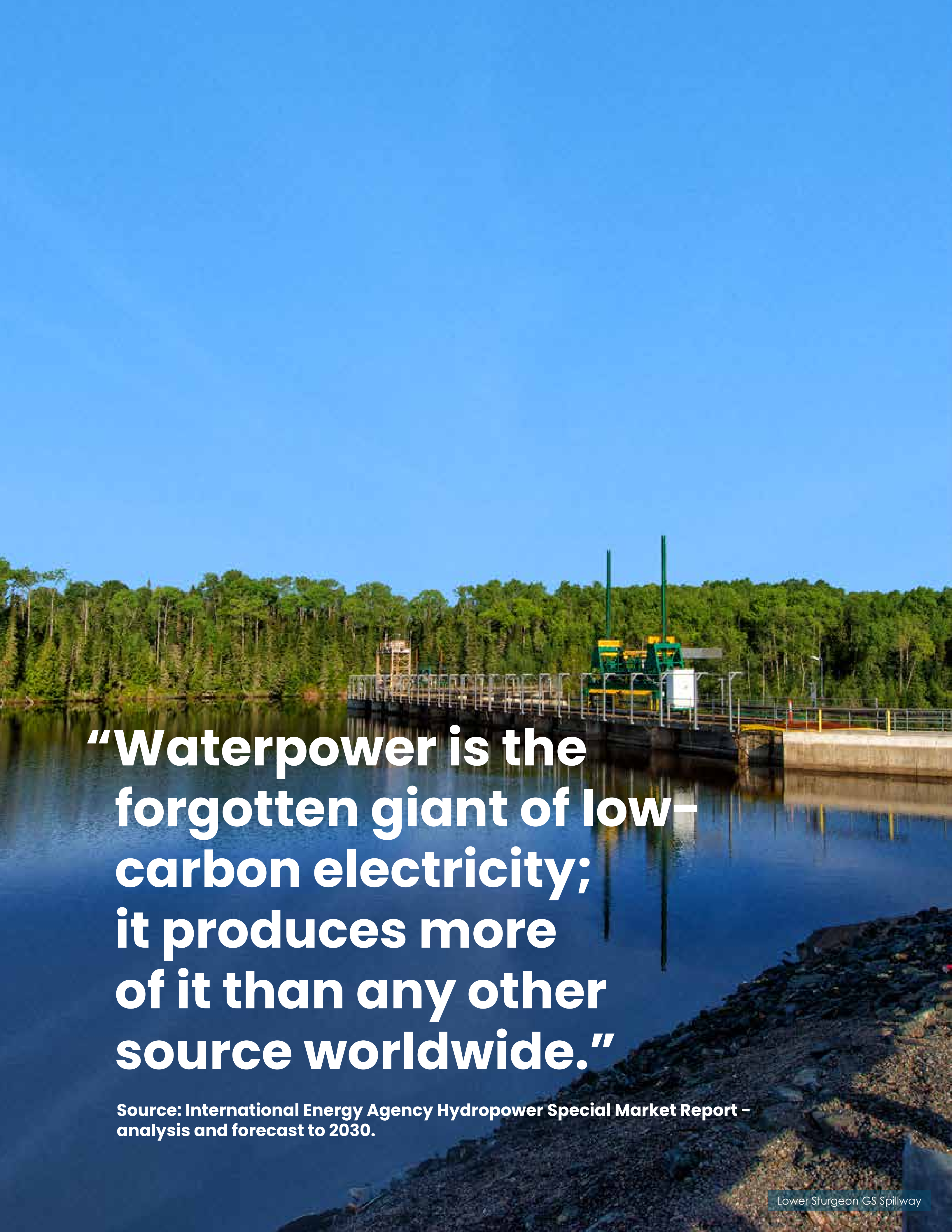
Renewable & clean

Reliable & flexible

Sustainable, long life asset

Accelerates economic growth

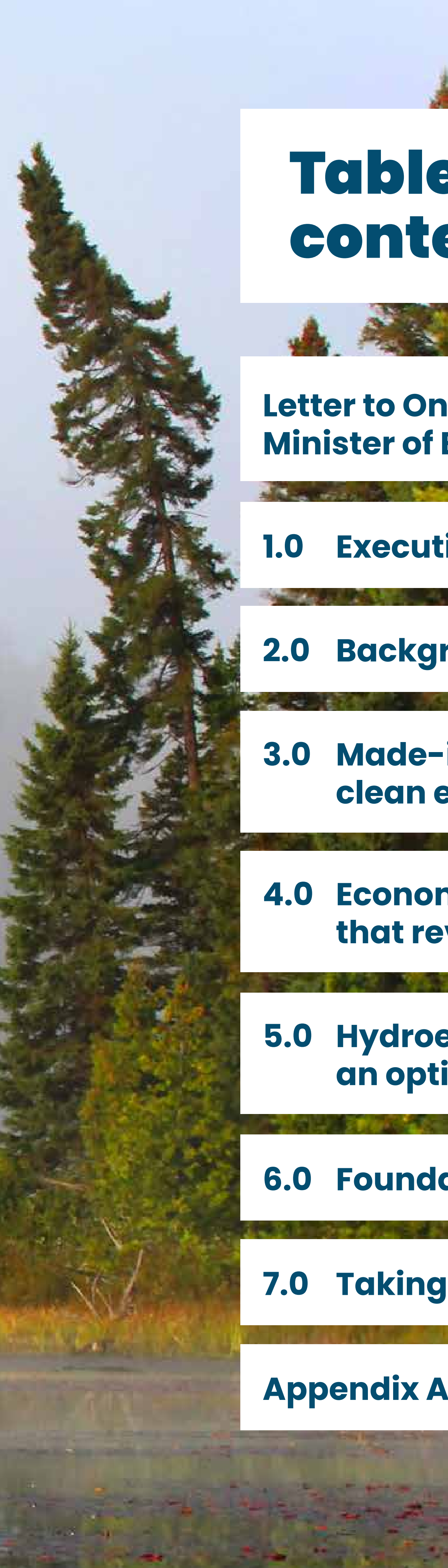
Water is an abundant resource



“Waterpower is the forgotten giant of low-carbon electricity; it produces more of it than any other source worldwide.”

Source: International Energy Agency Hydropower Special Market Report - analysis and forecast to 2030.

Lower Sturgeon GS Spillway



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"For more than a century, Ontario Power Generation and its predecessor companies have reliably produced clean and economical hydroelectric power for Ontarians. As electrification to help meet climate change goals progresses, there will be a need for additional clean electricity, and new non-emitting waterpower from Ontario's north has the potential to help fill that need. Through this study, we will apply our experience in this area to help unlock this potential."

– Ken Hartwick

1.0 Executive summary

Ontario is fortunate to have significant untapped hydroelectric potential. As economies around the world face pressure to decarbonize, few have this enviable clean energy advantage. While there are sizeable, initial development costs, once built, these sites become multi-generational, perpetual assets that provide clean, renewable energy and economic benefits for Indigenous communities and Ontario. Dozens of the province's hydroelectric generation stations are over 100 years old, benefiting the ratepayer through low cost operation.

This report highlights the importance of new northern Ontario hydroelectric generation as a part of a made-in-Ontario clean energy system. Many of those engaged have emphasized that hydroelectricity represents a powerful driver of jobs and growth for northern Ontario, both directly via the development of projects, and as an enabler of economic activities and strategies, such as *Ontario's Critical Mineral Strategy*.

The province's clean electricity supply provides Ontario with an advantage when looking to attract investment and create jobs in key sectors like mining. Additional hydroelectric development in northern Ontario, where critical minerals are found, will strengthen this advantage.

Approach

In response to the Minister's request, OPG has identified areas of high generation potential (subsequently referred to as 'pockets' of generation) and has provided initial estimates to develop this potential. The lifecycle costs of hydroelectric generation were also compared to other forms of non-greenhouse gas emitting generation.

As directed, OPG consulted with various energy system partners, including the IESO, the OWA as well as relevant ministries. An initial series of parallel engagements and listening sessions were held with the support of the OWA. These sessions included Indigenous communities, equity partners, industry representatives, regulators, as well as other stakeholders. This report outlines, by theme, what Indigenous communities indicated in terms of how they would like to participate and benefit from future developments, as well as the role and value that northern hydroelectric developments can provide as a made-in-Ontario legacy asset.

The updated estimate for hydroelectric potential in northern Ontario is 3,000 - 4,000 MW. Up to an additional 1,000 MW of potential in southern Ontario was not assessed, nor was the incremental potential associated with existing hydroelectric stations, water management infrastructure or pumped storage. All of these resources remain available to expand the system as electrification creates need.


Smoky Falls GS

Indigenous perspectives

Ontario is committed to consulting with Indigenous communities and honouring existing agreements related to hydroelectric development. OPG together with the OWA, engaged with Indigenous community representatives to better understand how communities themselves would define success in hydroelectric development in their regions. This included gathering insights from communities who have experience pursuing shared or full ownership in hydroelectric generating facilities, as well as those whose traditional territory encompasses some of the high potential opportunities reviewed in this report.

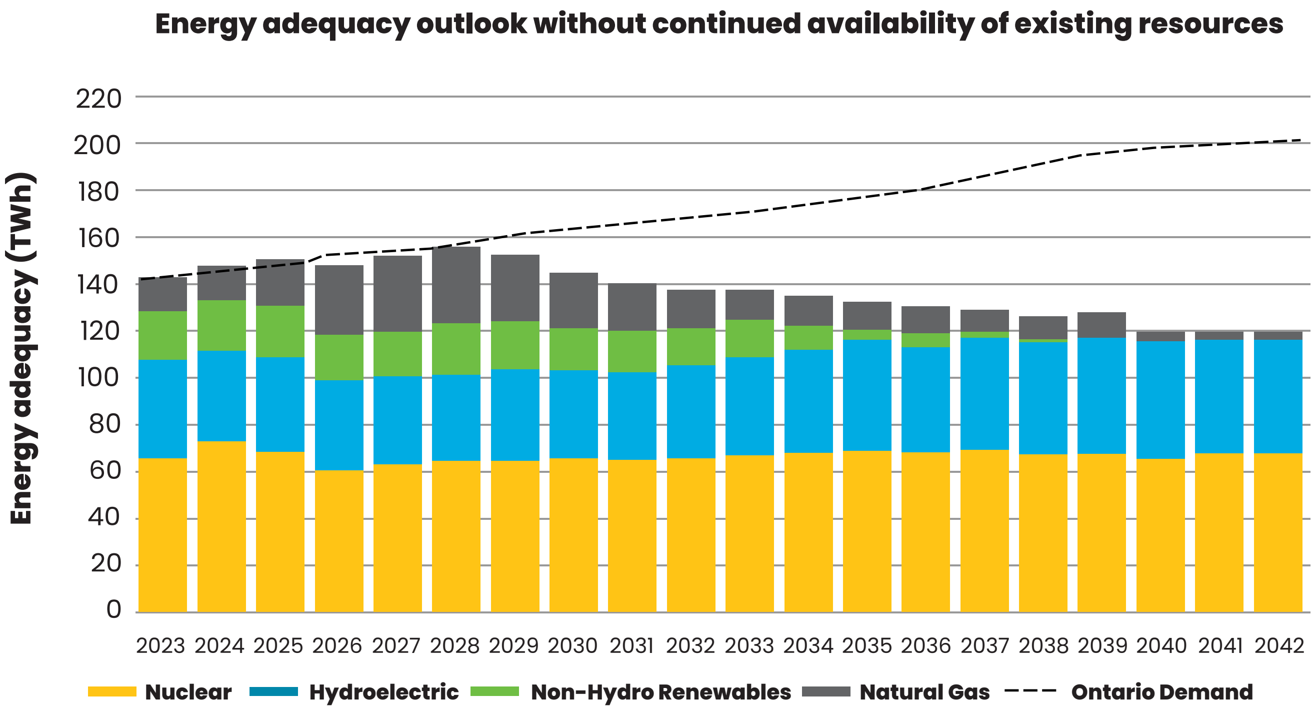
Though every community has unique needs and perspectives, the Indigenous communities OPG was able to have initial conversations with were supportive of hydroelectric development, provided it is done responsibly, there is early, meaningful participation, and community benefits that further economic and social progress. In turn, the development plans will also benefit from the connection that Indigenous partners have to the lands and rivers where these sites are located. Continued dialogue is needed as plans and policies are further developed.

Key findings

This report highlights that Ontario's untapped hydroelectric potential is becoming increasingly valuable to our electricity system. The need to electrify sectors of the Ontario economy, such as the transportation sector, and to meet demand driven by population and economic growth, will put pressure on the system beginning 2029 or sooner. By 2040, without continued availability of existing resources (renewal of expiring contracts), there could be a gap of 70 TWh, or 35%, of required energy supply, as shown in the IESO's *2021 Annual Planning Outlook* (see Figure 1.1). Hydroelectric generation can deliver significant baseload power to help fill this deficit, while also generating development opportunities in critical areas of Ontario's economy.

To estimate the potential range of costs for different sites across northern Ontario, as well as to compare hydro to other sources of non-emitting generation, 21 sites were selected in four geographic areas. A range of development sizes was selected, using sites with available cost or site condition information, potential for remote community connection and proximity to new potential roads or transmission. Of the generation sites assessed, 7 are located in provincial parks which presents significant development constraints. Many other sites have the potential for hydro

Figure 1.1: Ontario's emerging capacity gap



development across northern Ontario that can be explored beyond this report.

OPG estimates the cost to develop hydroelectric generation in northern Ontario can be expected to have a wide range of $5 - 22 M/MW, including transmission connection costs. This report further narrows that range for different geographical areas but stopped short of prioritizing or optimizing specific sites as most cost effective and viable. Further cost reduction mechanisms can be identified as part of a Hydroelectric Development Strategy. The IESO estimates that transmission system reinforcements needed to release new generation to load centres will require an additional $0.9 - 2.9 M/km, depending on circuit and voltage requirements (see IESO Report). Based on transmission system reinforcements already in construction, some new generation can be developed without further system reinforcement. This includes the Jackfish River Hydroelectric Project, near the East-West Tie as well as sites on the Severn/Windigo Rivers near the new Wataynikaneyap transmission line.

Hydroelectric generation rated highest in a multi-criteria assessment that compared non-emitting generation technologies, considering financial, socio-economic, environmental and technical factors. While capital-intensive to construct, hydro generation offers long-term value to Ontario’s future supply mix because of its ability to stabilize the transmission network, generate revenues for the Province and benefits for Indigenous communities, provide construction employment opportunities, and avoid greenhouse gas emissions.

Note to reader:
All information is provided as high-level, preliminary estimates using readily available data. Refinement of development costs would occur over a number of years.

Recommendations and next steps

To unlock all of the potential hydropower that is needed to secure a made-in-Ontario, clean electricity system, OPG recommends the following:

1. **Take a step towards new hydroelectric generation in northwestern Ontario to meet mid-term demand by accelerating the Little Jackfish Project.** OPG to finalize the Environmental Assessment and reinitiate planning on the Little Jackfish Project, which is the most advanced hydroelectric development opportunity in northwestern Ontario. In addition, request OPG and the IESO to coordinate and develop analysis on the system value of the project while contemplating its inclusion in the Pathways to Decarbonization Report. Furthermore, request that OPG assess the economic and ratepayer impact of the proposed project and report its findings to the Ministry of Energy.

2. **Take a step to unlock up to 1,250 MW of hydro potential in the Moose River Basin in northeastern Ontario.** Advise the Ontario government to initiate co-planning discussions with certain First Nations, using OPG as a facilitator to bring governments and industry representatives together. Moose Cree First Nation and Taykwa Tagamou Nation will advise on the best timing to proceed based on discussions with the Ontario government.

3. **Unlock hydro potential from existing assets across Ontario to meet emerging demand.** Tabulate all of the other potential hydro development, re-contracting

and redevelopment opportunities across Ontario, including refurbishments, pumped storage opportunities, and powering-up control dams. OPG, with the support of the OWA can provide this information to IESO for inclusion in its *Pathways to Decarbonization Study* to ensure that Ontario is leveraging its existing assets when defining hydropower's role in Ontario's future electricity system.

4. **Build out a reliable system.** OPG, in collaboration with the OWA, Indigenous communities, Hydro One and the IESO, will develop a long-term outlook and assessment that details how Ontario can effectively plan and develop transmission and hydroelectric assets in northern Ontario. This assessment will evaluate incremental hydroelectric generation and transmission projects using metrics, such as: system value, provincial and northern Ontario demand assessments, cost-effectiveness, and market conditions. The proposed assessment will also consider potential synergies with socioeconomic initiatives, economic development opportunities, remote community development, and other provincial priorities.

Peter Sutherland Sr. GS

2.0 Background

2.1 Scope

In January, 2022, the Minister of Energy requested OPG provide a preliminary assessment regarding new hydroelectric development opportunities in northern Ontario.

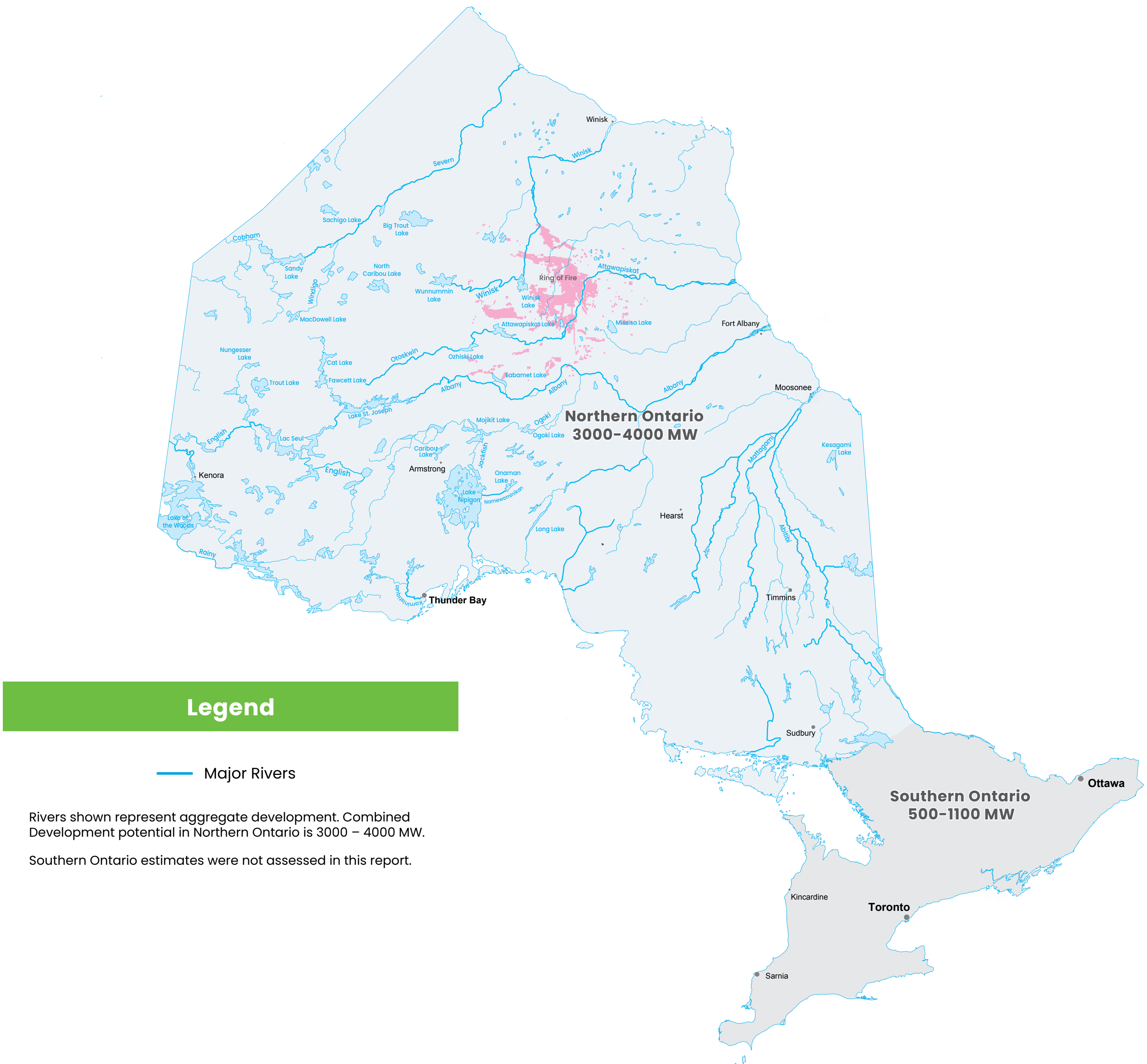
To estimate a range of development costs, 21 sites were selected in different pockets of northern Ontario, representing up to a third of the total northern Ontario hydroelectric potential. Sites were selected where previous cost analysis or site condition information was available and to provide a range of hydroelectric development opportunities, such as small and large capacity sites, potential for remote community connection and proximity to new potential roads or transmission.

OPG compared hydroelectricity to other forms of non-emitting generation, including wind, solar and small modular reactors using socio-economic, environmental, technical and financial criteria. This multi-criteria assessment (MCA) helped to summarize the relative benefits and impacts of each technology.

Throughout the study, OPG engaged with the Ministry of Natural Resources and Forestry, Ministry of Environment, Conservation and Parks, (Environmental Assessment Division) and Ministry of Indigenous Affairs to collect and share perspectives related to their mandated areas of responsibility. The broader industry was also engaged, including various transmitters and generators, particularly those who have also successfully partnered with Indigenous communities.

OPG worked closely with the IESO to share information in this study to answer two key questions: how increased hydroelectric power from northern Ontario could impact the province's power system and how transmission upgrades required to accommodate northern Ontario's new hydro developments might impact the costs. Developers offered their experiences and analysis of connection costs and other necessary investments to support the cost estimates and recommendations made in this report.

Map of Ontario's untapped hydropower potential



2.2 Role of OPG

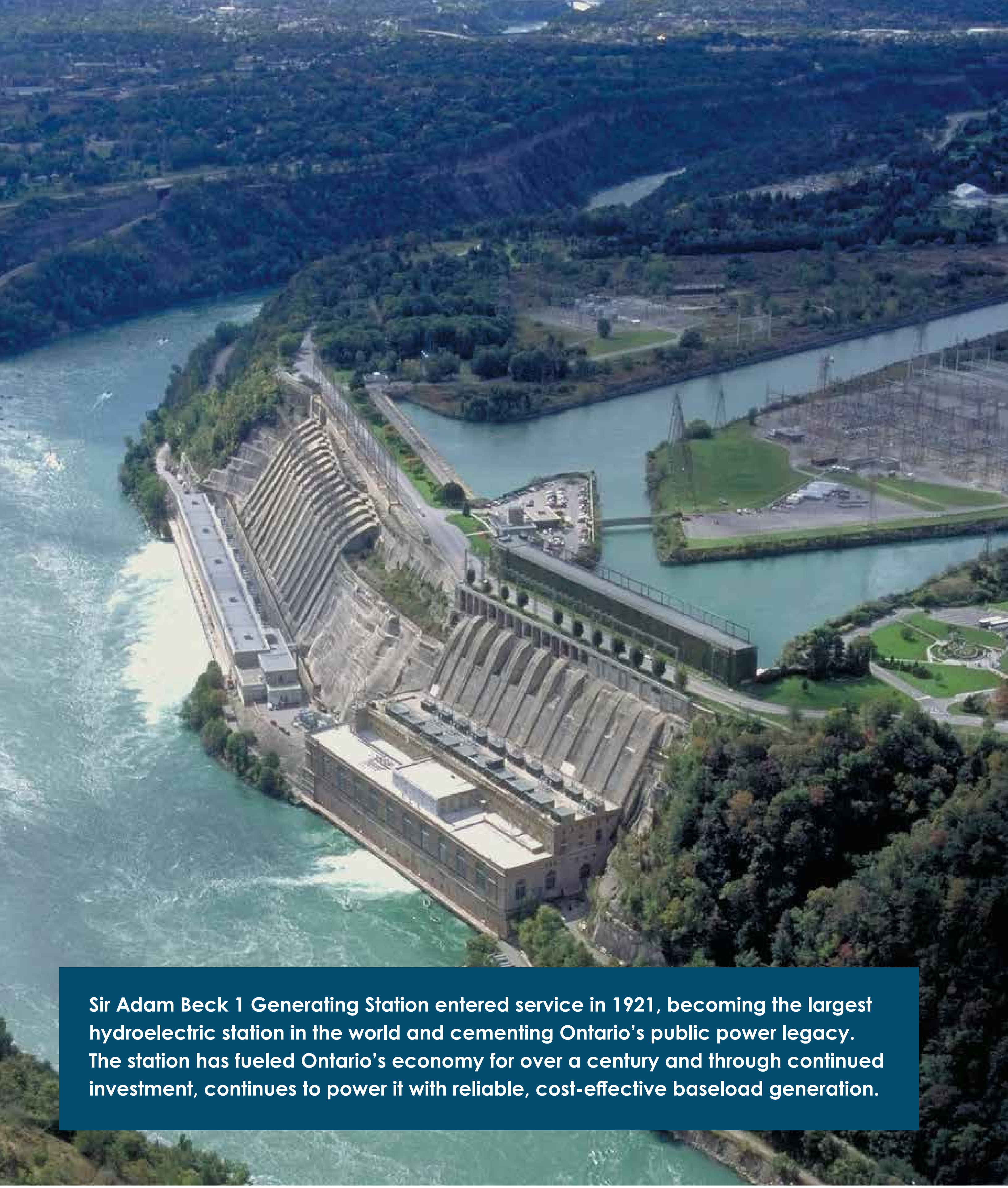
OPG is a climate change leader with one of the most diverse generating portfolios in North America. OPG invests millions in local economies and employs thousands of people to maintain a reliable, sophisticated energy fleet.

OPG works with Indigenous communities, as well as local and environmental interest groups to improve the well-being of the communities that are in the vicinity of its operations. Over OPG's and its predecessor's, Ontario Hydro, combined 115-year history, it has produced reliable, low-cost, clean electricity that powers the lives of millions. Having delivered one of the world's single largest climate change actions by closing its coal stations, OPG is now investing in new technologies that will drive the clean economy, including transportation electrification, small modular reactors, energy storage, micro grids, and medical isotopes.

Hydroelectric power, or waterpower, is a timeless, renewable resource that has fuelled Ontario's economic growth since the beginning of the 20th century. Today, OPG continues its 115-year legacy as it maintains 66 hydroelectric facilities across the province, which account for nearly 7,500 MW of installed capacity and produce approximately 33% of OPG's electricity production, and remain Ontario's lowest cost

700 University Ave.


Sir Adam Beck GS



Sir Adam Beck 1 Generating Station entered service in 1921, becoming the largest hydroelectric station in the world and cementing Ontario's public power legacy. The station has fueled Ontario's economy for over a century and through continued investment, continues to power it with reliable, cost-effective baseload generation.

generation source. Further, there are dozens of operating hydroelectric stations in Ontario that are now over 100 years old.

OPG continues to explore new development opportunities that will build on the successes of recent hydroelectric developments done in partnership with First Nations. Examples include the Peter Sutherland Sr. Generating Station built in partnership with Coral Rapids Power, a wholly owned subsidiary of Taykwa Tagamou Nation (TTN); Lac Seul/Obishikokaang Waasiganikewigamig Station built in partnership with Lac Seul Nation; and the Lower Mattagami River Project, a hydroelectric redevelopment partnership with Moose Cree First Nation.


Lower Mattagami construction

2.3 Legislative, regulatory and policy framework and restrictions

Hydroelectric developments have a long lead time due to a complex legislative, regulatory and policy framework, some of which is unique to Ontario's Far North. Key legislative authorities are divided between the Ministry of Natural Resources and Forestry (MNRF) *(Public Lands Act, Far North Act 2010, Lakes and Rivers Improvement Act)* and the Ministry of Environment, Conservation and Parks *(Provincial Parks and Conservation Reserves Act, Environmental Assessment Act and Endangered Species Act)*. During the development process, there is extensive consultation with Indigenous communities.

The existing *Renewable Energy on Crown Land Policy*, including the 25 MW limit on Northern Rivers Watershed, commitment to co-planning in the Moose River Basin and the approach to allocating new development opportunities, will require renewed consideration with Indigenous communities and municipalities. A revision may be helpful in enabling northern hydroelectric development to proceed with the support of Indigenous communities. For example, this report identifies

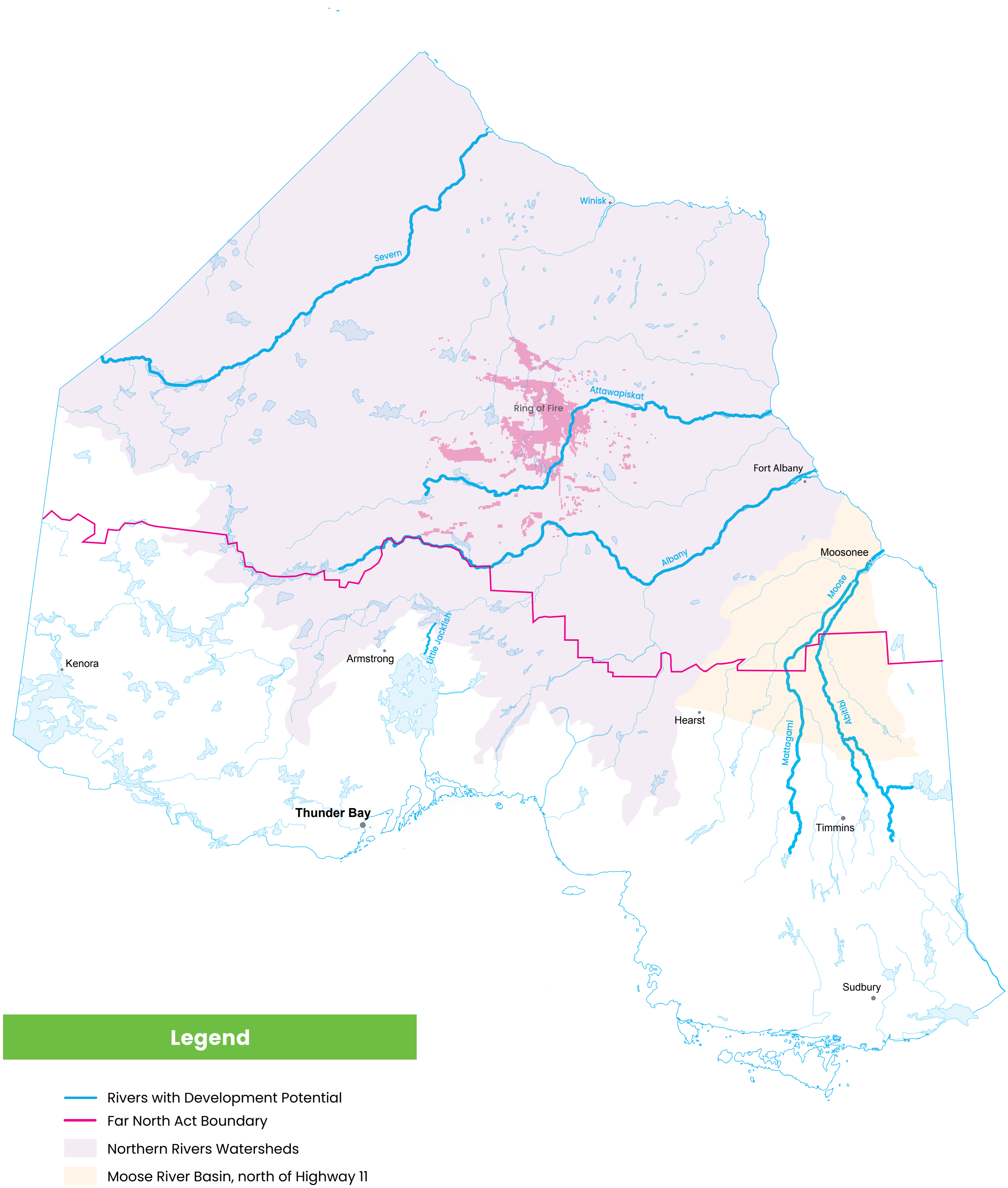

Healey Falls GS

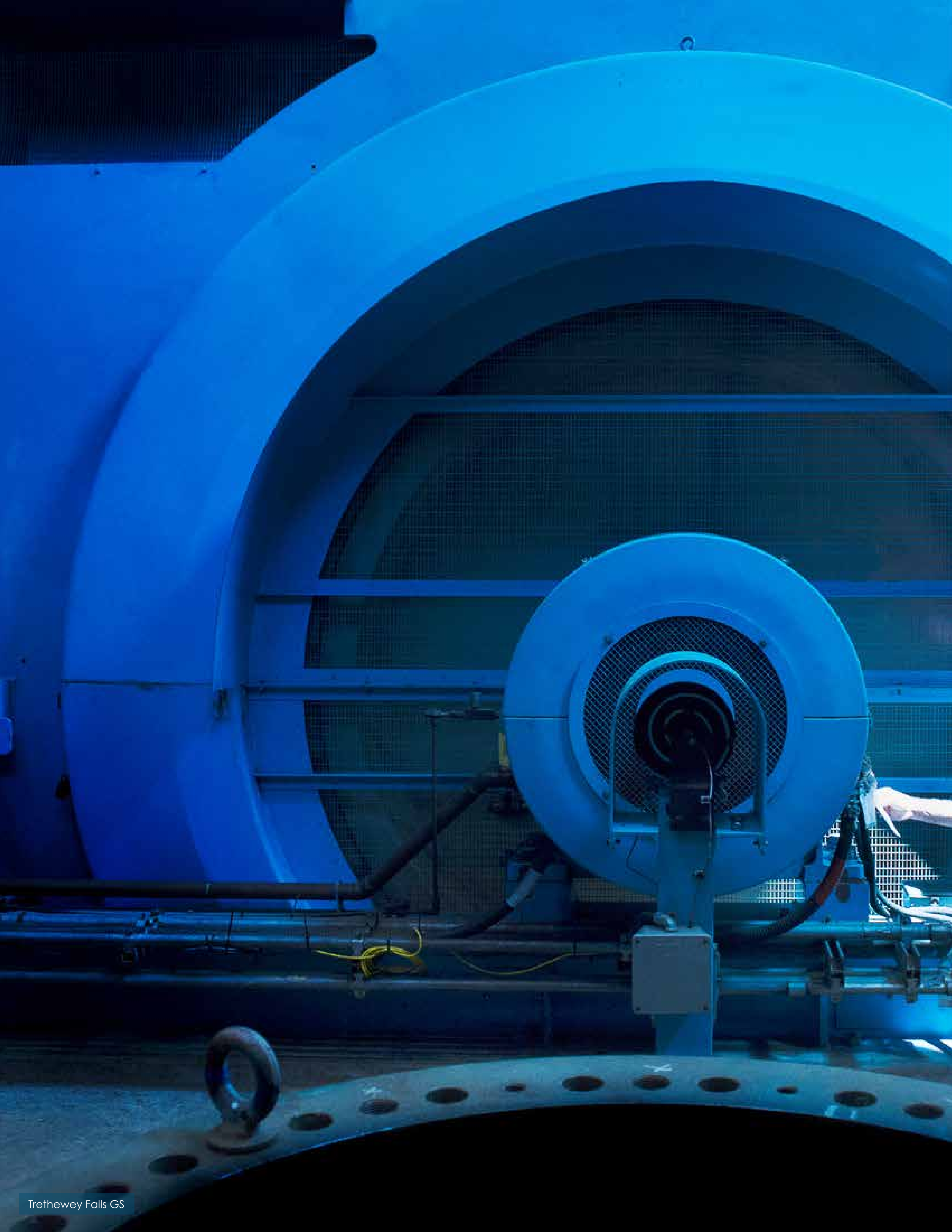
that the 25 MW limit on the Northern Rivers Watershed significantly increases the cost to construct new facilities on a price per MW basis. This is because once capacity is limited for any reason, the cost significantly increases as fixed costs have to be split into less MW. This warrants further policy analysis by government, industry and Indigenous communities. Another example is the Peter Sutherland Sr. Generating Station, which was subject to co-planning and located on lands that, prior to construction, were partially located within a provincial park.

The model that was used to develop this station could be considered for other strategic sites that are located in a provincial park or conservation reserve.

Appendix A summarizes the key legislative, regulatory and policy frameworks for the hydroelectric sector that, in OPG's view, require review, revision or realignment for northern hydroelectric opportunities to be more fully optimized and to increase investment certainty.

Map of geographic basis for *Renewable Energy on Crown Land Policy Framework*





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3.0 Made-in-Ontario clean energy opportunity

3.1 Northern Ontario hydro opportunities

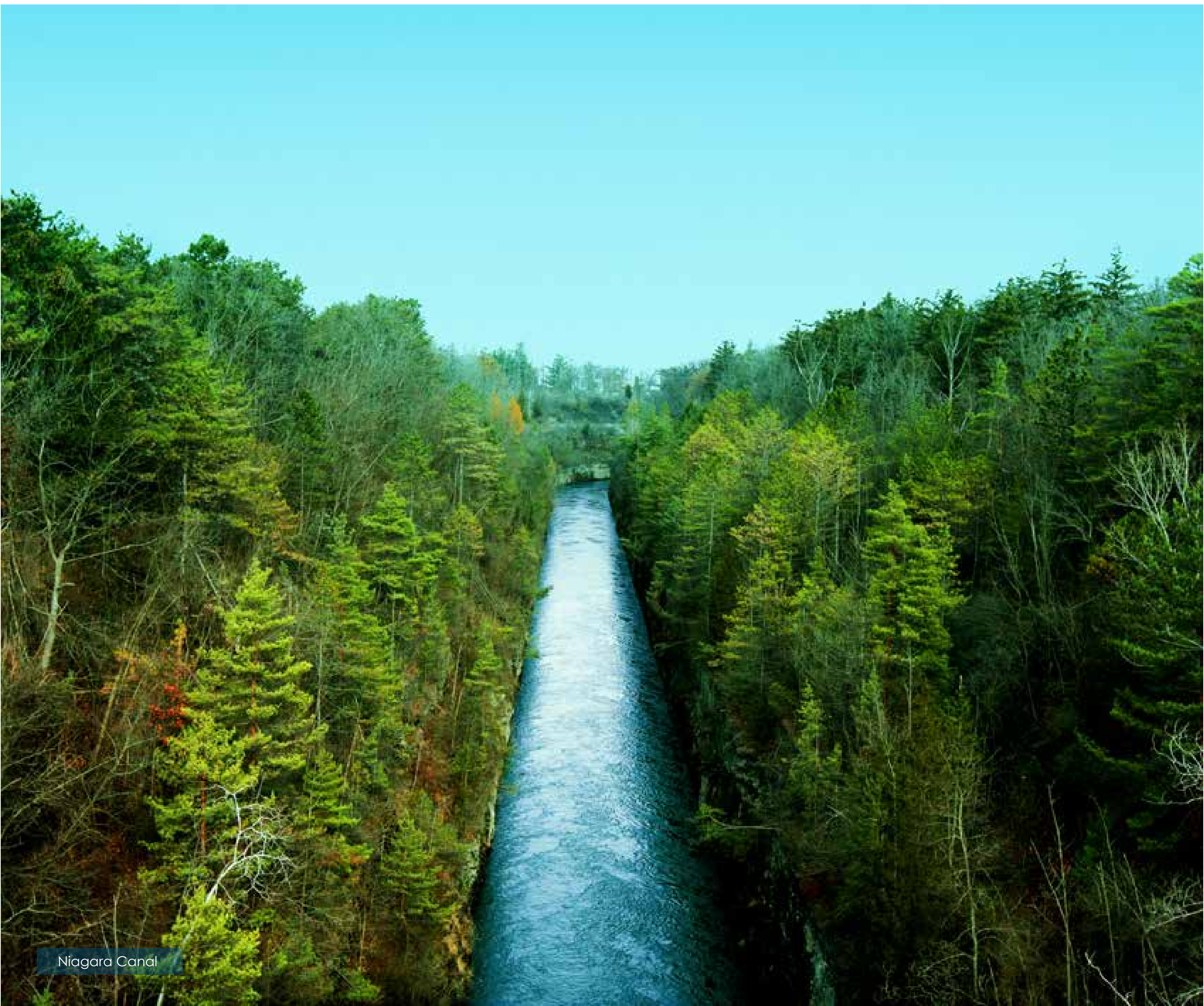
There are wide ranges of achievable hydroelectric opportunities in northern Ontario, which can be pursued on a short and long-term basis extending to 2040s and beyond. Ontario's hydroelectric potential is estimated to be in the range of 4,000-5,000 MW, with much of this 3,000-4,000 MW in northern Ontario. This updated range has been validated with the OWA.

Current understanding of the limitations that prevent development of this magnitude include: updated site and geotechnical conditions; passage of time that has made some developments no longer viable; over-accounting of multiple sites on the same river section; avoidance of significant environmental impacts

Crystal Falls GS

through large-scale inundation; Crown land policy constraints, prohibition against development in parks and conservation reserves; and other factors. In addition, a better understanding of the socioeconomic constraints of operating in remote locations has enabled improved targeting of optimal sites for development.

To develop a high level estimate on the range of costs for different sites across northern Ontario, as well as to compare hydro to other sources of non-emitting generation, 21 sites were selected across four geographic areas of northern Ontario. A range of


Niagara Canal

Hydropower potential in northern Ontario 3000-4000 MW

Legend

Major Rivers

Rivers shown represent aggregate development. Combined Development potential in Northern Ontario is 3000 – 4000 MW.

Additional up to 150 MW from improvements of existing facilities and control dams.

practical and feasible development sizes was selected, using sites with available cost or site condition information, potential for remote community connection and proximity to new potential roads or transmission. As only sites greater than 10 MW were carried forward, approximately a third of the total northern Ontario hydroelectric potential or 1,400 - 2,800 MW was analyzed in this report. Many other sites have the potential for hydro development across northern Ontario that can be explored beyond this preliminary industry report.

2.2 Summary of opportunities assessed

Little Jackfish River hydroelectric project in northwestern Ontario

Little Jackfish River

With the earliest projected in-service date, this is the most advanced, medium scale hydroelectric project in northern Ontario. It was deferred in 2015 due to lack of energy demand, and forecasted needs have significantly shifted from this time. This proposed single site project can provide approximately 80 MW of daily peaking and seasonal storage to the grid. Significant investment of time and resources has been made towards completing the environmental assessment process, as well as a shared equity partnership between OPG and six Lake Nipigon First Nations. The IESO has indicated that transmission system reinforcements would not be required for this project.

All six of the Lake Nipigon First Nations have indicated a renewed interest in the Little Jackfish Project. Before re-engaging extensively with the communities that would benefit from the Project, the Chiefs have highlighted the importance of a path forward on the revenue mechanism to underpin the project economics. Previous attempts to develop the Little Jackfish River were deferred due to lack of energy demand and not a lack of community support. Rather, the Lake Nipigon First Nations participation in the project will add value to its design and implementation through broad regional commercial participation and other benefits.

Moose River Basin in northeastern Ontario

Moose River Basin

These sites provide the greatest amount of hydroelectric potential and is closest to Ontario's southern load centres. The Moose River Basin includes the Mattagami, Moose and Abitibi Rivers. The total remaining practical development potential in the Moose River Basin is between 640 - 1,250 MW. According to the IESO, transmission network reinforcements would be required due to the amount of installed capacity in this pocket.

An important first step to develop the Moose River Basin would be for the Government of Ontario to advance co-planning discussions with certain First Nations. This could be narrowed to focus on shared decision making about hydroelectric development site release (see Appendix A for more information).

Remote communities

In 2013 the OWA, with support from the Ontario government, commissioned an analysis of Northern Hydro Potential with a focus on Remote First Nation communities to be connected to the Ontario grid. The report found that there are cost effective small hydro sites in reasonable proximity to the majority of the communities to be connected. An update of this assessment is recommended.

Hydroelectric potential on Severn and Windigo Rivers may be more feasible and practical in light of new transmission infrastructure by the Wataynikaneyap Project. Development sites on these two rivers is worthy of a more detailed assessment. Early dialogue with one First Nation in the area expressed the need for consistent engagement with all of the communities in the area.

Ring of Fire

Hydroelectric development in northern Ontario can be an enabler of other economic activities, such as the Ring of Fire and other mining sites, in support of *Ontario's Critical Mineral Strategy*. Close to the Ring of Fire and along the proposed northern access link road is another new pocket of potential development sites on the Upper Albany and Attawapiskat Rivers. These potential developments could bring about socioeconomic benefits to Indigenous communities and significant regional economic

Peter Sutherland Sr. GS

development by supplying energy to communities and local mines. There may also be other cost advantages related to sharing of common access and infrastructure requirements. In this pocket, there is 680 - 1,300 MW of hydroelectric potential, including two large sites on the Lower Albany River.

Drawing on previous investments and existing infrastructure

In addition to large pockets of potential generation, there are dozens of small (< 50MW) hydro development sites across northern Ontario that were not costed out or assessed in this report. Some have had advanced site investigation and environmental assessment work that could be re-visited. There are also existing water control structures that could be redeveloped into generating facilities. Developing sites with existing infrastructure is beneficial from a cost perspective.

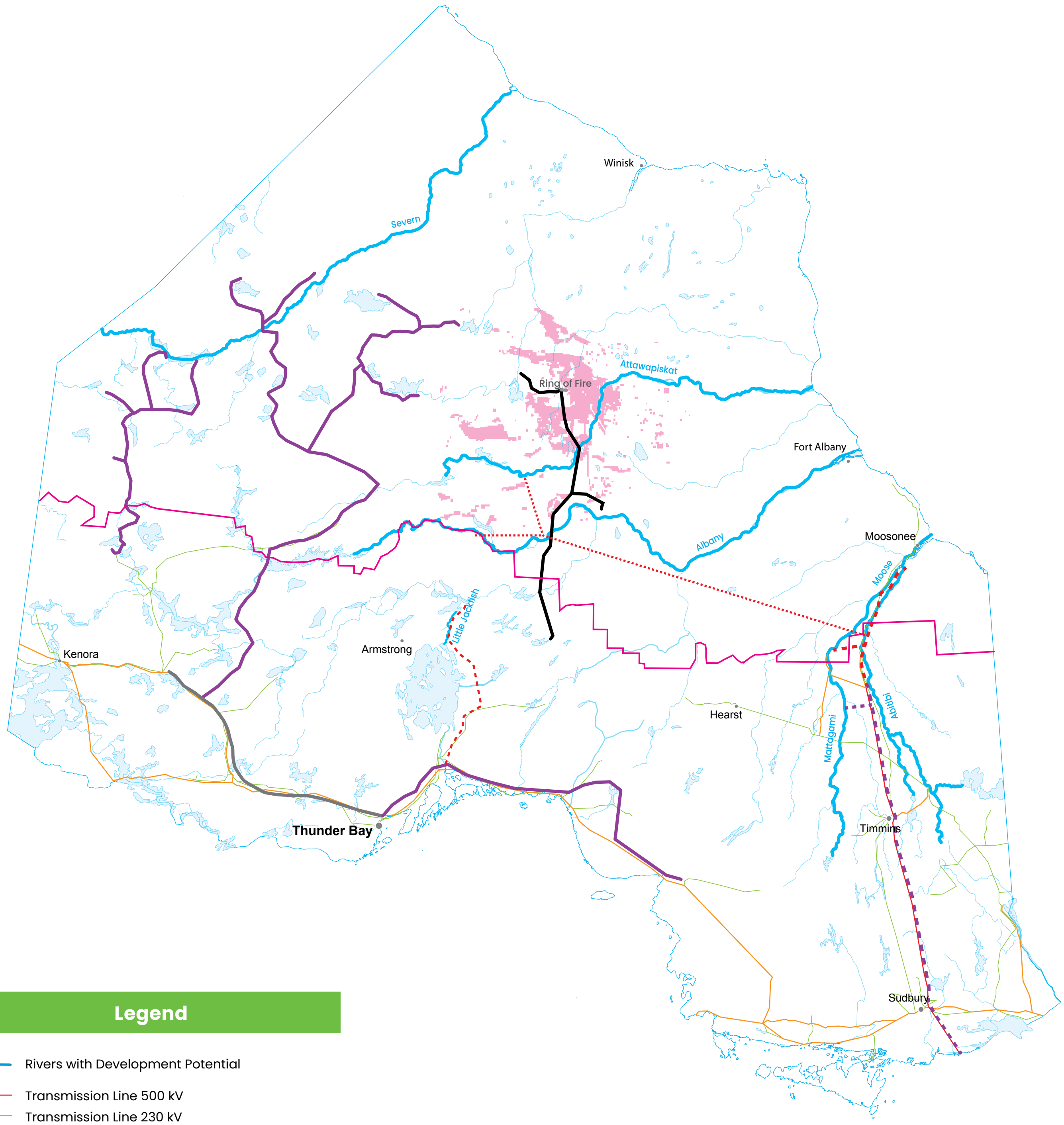
From an environmental perspective, it takes advantage of existing water management practices via dam operations. Further, some Indigenous communities have indicated an interest to participate and benefit from these types of projects.

To assist with these efforts, Ontario has made advancements to help build and connect more waterpower by updating the almost 50-year old Environmental Assessment program and approving amendments to the Ontario Waterpower Association's Class Environmental Assessment, which helps advance and identify low-risk waterpower projects (< 200 MW).

These changes align assessment requirements with environmental impact, reduce duplication and streamline the process while maintaining strong environmental oversight and protection.

In order to ensure the cumulative system and socioeconomic benefits of these opportunities are not forgotten, further assessment is recommended in this area to see what can be done to improve the investment climate for small hydro development and redevelopments.

Transmission connections and reinforcements to enable growth and development

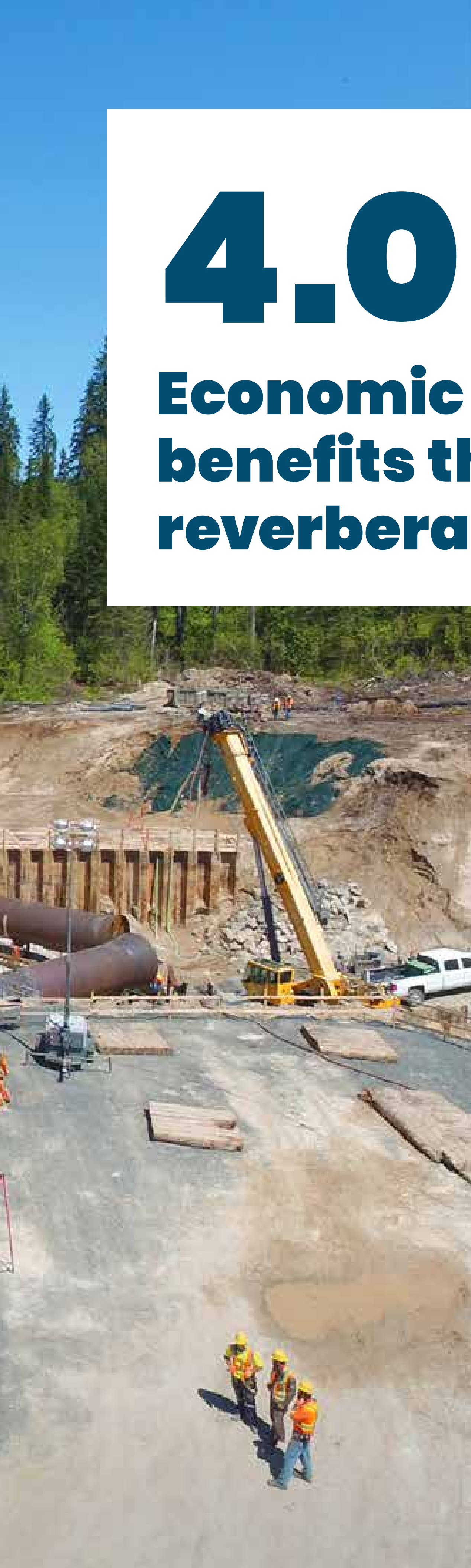


Legend

- Rivers with Development Potential
- Transmission Line 500 kV
- Transmission Line 230 kV
- Transmission Line 115 kV
- Transmission Line - In construction
- Transmission Line - In development
- Transmission Line 500 kV - OPG - Proposed
- Transmission Line 500 kV - Hydro One - Proposed
- Transmission Line 230 kV - OPG - Proposed
- Far North Act Boundary
- Ring of Fire Road Development

The rights of way proposed may differ.

Peter Sutherland Sr. GS



4.0 Economic benefits that reverberate

4.1 A clean technology providing economic benefits

Investments in hydroelectric development will directly benefit Ontario's economy, as do other major infrastructure projects such as subways, roads and bridges. In hydroelectric development, at least 75% of capital expenditure and 90% of lifetime operational expenditure will be spent in Ontario.

As a comparison, these percentages drop to 50% and 70%, respectively, for solar and 30% and 80%, respectively, for wind technologies. This means that hydroelectric development can provide a valuable made-in-Ontario solution to meet emerging clean energy demands in the 2030's and beyond.

An investment in hydroelectric development isn't just an investment in today's economy. Enduring, long life hydroelectric stations, built by previous generations, are not only the source of Ontario's least expensive generation today, but continue to provide valuable economic output through redevelopments, maintenance, and community partnerships. An investment in hydroelectric now is an investment in Ontario's future.

4.2 Clean power that keeps Ontario on the leading edge

According to the IESO, Ontario is currently on pace to experience energy shortfalls, if expiring contracts are not renewed, emerging in 2029, and potentially sooner. This increased demand is driven by several factors, including population and economic growth. One of the most significant consumer and business trends is the electrification of transportation, including personal automobiles and transit vehicles. Other sectors such as industry and buildings will also look to the electricity sector to help decarbonize. To enable electrification, Ontario can invest in clean reliable baseload generation source to fully realize the environmental benefits of a clean economy.

As outlined in the IESO's *2021 Annual Planning Outlook*, increased electrification will significantly increase Ontario's electricity system needs, estimating a demand increase of about 40% by 2040. OPG's high electrification scenario concurs with the IESO and forecasts a demand increase of 57 TWh by 2040 due to increased economic growth and the electrification of transportation. If we are to examine a net-zero by 2050 scenario, the demand increase would be much higher than either the IESO or OPG high scenario.

800,000+ people

Over 802,000 square km (Density: 1 person/km^2)

7% of Ontario's population

and approximately 13% are Indigenous

Over 50% of Northern Ontarians

resides in large urban centres

24,000 people in the far north

90% are First Nation peoples

Key industries:

mining, forestry, agriculture, manufacturing, and tourism

Source: MTO, Connecting the North, Dec 2020.

Without increased electricity supply, Ontario will need to determine how much it relies on imports from neighbouring jurisdictions to meet its growing clean energy needs. In the same way that Ontario sees increased demand for electricity, other jurisdictions are seeing the same impacts. As a result the ability to rely on neighbouring power supply no longer exists other than for load balancing purposes. For example, this past winter, Quebec set a new record for electricity

5.8 ¢

Affordable:

Waterpower is a price moderator because existing electricity sources are the lowest cost power. (cents/kWh)

(Data source: OEB Regulated Price Plan Report, 2021)

100+ years

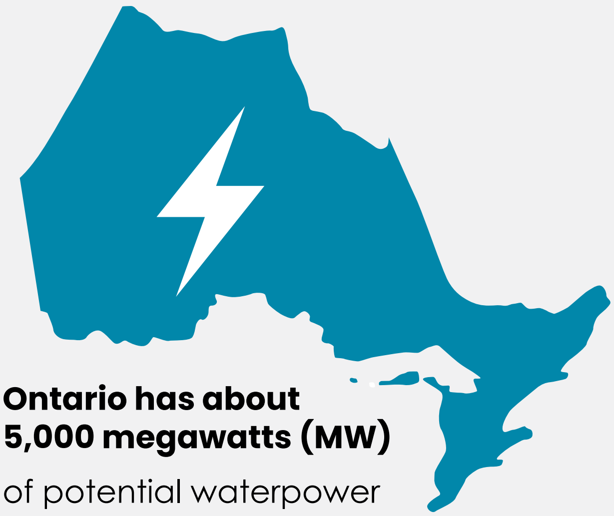
Endless lifetime,

if properly maintained and refurbished.

Waterpower

the only clean, renewable and abundant source of electricity that is always available.

5,000 MW



Ontario has about 5,000 megawatts (MW)

of potential waterpower capacity to explore for development.

demand (39,833 MW) in the province. To meet their demand, it had to import 2,000 MW from New York and Ontario. The mix of imported energy could also include high emission sources. Even if imports are relied upon, it is not certain they will be available when needed. Ontario's ability to generate ample clean power will enhance its ability to attract industry investments as companies seek jurisdictions that enable their environmental targets in a cost-effective manner.

Ottawa River

4.3 Powering up other local industry

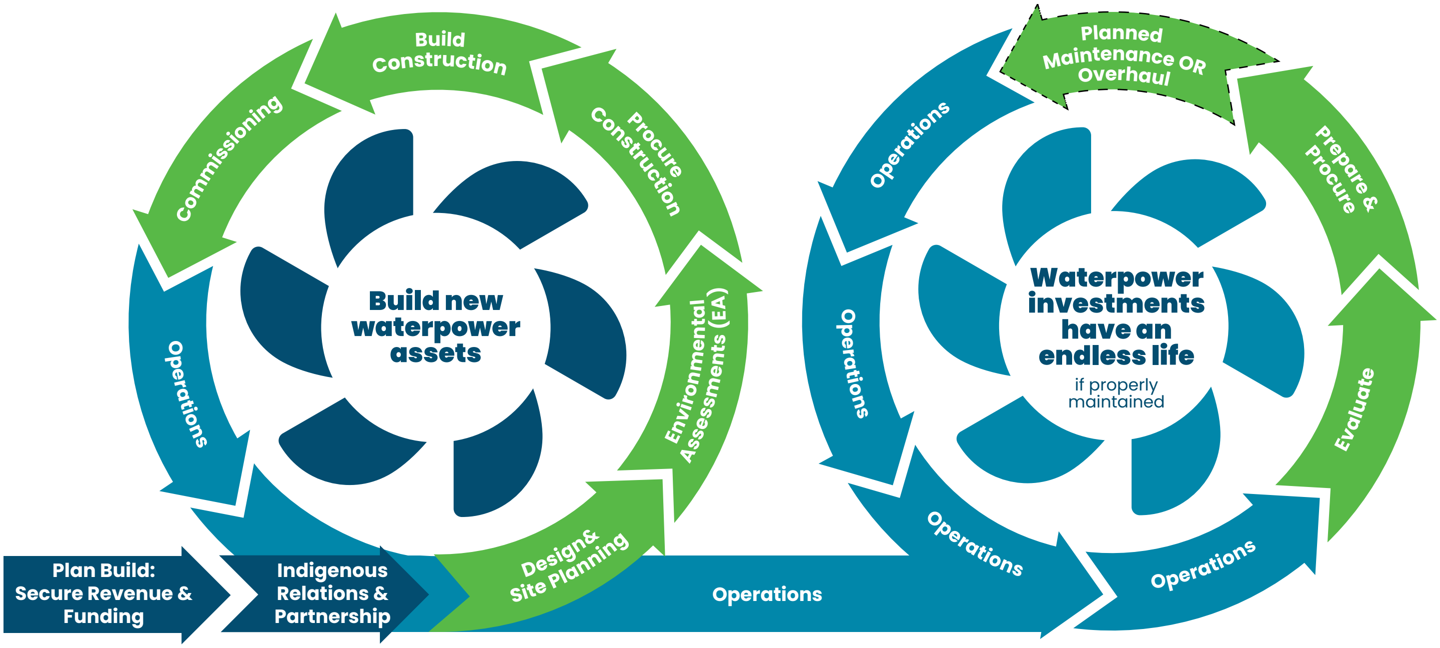
The expected boom in the electric vehicle industry, and the need for batteries to power them is driving the growing demand for such critical minerals as nickel and lithium. The provincial government's *Critical Minerals Strategy and Driving Prosperity Study*, envision auto makers in Ontario building 400,000 electric and hybrid vehicles annually by 2030, powered by batteries made in the province, using minerals extracted and processed in Ontario. Hydroelectric development in northern Ontario could generate infrastructure investments that have complementary benefits for mining development, including proximity to clean sources of power. As noted in Driving Prosperity, Ontario has "an incredible opportunity to connect and vertically integrate our northern and southern economies to build a made-in-Ontario supply chain for innovative technologies like electric vehicles and battery storage." Future hydroelectric development should be planned now to leverage an emerging need to supply the north.

4.4 Revenues that support public services

The economic analysis conducted as part of the multi-criteria assessment indicates that hydroelectric development sustains the most jobs annually, in addition to contributing the most to Ontario's gross domestic product (GDP) on an annual basis over the construction period. This is driven by the upfront capital intensity of hydroelectric development, when compared to other technologies, but is balanced by the fact that hydroelectric generation offers a perpetual life asset, compared to other technologies, which can become unviable generation sources in as little as 20 years.

For any new hydroelectric site, 300 - 1,000 direct jobs are created per 100 MW during construction, plus additional indirect and induced jobs. From an operational perspective, hydroelectric generation sites can be expected to employ between 13-19 direct jobs per 100 MW of installed capacity. Hydroelectric sites range in size significantly, however, and smaller sized projects will result in more local benefits scaled to the capacity of the station.

Figure 4.1: Waterpower asset lifecycle



Hydroelectric assets also provide fuel revenue which is available to the Province of Ontario through water rental fees, on an ongoing (perpetual) basis. For each hydroelectric site, additional direct tax revenues are also expected to be generated through the Gross Revenue Charge (GRC). Likewise, corporate income tax revenues have also been estimated at approximately $80,000/MW. Cumulative direct water rental, property-tax, and corporate income taxes generated over a 90-year period for sites are presented in Table 4.1. These figures are based on estimates for four representative sites, which represent approximately 10 % of the total potential northern Ontario hydroelectric potential.

To develop all the hydroelectric potential, it is recommended that a planned approach be established that sees it occur gradually on timeline ranging from 20 to 30 years. This will take further analysis to establish the strategic approach, and the associated economic and social benefit.

Table 4.1: Estimated direct cumulative water rental, property, and corporate income tax revenues for select hydropower sites (over 90-year period, 10-year GRC holiday is not applied)

Potential Development Sites	MW	Water Rental ($ Millions)	Property Tax ($ Millions)	Income Tax ($ Millions)	Employment During Construction (Person Year)
Little Jackfish River Lower Site	80	130	60	500 - 600	2,500 - 5,300
Abitibi River Site	115	140	60	750 - 900	1,200 - 4,700
Albany River Site	250	340	400	1,600 - 2,000	3,300 - 13,100
Severn River Site	10	30	10	70 - 90	300 - 1,100
Total	**455**	**640**	**530**	**2,900 - 3,600**	**7,300 - 24,200**

Kipling GS

5.0 Hydroelectric: an optimal energy choice

5.1 Cost estimates

OPG identified a cross section of hydroelectric sites in northern Ontario. This was done for the purposes of conducting an economic estimate and not site selection. Many other sites that have the potential for hydro development across northern Ontario can be explored beyond this report, including two thirds of the total northern Ontario hydroelectric potential.

The sites were chosen based on features that influence development cost, such as size, location, proximity to linear infrastructure or remote communities and geotechnical conditions, where information was available. As hydroelectric development can vary dramatically from site to site, it is important that a broad range of sites were examined to estimate a range of potential costs and benefits. The sites were not selected because of low cost or readiness for initial development, but rather as representative sites.

The analysis was carried out for two scenarios: maximum generation capacity (High Scenario) and reduced capacity (Low Scenario) at each site. The Low Scenario was elaborated to minimize inundation impacts from dam construction. It is expected that each development site will be optimized through Indigenous participation, engineering analysis and environmental assessment processes and the

Table 5.1: Summary of opportunity sites in northern Ontario used to estimate updated lifecycle costs

Area	Number of Sites	Rivers	Total Capacity	
			Low Scenario	High Scenario
Moose River Basin	9	Abitibi Mattagami Moose	640 MW	1,250 MW
Albany and Attawapiskat Rivers[1]	8	Albany Attawapiskat	680 MW	1,300 MW
Little Jackfish River	2	Little Jackfish	80 MW	105 MW
Severn River Basin[2]	2	Severn Windigo	20 MW	35 MW

eventual capacity would be between the Low and High Scenario.

Transmission connection development costs are the responsibility of the generator under the Ontario Energy Board's Transmission System Code and have been included in all generation development costs shown. Updated transmission connection costs that reflect the latest inflationary pressures from 2022 are detailed in the report: *IESO Assessment of OPG's Northern Ontario Hydroelectric Facilities*. Transmission development that connects new generation provides an opportunity to enable other emerging needs in areas where infrastructure previously didn't

A report by the *International Renewable Energy Agency*, entitled *Renewable Power Generation Costs* in 2017, found that hydroelectricity remains the lowest-cost source of electricity worldwide.

1 Six of these sites have been reduced to a capacity of 25 MW each in the Low Scenario to mirror that size constraint in *Renewable Energy on Crown Land Policy*. Some sites are located close to the Ring of Fire Road to capture multiple interests.

2 The sites reflect the 25 MW limit of the *Renewable Energy on Crown Land Policy*

exist. For instance as the IESO has identified in its report, transmission connection for a subset of the Albany-Attawapiskat facilities could be used to support the Ring of Fire due to the proximity of potential development sites to the proposed North-South road. Cost for bulk system upgrades will be refined with cooperation from IESO, transmission developers and OPG.

After preliminary analysis, one site was excluded for the purposes of developing ranges due to poor viability. The high-level estimate of capital expenditures to develop the remaining sites is $5 - 22 M/MW, including grid connection costs that could potentially benefit other northern developments. The existing Northern Rivers Watershed capacity constraint in the *Renewable Energy on Crown Land Policy* could drive costs above this range because it is not possible to optimize cost while keeping the capacity below 25 MW. With Indigenous community support, this could be removed, which would allow Indigenous communities to participate in optimization of sites, and this has been assumed for the purpose of this analysis.

The IESO estimates that reinforcements to the existing transmission network would require an additional $0.9 - 2.9 M/km, depending on circuit and voltage requirements; however, not every development pocket requires transmission network reinforcement, including Little Jackfish and Severn/Windigo Rivers.

The estimated range of capital costs for each of the development pockets include the cost of transmission and ancillary infrastructure to enable site access and construction. If projects were to proceed, cost refinements will occur to minimize rate payer impact.

- Little Jackfish River
  $14 - 17 M/MW
- Moose River Basin
  $5 - 17 M/MW
- Severn and Windigo Rivers
  $11 - 16 M/MW
- Upper Albany and Attawapiskat Rivers
  $7 - 21 M/MW

Capital expenditures for hydroelectric development in remote northern Ontario will be more expensive, particularly where there are access constraints, construction camp requirements, flatter land and site-specific geotechnical conditions.

Small or remote hydroelectric opportunities should not be ignored. Power in Ontario had its roots in “small hydro” going back to London Street Generating Station built in 1884. These projects can bring forth smaller scale economic activity in northern Ontario for Indigenous communities and local manufacturing and trades.

What makes hydroelectric development truly attractive from a value perspective is that these generating stations become a moderating influence on electricity rates because of their low operating cost and longevity. Orderly development of the remaining potential can be expected to offer stable and sustained socioeconomic benefits and employment in high quality jobs in manufacturing, engineering and trades.

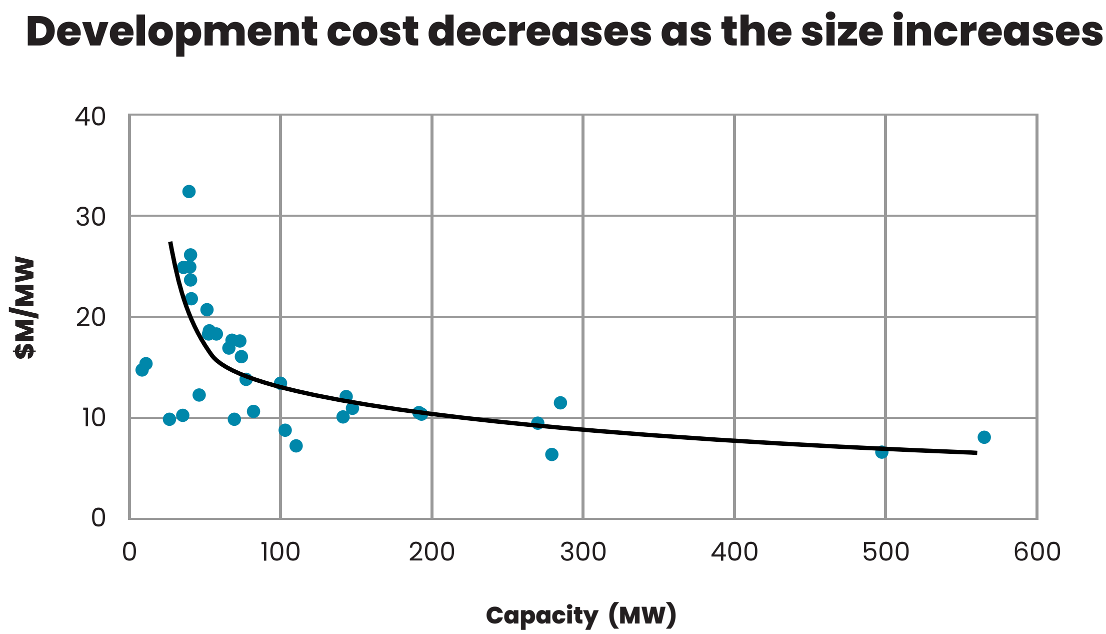
Further, costs may come down based on other activity in northern Ontario. Sites on the Upper Albany and Attawapiskat Rivers near the Ring of Fire could benefit from reduced costs over the next decade due to revisions to policy constraints (e.g. 25 MW limit), improved local site access and connection to the transmission network, which is why it is important for hydroelectric development to be coordinated with other northern Ontario development opportunities.

"The economic assessment of the hydro development facilities… found that by 2042 system benefits amounted to between 30% and 50% of revenue requirement, depending on the facility. Recognizing that hydroelectric facilities are long lived and that the need and value of energy will continue to grow, system benefits increase to between 80% and 120% of revenue requirement, depending on the facility, when considering the full lifetime of the asset (90 years)." - IESO

The cost estimates provided are at best an initial approximation, because hydroelectric development costs vary greatly based on the unique aspects of site locations and require site investigation to validate estimates. Further, development costs may be reduced through:

- competitive transmission procurement;
- planned sequencing to develop a cluster of hydroelectric development sites to share expenditures associated with costly activities such as construction camp, grid connection and site access;
- grouping of adjacent or neighbouring development sites that could be executed into a single project;
- staged hydroelectric development across northern Ontario over the full time horizon in the IESO's *Pathways to Decarbonization Study* to avoid issues with boom-bust cycles;
- planning for labour and human resources across the development period to avoid costly delays; and
- timing hydroelectric development with other local economic development activities to enable broader regional growth and promote the sharing of resources (human and infrastructure).

Figure 5.1: Development cost of hydro projects in northern Ontario per capacity (Data source: WSP, 2022)



Costs used in this report are consistent with the range recently published by the IESO for hydro as part of the assumptions outlined in the *Pathways to Decarbonization Study*.

The wide range of costs strongly suggests that further assessment is required to narrow which sites would be the most cost effective to implement among these sites as well as other potential sites in northern Ontario. Consideration will also be required for assessment of electricity system value and Indigenous community participation and benefits.

It is recommended that OPG continue working with the IESO on its *Pathways to Decarbonization Study* to further explore how to implement hydroelectric development across northern Ontario in a way that will fulfill some of the system needs emerging in the 2030s. This should consider how hydroelectricity can be made even more attractive by enabling other local development and socioeconomic initiatives, while bringing on incremental renewable generation in a cost-effective manner.

A formal Hydroelectric Development Strategy, facilitated by OPG, could ensure these cost reducing strategies are incorporated into long-term energy plans, coordinating with other government- led strategies, such as the *Critical Minerals Strategy* and the *Northern Transportation Plan*.

Multi Criteria Assessment

A multi-criteria assessment (MCA) was used to rank generation technologies using financial, socioeconomic, technical, and environmental criteria.

The MCA compares the life-cycle costs and benefits of building new hydroelectric generation to wind, solar and SMR.

Factors unique to each technology can include environmental factors such as availability of water or sunlight, as well as land costs and existing infrastructure and local regulations.

Ranking is influenced by value to the system, including elements such as existing baseload availability, capacity (including peaking demand), voltage regulation and operating reserve.

Lifecycle of the asset and socioeconomic considerations also factor in to value (e.g., cost of carbon and other emissions, local community support and engagement).

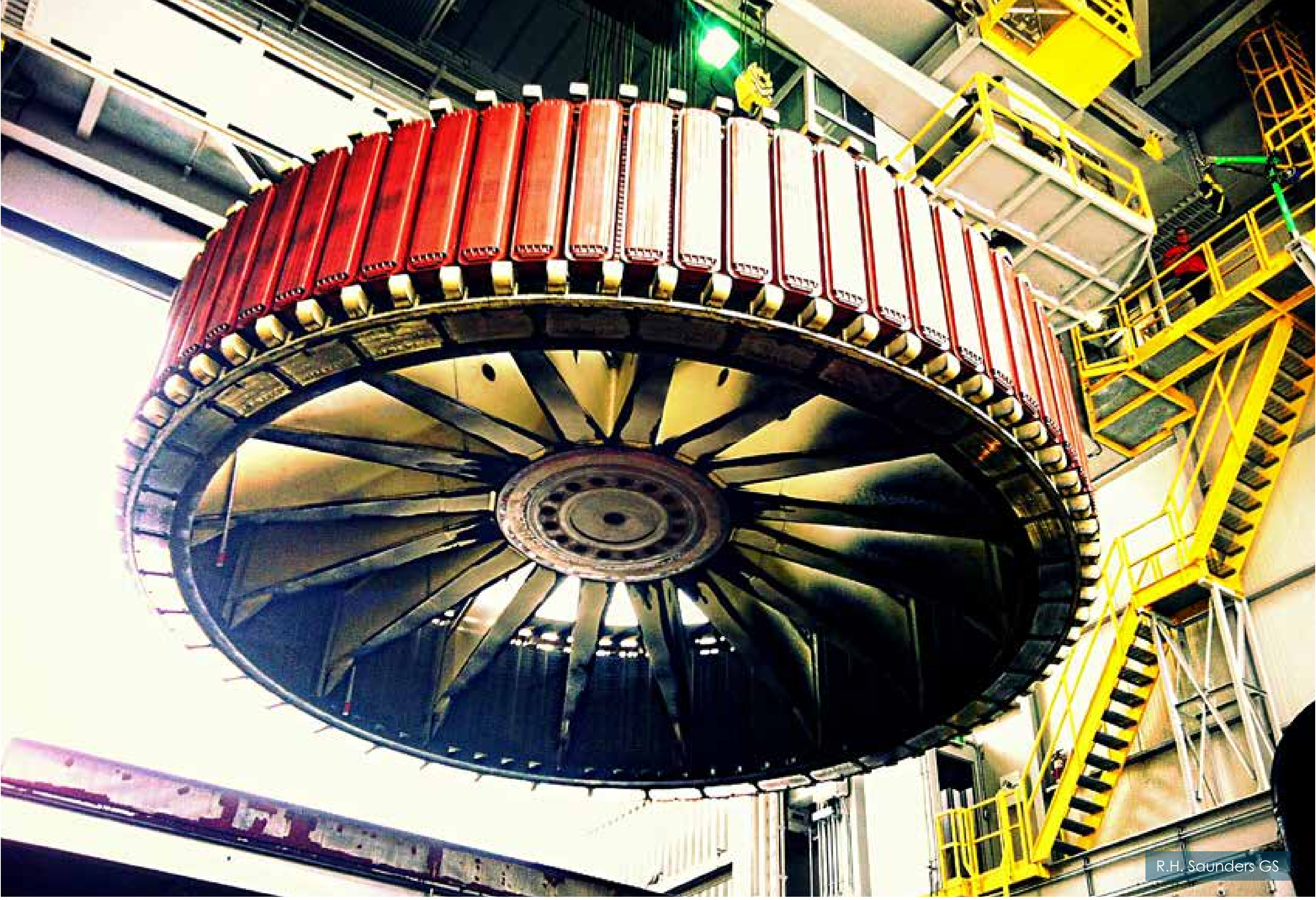
5.2 Comparing hydroelectricity to other technologies

OPG was asked to compare hydroelectricity to wind, solar photovoltaic (solar), and small modular reactors (SMR).

Comparing different forms of electricity generation cannot be done using a single metric because factors unique to each technology are excluded, such as: value to the electricity system, lifecycle of the asset and redevelopment requirements, socioeconomic considerations, jobs, localized economic impact, location and environmental factors. It is recognized that assessment and ranking can be subjective in cases where precise numeric metrics are not available and ultimately different technologies will be needed to meet future electricity demand.

To conduct a life cycle analysis, three hydro sites were used in a more detailed MCA. These sites were selected because there was engineering information available, geographic spread across northern Ontario and distinct geotechnical conditions.

The MCA used four criteria and associated sub criteria. Sensitivity cases were developed to simulate different perspectives and priorities and to evaluate the stability of the ranking across a range of views on different forms of electricity

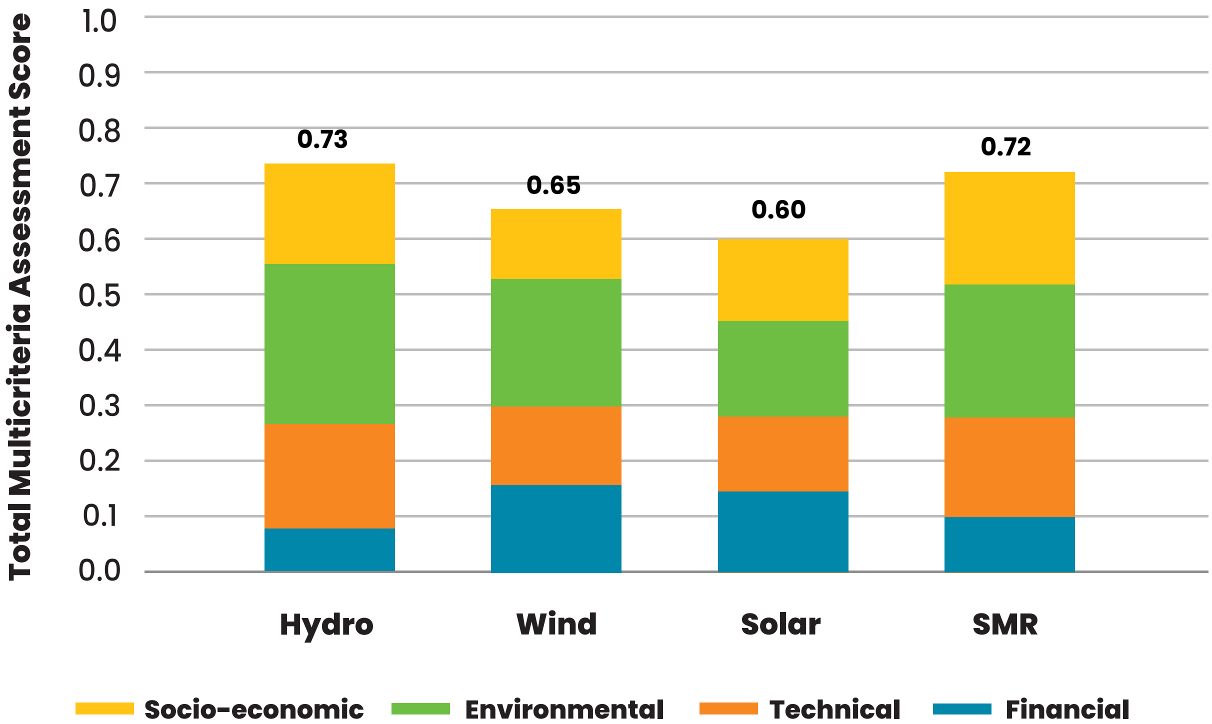

R.H. Saunders GS

generation. These sensitivity cases assigned different weightings to each of the four criteria. Each of the three hydroelectric sites selected scored higher than the other generation technologies for all considered sensitivity cases.

One-reason hydroelectric compares so well to other technologies is the socioeconomic benefit, because at least 75 cents of every dollar spent for hydroelectric development will stay in Ontario. Hydroelectric generating stations are legacy assets that offer strong value-for-money when considering the initial construction employment and GDP, followed by water rentals and taxes during operations, sustained electricity system value, avoided greenhouse gas emissions, and minimal decommissioning costs relative to other technology. Hydroelectric is a perpetual asset which undertakes periodic life extension projects that allow for infrastructure to be recycled, reused, and re-purposed.

This economic benefit is similar to OPG's SMR project that will provide substantial benefit to the province.

Figure 5.2: Sample of a hydro development score compared with other generation technologies in a multi-criteria assessment, with a higher score indicating a more favourable result (Data source: WSP, 2022)



Abitibi Canyon

Ombabika Bay

5.3 Ontario Waterpower Association perspective

There are dozens of smaller (<50 MW) sites across northern Ontario that may present attractive opportunities for development. As a result of waterpower promotion by the Province of Ontario in the early 2000s, site investigation and environmental assessment has already occurred for many of these sites. There is still potential for significant local and regional socioeconomic benefits through water rentals, taxes and construction employment. These sites should not be missed while focusing on larger capacity sites and pockets of higher potential. Moreover, the industry has demonstrated leadership in advancing partnerships with Indigenous communities in northern Ontario with more than a dozen successful projects brought on line.

The broader waterpower industry is paying attention to the treatment of existing facilities in northern Ontario when considering whether to pursue future developments. Existing facility owners are potential developers of new facilities, and their long-term viability serves as a confirmation to others that future investment is worthwhile. Re-contracting programs for non-rate regulated facilities will promote the legacy asset concept and will improve investment confidence and certainty necessary if Ontario wishes to proceed with further hydroelectric generation.

Lac Seul GS

6.0 Foundational partnerships

Success factors for the next wave of hydroelectric developments:

- Earlier and broader participation by Indigenous communities who can contribute knowledge about the lands and rivers where potential development sites are located
- Greater collaboration to enable other local developments, such as mines
- Earlier and more stable revenue and rate certainty to account for long lead time and asset life
- Greater recognition by regulators that capital expenditures to put assets into service will be offset by multi-generational benefits to Indigenous and local communities as well as the ratepayer
- Recognition that policy constraints require revisiting to reflect climate change urgency and Indigenous commercial partnership models that have been proven to work in Ontario
- Remote community support for energy supply and/or transmission connection
- Public and community support for hydroelectric generation technology


"Ode to the Canoe" by Patrick Hunter

6.1 Indigenous communities

Indigenous communities are essential partners in developing hydroelectric generation in northern Ontario. Meaningful engagement and consultation with Indigenous communities must occur at the earliest stages, including policy development, as well as during project planning, execution and operations. Though every community has unique needs and perspectives, various Indigenous communities see the potential for meaningful participation in hydroelectric development as a means of furthering economic and social progress. This includes both the direct benefits of hydroelectric project development, as well as the secondary benefits of hydroelectric investment and infrastructure in developing other natural assets, such as mining operations.

Ontario is committed to consulting with Indigenous communities and honouring existing agreements related to hydroelectric development. OPG together with the OWA, engaged with Indigenous community representatives to better understand how communities themselves would define success in hydroelectric development in their region. This included gathering insight from communities who have experience pursuing and shared or full ownership in hydroelectric generating facilities as well as those whose traditional territory encompasses some of the high potential opportunities reviewed in this report. The Métis Nation of Ontario was contacted and it was decided that discussion with community councils should occur once more is known about the pockets of generation potential and where further hydroelectric development might occur.

The discussions produced three broad themes.

Strike a balance between economic, social and environmental considerations

The protection and the ongoing stewardship of traditional homelands of communities is the paramount concern, outweighing the appeal of shorter-term economic benefit. To balance these two considerations, Indigenous communities want to participate as early as possible in a project development, including optimization processes to support decision making on the balance of cost, energy and inundation. Career planning is essential so that hydroelectric development supports other projects and investments outside and inside the community.

In generating environmentally sustainable jobs, communities seek employment opportunities in all aspects of a project lifecycle, including planning, construction, rehabilitation, operation, maintenance and monitoring. To build community support for project development, as many members as possible should see how their interests and skills, or potential skills development, can open doors to opportunity.

Black-crowned Heron - Sir Adam Beck GS

Commercial participation, including shared equity partnerships has been a positive experience

Equity partnerships on hydroelectric assets have generated meaningful economic benefits and built capacity for other economic development activities. Communities can invest stable, consistent revenues into new economic development projects, some of which deliver immediate returns, such as housing. Equity ownership provides a financing tool for further investment in emerging economic opportunities for an Indigenous community, while contracting opportunities builds capacity to execute on new enterprises. Even in cases where workers leave one northern community to work in another, some have returned to their community with rich employment experience to share. Partnerships can extend beyond commercial agreements and industry needs to listen to partner communities to understand expectations.

Show flexibility in achieving Indigenous participation and equity investments in the hydro sector

Government policies, regulatory processes and financial instruments should be designed to facilitate resource revenue sharing and improve the financial participation value proposition for Indigenous communities. Communities that have been successful with hydro developments would like to see greater rate and revenue certainty and stability to allow for prudent asset management and investment, such as maintenance of the assets. Communities that have started hydro developments, but not brought them to completion, require more certainty upfront. This means assurance that time and resources invested in partnership development and environmental assessment participation will result in project procurement. Simplifying financial incentive application processes and access to financial capital will more easily enable further Indigenous equity investment.

In March 2022, the OWA commissioned a poll on new hydro development that found northerners to be overwhelmingly positive. In response to the question, "Would you support or oppose waterpower development in your region?" positive responses were 88% in the northeast, 80% in north central and 87% in northwest. When asked about waterpower projects developed in cooperation with local Indigenous communities, respondents were even more supportive.

Chenaux GS

Mattagami River

7.0 Taking action

7.1 Taking steps to secure a clean energy future

This report is a preliminary industry update on opportunities for new hydroelectric development in northern Ontario. As indicated by the IESO, work needs to start as soon as possible so that Ontario has options and opportunities to take advantage of work already completed and to accelerate development of new projects. Hydroelectric development is a long process that needs to start early in order to meet the needs of the future.

Advancing new northern hydroelectric development opportunities would ensure province-wide infrastructure benefits, enhance system reliability through incremental baseload generation, and would bolster the development of other northern economic sectors such as mining.

To unlock all of the potential hydropower that is needed to secure a made-in-Ontario, clean electricity system, OPG recommends the following:

1. **Take a step towards new hydroelectric generation in northwestern Ontario to meet mid-term demand by accelerating the Little Jackfish Project.**
   OPG to finalize the Environmental Assessment and reinitiate planning on the Little Jackfish Project, which is the most advanced hydroelectric

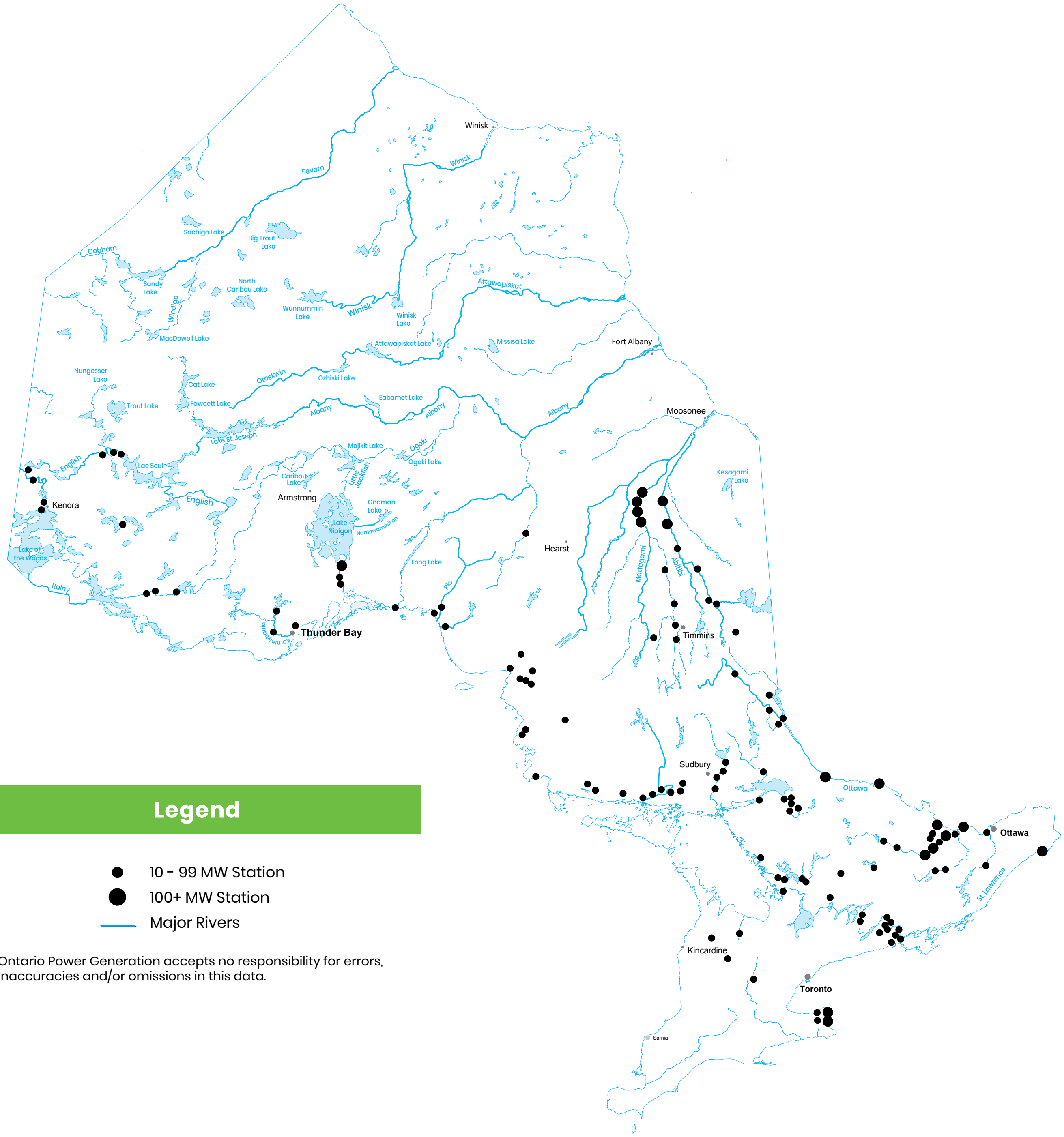
development opportunity in northwestern Ontario. In addition, request OPG and the IESO to coordinate and develop analysis on the system value of the project while contemplating its inclusion in the Pathways to Decarbonization Report. Furthermore, request that OPG assess the economic and ratepayer impact of the proposed project and report its findings to the Ministry of Energy.

2. **Take a step to unlock up to 1,250 MW of hydro potential in the Moose River Basin in northeastern Ontario.** Advise the Ontario government to initiate co-planning discussions with certain First Nations, using OPG as a facilitator to bring governments and industry representatives together. Moose Cree First Nation and Taykwa Tagamou Nation will advise on the best timing to proceed based on discussions with the Ontario government.

3. **Unlock hydro potential from existing assets across Ontario to meet emerging demand.** Tabulate all of the other potential hydro development, re-contracting and redevelopment opportunities across Ontario, including refurbishments, pumped storage opportunities, and powering-up control dams. OPG, with the support of the OWA can provide this information to IESO for inclusion in its *Pathways to Decarbonization Study* to ensure that Ontario is leveraging its existing assets when defining hydropower's role in Ontario's future electricity system.

4. **Build out a reliable system.** OPG, in collaboration with the OWA, Indigenous communities, Hydro One and the IESO, will develop a long-term outlook and assessment that details how Ontario can effectively plan and develop transmission and hydroelectric assets in northern Ontario. This assessment will evaluate incremental hydroelectric generation and transmission projects using metrics, such as: system value, provincial and northern Ontario demand assessments, cost-effectiveness, and market conditions. The proposed assessment will also consider potential synergies with socioeconomic initiatives, economic development opportunities, remote community development, and other provincial priorities.

Map of existing hydroelectric stations in Ontario



Legend

- 10 - 99 MW Station
- 100+ MW Station
- Major Rivers

Ontario Power Generation accepts no responsibility for errors, inaccuracies and/or omissions in this data.

Cameron Falls GS

Appendix A

Legislative, regulatory and policy framework for waterpower development in northern Ontario

Appendix A summarizes the key legislative, regulatory and policy frameworks for the hydroelectric sector that, in OPG's view, require review, revision or realignment for northern hydroelectric opportunities to be more fully optimized and to increase investment certainty.

Public Lands Act (MNRF)

Under the Public Lands Act, the Minister (MNRF) has the authority over the management, sale and disposition of the public lands and forests, often referred to as "Crown lands". About 77% of the province's land mass is made up of public land. Section 42 of the Act speaks to the disposition of water powers or privileges, providing that:

> *"The Minister in his or her discretion may fix the terms and conditions upon which water powers or privileges granted by the Crown and any public lands necessary for the development thereof may be leased or developed"*

Development of waterpower is dependent on access to land. Where access to public lands is required, the Minister may grant a lease for the use of the lands. MNRF Policy PL 4.10.06 **Renewable Energy on Crown Land** issued February 10, 2014, states:

Waterpower development on Crown land may include the following development types:

- peaking facilities or run of river facilities which require the construction of dams or infrastructure
- in stream flow technology,
- greenfield development,
- retrofit of water control structures and redevelopment of waterpower facilities, and
- pumped storage generation, where pumped storage generation is supported by provincial energy needs or specific economic development objectives.

This policy also provides land use direction for the Northern Rivers Watershed:

> Crown land use policy direction since 1993 has provided for a 25 MW limit on waterpower development at individual sites within the Northern Rivers Watersheds. This 25 MW limit on individual waterpower sites may be reviewed through:
>
> - community based land use planning processes in the Far North, or
> - land use planning or other processes for areas south of the Far North.
>
> A review of the 25 MW development limit will include broader landscape and watershed level considerations and provide for dialogue with First Nations located within the subject river basin. In the absence of a land use planning review, the 25 MW limit on individual waterpower sites shall remain in place.

The *Renewable Energy on Crown Land Policy* of MNRF provides that the Ministry will encourage Aboriginal community economic benefits from renewable energy development on Crown land including by committing to the following:

1. **Far North**

   In the Far North Act area, access to Crown land for waterpower, wind power and solar power development opportunities will only be granted to local Ontario First Nation communities and/or their partners.

2. **Northern Rivers**

   Access to Crown land for waterpower development opportunities within that portion of the Northern Rivers Watersheds south of the Far North Act boundary will only be granted to local Ontario Aboriginal communities and/or their partners.

3. **Moose River Basin**

   The policy acknowledges and recognizes the continued Ontario government commitment to co-planning with certain First Nation communities about the potential future waterpower development within the Moose River Basin, north of Highway 11.

Provincial Parks and Conservation Reserves Act (MECP)

The purpose of the Provincial Parks and Conservation Reserves Act (PPCA) purpose is to:

> *"permanently protect a system of provincial parks and conservation reserves that includes ecosystems that are representative of all of Ontario's natural regions, protects provincially significant elements of Ontario's natural and cultural heritage, maintains biodiversity and provides opportunities for compatible, ecologically sustainable recreation "*

Under Section 16, certain activities are prohibited within provincial parks and conservation reserves. The prohibited uses include the "generation of electricity", defined as:

> *"generation of electricity" means the generation of electricity through the deployment or construction of electrical energy producing devices or facilities and supporting infrastructure, including wind turbines, solar panels, pump storage facilities, reservoirs, impoundments and water control structures or weirs;*

Section 19 provides limited exceptions from the prohibition, including an exception for existing waterpower facilities (existing on the day the section was proclaimed in force) within provincial parks and conservation reserves, which may continue to operate and be maintained and, with the approval of the Minister, may be improved, rebuilt or altered. In addition, an exception is included for remote communities that are not connected to the IESO-controlled grid:

> *"…subject to the approval of the Minister, facilities for the generation of electricity may be developed in provincial parks and conservation reserves for use within communities that are not connected to the IESO-controlled grid."*

Exemptions also apply for existing commitments, whereby if a facility for the generation of electricity was specifically identified in a ministry land use plan before the site where the facility is to be located was regulated as part of a provincial park or conservation reserve, the facility may be developed subject to the approval of the Minister.

Approvals for generation of electricity under the exemptions (and approvals for utility corridors) are subject to the Minister being satisfied that certain conditions are met (section 21). Furthermore, occupational authority is required under the PPCRA to use and occupy land within a provincial park or conservation reserve, and work permits are also required to permit any construction.

Environmental Assessment Act (MECP)

New waterpower developments less than 200 MW nameplate capacity are required to adhere to the Ontario Waterpower Association's Class Environmental Assessment for Waterpower Projects under the Environmental Assessment Act. New waterpower developments with a nameplate capacity of 200 MW or greater require the completion of a more formal Comprehensive Environmental Assessment, which requires a Terms of Reference followed by an Environmental Assessment.

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Where a brighter
tomorrow begins.

IESO Assessment of OPG’s Northern Ontario Hydroelectric Facilities

April 1, 2022

Connecting Today.
Powering Tomorrow.

Table of Contents

1. Executive Summary

Ontario Power Generation (OPG) has been asked by the Minister of Energy to update opportunities for new hydroelectric development in northern Ontario. As detailed in OPG's report, 21 potential hydroelectric facilities across northern Ontario have been identified, with a low and a high range of total installed capacity, between 1,420 MW and 2,770 MW respectively, distributed into four geographical pockets. As part of the Minister's request, the Independent Electricity System Operator (IESO) has been asked to identify: the transmission infrastructure associated with enabling these new hydroelectric facilities, together with an estimate of its cost, and the value of these facilities to the system.

This report summarizes the IESO's high-level assessment of OPG's hydroelectric facilities from a system value and a transmission perspective, the latter of which is broken into connection and bulk transmission requirements.

From a system value perspective, the economic assessment of the proposed hydro facilities found that by 2042, system benefits amounted to between 30% and 50% of revenue requirement, depending on the facility. Recognizing that hydroelectric facilities are long-lived and that the need and value of energy will continue to grow, system benefits increase to between 80% and 120% of revenue requirement, depending on the facility, when considering the full lifetime of the asset (90 years). Note that this assessment does not include any allocation of cost for necessary transmission build-out or reinforcement.

The transmission assessment considered the key connection infrastructure to connect all of the 21 hydroelectric facilities (with low and high capacity ranges) to the bulk transmission network, and the reinforcements to the bulk transmission network to reliably transfer the electricity from the point of generation, within the four geographic pockets, to the load centres in the southern portions of the province. The bulk transmission path connecting northern Ontario to southern Ontario has reached its capacity and, therefore, any sizeable hydroelectric facilities with output not consumed at or near its location will require bulk reinforcement to this north-south path. This is the case for hydroelectric facilities in the Moose River Basin and Albany-Attawapiskat pockets.

The transmission reinforcements described in this report are conceptual and meant to illustrate the scale of development and costs that could be required from a transmission perspective. For example, the connection facilities can vary significantly depending on the exact routing and distance to the existing bulk transmission network and the total amount of generation in the pocket to be enabled. Further, the scale of bulk reinforcement will similarly depend on the total amount of hydroelectric generation across the north that needs to be enabled.

Total transmission costs for each geographical pocket are estimated as: $365-425 M for Little Jackfish, $15-25 M for Severn-Windigo, $2,470-3,095 M for Moose River Basin, and $3,400-4,235 M for Albany-Attawapiskat generation pockets. Under the low capacity scenario, the total transmission costs for each geographical pocket are estimated as: $330-385 M for Little Jackfish, $15-25 M for

Severn-Windigo[1] and $3,075-3,845 M total for the Moose River Basin and Albany-Attawapiskat pockets, recognizing that they make use of the same bulk infrastructure in the low scenario. These costs are based on historical typical planning-level allowance provided by Hydro One, which are subject to a margin of +100/-50%.

The bulk transmission reinforcement costs make up an appreciable portion of the total costs for the Moose River Basin and Albany-Attawapiskat facilities; whereas no bulk reinforcements are anticipated for Little Jackfish and Severn-Windigo facilities. Under the high capacity scenario, the bulk transmission network would require two new single-circuit 500 kV transmission lines from Pinard TS to Porcupine TS to Hanmer TS (approximately 370 km in total length each), as well as two new single-circuit 500 kV transmission lines from Hanmer TS to Essa TS to an existing or new 500 kV station in the GTA (approximately 350 km in total length each). This would account for approximately $3,790-4,800M of the total transmission costs in the high scenario and would take upwards of 10 years to develop. Under the low capacity scenario, one single 500 kV transmission line would be required along the same pathways, costing approximately $1,895-2,400M.

It is important to state that this assessment does not identify actionable recommendations. Instead, the assessment is meant to provide an indication of the system value and the scope of what may be required from a transmission perspective considering the potential range of development. This work is expected to continue as part of the IESO's Pathway to Decarbonization Study, in which these hydroelectric facilities will be further considered.

[1] The same as the high scenario

2. Assessment Approach

This section summarizes the IESO's high-level approach to assessing OPG's hydroelectric facilities from a system value and transmission perspective.

2.1 Approach to the Transmission Assessment

This report outlines high-level estimates of potentially required transmission infrastructure and associated costs to enable the high and low range of installed capacity resulting from OPG's 21 hydroelectric facilities, in terms of:

- Connection to the bulk transmission network[2]; and,
- Reinforcements to the bulk transmission network to reliably transfer the electricity from the point of generation to the load centres, particularly in the southern portions of the province.

The transmission reinforcements described in this report are conceptual and meant to illustrate the scale of development and costs that could be required from a transmission perspective. These hydroelectric facilities will be considered as part of the IESO's Pathways to Decarbonization Study, where the required transmission reinforcements will be explored further.

Connection and bulk transmission infrastructure outlined in this report is limited to conceptual high voltage transmission line and station facilities, which provide a sense of the anticipated costs involved. Further detailed project-level studies would be required to determine the exact configuration of the connection and bulk transmission and thus the full set of infrastructure required.

The costs of the high voltage circuits identified in this report have been estimated using the approximate distance of new transmission circuits and typical planning-level costs[3] of new transmission circuits in northern Ontario on a per kilometer basis, provided by Hydro One. The approximate distance of new transmission circuits considers direct routing from existing infrastructure; the actual distance could vary to accommodate land, consultation with impacted communities and natural features that would be studied at the project level.

Finally, the transmission assessment is first presented for OPG's high scenario of installed capacity. Commentary on how the required transmission could change according to the low scenario is then provided. It is recognized that ultimate development of these facilities, or a subset thereof, would likely occur in a phased manner; this may allow for some of the connection costs to be phased to the extent they are not contingent on other facilities. However, reinforcements to the bulk network are

[2] These costs are the responsibility of the connection applicant, i.e., OPG, under the Ontario Energy Board's Transmission System Code. The connection costs included in IESO's report are based on typical planning allowance and reflect current market conditions. OPG has included an estimate of its connection costs in all generation development costs shown in their report; these costs will be updated as part of the Pathways to Decarbonization Study.

[3] Margin of +100%/-50%

less likely to be phased given the common transfer path and the life of the assets.

2.2 Approach to the System Value Assessment

This report includes a high-level economic assessment of a number of proposed OPG facilities in order to illustrate the value of the province's hydroelectric potential. The facilities are evaluated in the context of IESO's current reference outlook, the 2021 Annual Planning Outlook (the "2021 APO)", with further discussion on how this value may change as IESO and sector partners and participants embark on the Pathways to Decarbonization Study.

Below is a summary of approach to the economic assessment:

- Study Context: the 2021 APO, with system capacity and energy benefits realized from the displacement of natural gas-fired facilities and production[4]
- Hydroelectric Facility Inputs: facilities, performance characteristics and revenue requirements, confidential as provided by OPG
- Results Metric: a 2022 net-present-value (NPV) ratio of system benefits to revenue requirement using a 4% real social discount rate (SDR)
- Study Period: benefits and revenue requirement considered to the end of the 2021 APO planning horizon (2042), and to the end of facility life (~2120)

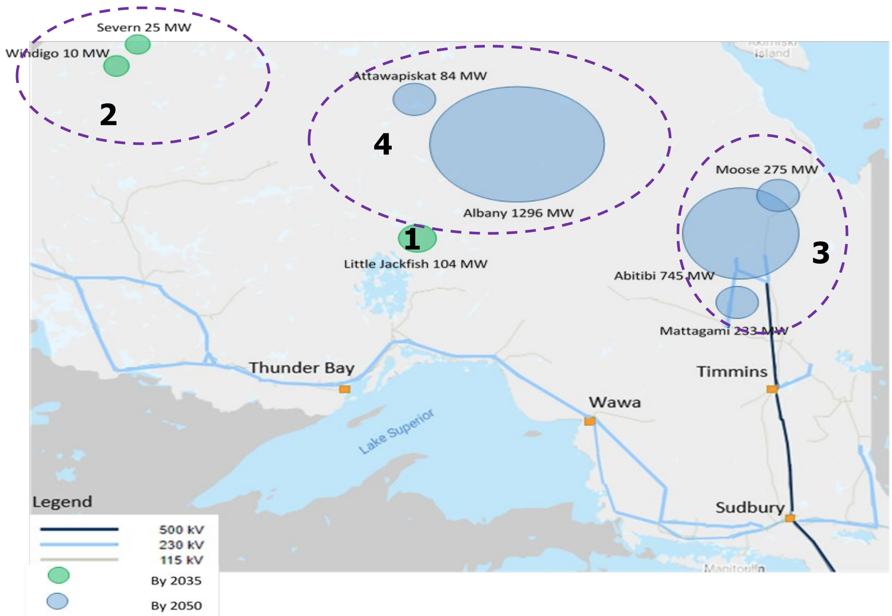
[4] This includes the proxy resource as described in Section 4.1.

3. Transmission Assessment

The transmission assessment was performed according to the following four main pockets of generation, as per OPG's report and illustrated in Figure 1:

1. Little Jackfish
2. Severn-Windigo (Severn River and Windigo River)
3. Moose River Basin (Abitibi River, Mattagami River and Moose River)
4. Albany-Attawapiskat (Albany River and Attawapiskat River)

Figure 1 | Map of Generation Pockets[5]



The total potential installed capacity for each pocket is listed in Table 1, as provided by OPG, for both the high and low scenarios. The transmission assessment is first provided for the high capacity scenario, followed by commentary on the low scenario.

Table 1 | Hydro Potential Capacity by Generation Pocket

Generation Pocket	Installed Capacity, Low Scenario (MW)	Installed Capacity, High Scenario (MW)
1: Little Jackfish	80	100
2: Severn-Windigo	20	35
3: Moose River Basin	640	1,250

[5] Note that boundaries in Figure 1 are approximate.

Generation Pocket	Installed Capacity, Low Scenario (MW)	Installed Capacity, High Scenario (MW)
4: Albany-Attawapiskat	680	1,380
Total	**1,420**	**2,770**

* Installed capacity by pocket and by total has been rounded

The anticipated connection and bulk transmission to enable each of the generation pockets is described in the sections that follow.

3.1 Little Jackfish

The Little Jackfish pocket consists of two facilities north of Lake Nipigon, totaling approximately 105 MW of capacity under the high scenario, that are approximately 25 km apart. The following diagram illustrates the location of this generation and the potential connection infrastructure that may be required to enable it.

Figure 2 | Map of Little Jackfish

3.1.1 Connection Transmission

These facilities would connect to the bulk transmission network at a new switching station connected to circuits between Marathon TS and Lakehead TS. This would require a 185 km single-circuit 230 kV path along the east side of Lake Nipigon to the new switching station in the south. Each facility will be connected together through a 25 km single-circuit 230 kV to form a junction site.

If this generation were to be developed, there may be an opportunity to integrate the connection of the generation with other potential needs emerging in the area, including electricity supply to the Ring of Fire, that are currently being studied under the IESO's Northwest Integrated Regional Resource Plan. It should be noted that connection of Little Jackfish as part of an integrated solution would likely change the connection configuration for this facility so as to align with the North-South road development to/from the Ring of Fire and other potential pockets of load growth and needs.

Under the low scenario, the second facility with an installed capacity of 26 MW would not be developed and, therefore, the 25 km of connection line to this facility would not be required.

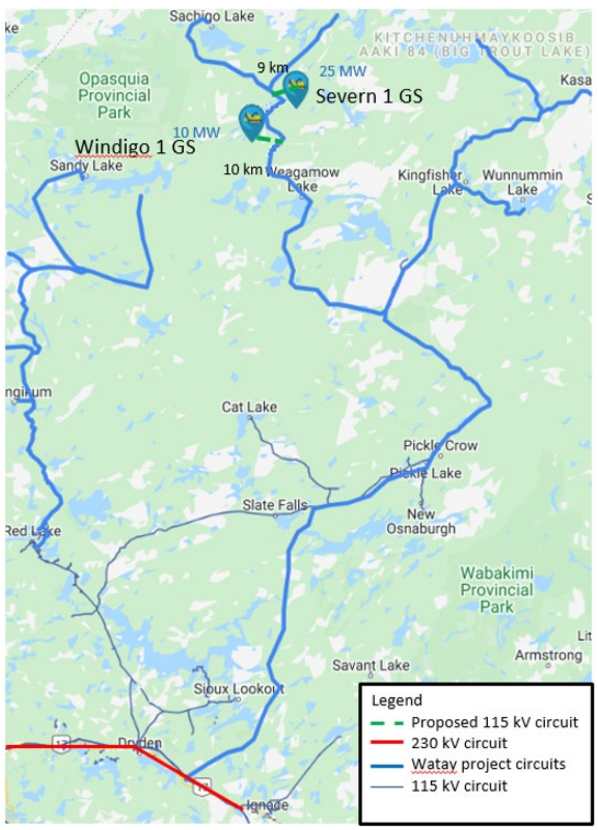
3.1.2 Bulk Transmission

No bulk reinforcements are anticipated to incorporate the high and the low installed capacity ranges from the Little Jackfish facility. The bulk network is expected to have the needed transfer capability to transfer power eastward, out of the northwest, and westward, to the western portion of the region, during times of high hydroelectric output from this facility. This is enabled via the East-West Tie, and potentially supported by the Waasigan Transmission Line, which is currently under development.

3.2 Severn-Windigo

There are two facilities identified on the Severn and Windigo river systems in Northwestern Ontario, totaling 35 MW of capacity under the high scenario. The following diagram illustrates the location of this generation and the potential connection infrastructure that may be required to enable it.

Figure 3 | Map of Severn-Windigo



3.2.1 Connection Transmission

Each of the facilities will require a single 115 kV tap connection to connect to the 115 kV

Wataynikaneyap Transmission Project. The approximate distances for the tap connections are approximately 10 km away from the transmission network, as illustrated in Figure 3. The connection facilities are not expected to change under the low installed capacity scenario, which includes the same capacity from the Windigo 1 facility and a reduced capacity from the Severn 1 facility.

3.2.2 Bulk Transmission

No bulk reinforcements are anticipated to incorporate the high and the low installed capacity ranges from the Severn-Windigo pocket. Phase 2 of the Wataynikaneyap Transmission Project will enable transfer of the output from these facilities on the 115 kV network to meet local electricity demand and southward to the 230 kV corridors that transfer power eastward, out of the northwest, and westward, to the western portions of the region, during times of high hydroelectric output. This is enabled via the East-West Tie, and potentially supported by the Waasigan Transmission Line, which is currently under development.

3.3 Moose River Basin (Abitibi, Mattagami and Moose River)

The Moose River Basin consists of nine facilities from the Abitibi, Mattagami and Moose Rivers totaling approximately 1,250 MW of capacity under the high scenario. The following diagram illustrates the location of this generation and the potential connection infrastructure required to connect it to the bulk transmission system at Pinard TS in Fraserdale.

Due to the amount of installed capacity in this pocket, and the limited capability of the existing transmission system to transfer generation from Pinard TS to the load centres in the southern portions of the province through the Flow-South interface, significant bulk transmission reinforcements would be required. The same applies to the generation in the Albany-Attawapiskat pocket, which would also connect to the bulk transmission system at Pinard TS, due to its geographical proximity and to provide the opportunity to integrate the required bulk reinforcements with those to enable the generation facilities in the Moose River Basin through a common network path. Therefore, the bulk transmission reinforcements required to enable deliverability of the generation in the Moose River Basin and the Albany-Attawapiskat pocket and are described together in Section 2.5.

This section describes the connection transmission required to connect the Moose River Basin generation facilities to the bulk transmission system at Pinard TS.

Figure 4 | Map of Moose River Basin

3.3.1 Connection Transmission

These facilities would connect to the bulk transmission network at Pinard TS, which is the closest point of connection to the bulk system. Six connecting sections are expected to be through a single - circuit 230 kV line and the remaining three sections from Abitibi 3 to Abitibi 4 to Abitibi 5 to Pinard TS, would connect through two single-circuit 230 kV lines when considering their capacities. The approximate distances between the circuit tap connections are illustrated in Figure 4.

Under the low scenario, the connections for all the facilities would be through a single-circuit 230 kV line.

3.4 Albany-Attawapiskat

There are eight facilities identified on the Albany and Attawapiskat river systems in Northwestern Ontario, totaling 1,380 MW of capacity in the high scenario. The following diagram illustrates the location of this generation and the potential connection infrastructure to connect it to the bulk transmission system at Pinard TS in Fraserdale.

As described in Section 2.3, the bulk transmission reinforcements to enable the Albany-Attawapiskat generation has been integrated with those to enable the Moose River Basin generation due to the common network transfer path that will be utilized. These bulk transmission reinforcements are described in Section 2.5. This section describes the connection transmission required to enable the Albany-Attawapiskat generation facilities.

Figure 5 | Map of Albany-Attawapiskat

3.4.1 Connection Transmission

The generation facilities included in the Albany-Attawapiskat pocket could conceivably connect to the bulk transmission network at Pinard TS, or to a new switching station connected to either M23L or M24L circuits between Marathon TS and Lakehead TS. Pinard TS has been selected as the connection point for this assessment given the geographical proximity and so as to enable integration of the bulk system reinforcements with those required to enable the generation in the Moose River Basin in a common network transfer path.

While a M23L or M24L connection arrangement could present opportunities to integrate the connection of Little Jackfish and the Albany-Attawapiskat generation with other emerging needs in the area, including electricity supply to the Ring of Fire, connecting this magnitude of generation capacity in this location would require additional reinforcements to the East-West Tie, in addition to the reinforcements required to enable the Moose River Basin generation. However, there may be an opportunity to connect some of the smaller facilities in the Albany-Attawapiskat pocket as part of an integrated solution to electrically supply the Ring of Fire given their alignment and proximity to the North-South road that is under development, to the extent that these facilities could be supported by the local demand and not trigger additional bulk reinforcements.[6] While this connection arrangement is not expected to reduce overall connection costs, it could help the local area in an electricity supply

[6] Refer to Section 2.5 for further details.

scenario through provision of voltage support. The decision on the exact connection arrangement will depend on how the needs in the area unfold in the coming years.

In order to connect to Pinard TS, each generation facility in the Albany-Attawapiskat pocket will connect through single-circuit 230 kV lines except the circuit between Albany 2 and Albany 1, which would require two single-circuit 230 kV lines when considering the total capacity that must be transferred. The Albany 1 junction will then connect through three 245 km single-circuit 230 kV lines to Pinard TS.

Under the low scenario, the connections for all the facilities would be through a single-circuit 230 kV line.

3.5 Combined Moose River Basin and Albany-Attawapiskat Bulk Transmission

The existing transmission system's capability to transfer generation not consumed in the northeast to the load centres in the southern portions of the province has reached its capacity. Development of the hydroelectric facilities in the Moose River Basin and the Albany-Attawapiskat pocket could add up to an additional 2,630 MW of capacity under the high scenario and will require significant bulk transmission reinforcement in the north-south direction to enable them.

Today, the northeast is connected to the south via a single-circuit 500 kV line that connects Pinard TS near Fraserdale to Hanmer TS in Sudbury, via Porcupine TS near Timmins. Two single circuit 500 kV lines with series capacitors at mid-point then connect Hanmer TS in Sudbury to Essa TS in Barrie, and Claireville TS in the Greater Toronto Area (GTA). There is a significant amount of existing hydroelectric generation (in the order of 5,550 MW) in the north whose output must be transferred southbound when it exceeds the local electricity demand in the region, particularly during peak hours and during spring run-off periods. Adding more hydroelectric generation at Pinard TS will violate the thermal ratings of the single-circuit 500 kV line such that it will not be able to be transferred to the south without reinforcement. Additionally, the loss of the existing single 500 kV circuit results in disconnecting most of the current generation capacity in the North and further exacerbating the capacity needs in the south.

In the high capacity scenario, in order to transfer the generation from Pinard TS and ensure bulk transfer capability, two options are available:

1. An *alternating current (AC) option* that would require two sets of upgrades:
    a) Two new single-circuit 500 kV transmission lines from Pinard TS to Porcupine TS to Hanmer TS, approximately 370 km in total length each.
    b) Two new single-circuit 500 kV transmission lines from Hanmer TS to Essa TS to an existing or new 500 kV station in the GTA, approximately 350 km in total length each.

This option would require expansions at the connected stations and voltage support along the circuits.

2. A *high-voltage direct current (HVDC) option* that would require two new 500 kV HVDC bi-pole that directly links Pinard TS to a station in the GTA, approximately 720 km in total length each. This would require AC to DC and DC back to AC converter facilities. This option can have a cost advantage over AC lines for very long transmission (~1,500 to 2,000 km), but

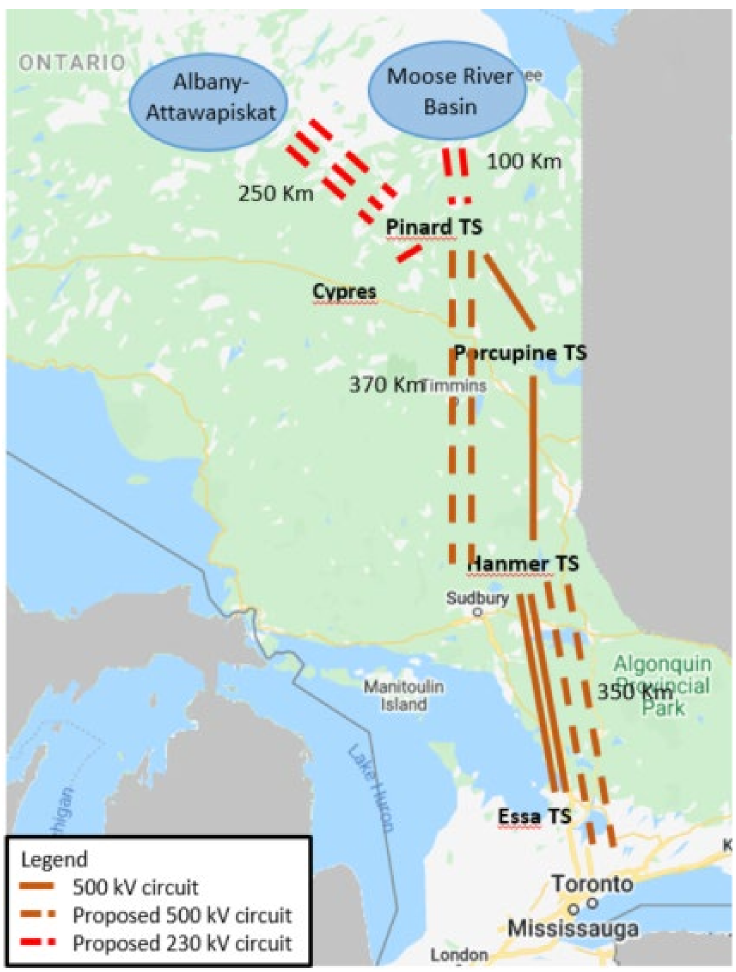
given that it is a direct link, it would not help reinforce the local area in the Northeast to the same extent as the AC option. This option is presented to illustrate the possibility of using HVDC technology, which would be considered in detail when additional studies are carried out at a later stage.

In the lower capacity scenario, if only one pocket of the generation were to be developed (i.e., the high capacity scenario for the Moose River Basin or the Albany-Attawapiskat pocket) these options are anticipated to only require one new single-circuit 500 kV transmission line or a bi-pole 500 kV HVDC line. This is based on the estimated incremental transfer capability of a single-circuit 500 kV line from previous studies i.e., 1,000 – 1,500 MW. This would also be the case if both pockets of generation are developed under the low scenario (i.e., 1,320 MW of installed capacity in total from both the Moose River Basin and the Albany-Attawapiskat pocket).

As per information provided by Hydro One, the existing right-of-way for the 500 kV circuits linking the Northeast to the GTA may require expansion in certain areas south of Sudbury to accommodate new circuits. For this reason, the development of this reinforcement may take upwards of 10 years, which is at the upper end of typical transmission development cost in order to account for securing the necessary approvals and right-of-way expansion.

These bulk transmission reinforcements are illustrated in Figure 6.

Figure 6 | Map of Bulk Transmission Required



4. Transmission Cost Assessment

This section provides the transmission cost assessment methodology and assumptions and summarizes the total cost estimates that may be required to enable each of the four generation pockets described in the transmission assessment, under the high and low scenarios.

4.1 Methodology and Assumptions

4.1.1 Bulk Transmission

Bulk transmission considered in this analysis consists of bulk circuit reinforcements, required to enable the additional generation to be transferred through the system, and bulk station costs to accommodate circuit terminations for the new circuits.

Bulk transmission circuit costs are calculated by applying the historical costs per kilometer to the estimated distances of new circuits required. Assumptions for bulk transmission costs are based on information of high and low estimates provided by Hydro One. These costs represent historical typical planning-level allowance for transmission circuits in Northern Ontario on a per kilometer basis and are subject to a margin of +100/-50%. Actual costs would depend on site specific conditions at the project level, including nature and availability of access roads, terrain and soil conditions, sensitive land features etc. These costs only cover engineering, material, and construction costs; they do not account for right-of-way acquisitions, special configurations, accommodations for sensitive land features, or costs of engaging and consulting with indigenous communities, for example. This also does not account for potential cost savings for development of multiple circuits along the same corridor at the same time, as would be required to enable the Moose River Basin and Albany-Attawapiskat generation pockets together. Also, it does not consider the specific network benefits of connecting multiple customers, such as indigenous communities and Ring of Fire mines, when combined with one or more generation projects.

Circuit lengths were estimated based on the site specific information provided by OPG. Actual circuit distances may be longer, based on the specific conditions in the vicinity of the projects, which can drive different routing terrain and feasible paths. These cost are meant to be illustrative, as there are various ways to connect the facilities within each generation pocket.

For bulk station costs, where a new circuit termination is required, station costs were assumed to be $20-40M/circuit diameter and 230/500 kV auto transformers were assumed to be $35M each. These costs do not account for reactive compensation that may be required to support the system voltages under the new configuration.

Table 2 summarizes the range of high and low transmission line cost allowance used in this assessment.

Table 2 | Transmission Line Cost Assumptions

Circuit	Cost - Low ($M/km)	Cost - High ($M/km)
Single-circuit 115 kV line	0.9	1.3
Single-circuit 230 kV line	1.3	1.6
Single-circuit 500 kV line[7]	2.2	2.9

4.1.2 Connection Transmission

Connection transmission considered in this analysis consists of circuits to connect the individual generation facilities to the bulk transmission network, and station connection costs for circuit terminations.

Circuit costs were assumed to be the same per-kilometer rate as the transmission line costs provided in the previous section. Circuit lengths were estimated using the site specific information provided by OPG. Actual circuit distances may be longer, based on the specific conditions in the vicinity of the projects, which can drive different routing paths. These costs are meant to be illustrative, as there are various ways to connect the facilities within each generation pocket. For, example if the assumed collection point is changed, this will affect the connection transmission circuits of each facility as well as back to the bulk transmission network.

The costs for a step-up transformer at each facility was not included, as this was part of OPG's cost considerations.

Where a new switching station is required or to connect to an existing bulk station, connection station costs were assumed to be $20M/circuit diameter.

Note that connection costs are the responsibility of the connection applicant, i.e., OPG, under the Ontario Energy Board's Transmission System Code. The connection costs included in IESO's report are based on typical planning allowance, as noted above, and reflect current market conditions. OPG has included an estimate of its connection costs in all generation development costs shown in their report; these costs will be updated as part of the Pathways to Decarbonization Study.

4.2 Cost Breakdown

Table 3 summarizes the range of transmission cost estimates for the high scenario, as outlined in Section 2, including line, station and bulk transformation costs.

[7] It was assumed that HVDC bi-pole costs are similar to single-circuit 500 kV line costs.

Table 3 | Transmission Cost Estimates by Generation Pocket, High Scenario

Generation Pocket	Capacity (MW)	Connection Cost ($M)*	Bulk Transmission Cost ($M)	Total Cost ($M)
Little Jackfish	105	365-425	-	365-425
Severn-Windigo	35	15-25	-	15-25
Moose River Basin	1,250	575-695	1,895-2,400	2,470-3,095
Albany-Attawapiskat	1,380	1,505-1835	1,895-2,400	3,400-4,235
Total	**2,770**	**2,460-2,980***	**3,790-4,800**	**6,250-7,780**

*Note that these costs are provided for completeness. OPG has included an estimate of connection costs in its generator development costs as previously noted.

Table 4 summarizes the range of transmission cost estimates for OPG's low scenario, accounting for the difference in connection requirements for Little Jackfish, Moose River Basin and Albany-Attawapiskat, as well as the reduced scope for bulk transmission required. Note in Table 4, bulk transmission costs for the Moose River Basin represents what would be required to enable both the Moose River Basin and the Albany-Attawapiskat generation pockets.

Table 4 | Transmission Cost Estimates by Generation Pocket, Low Scenario

Generation Pocket	Capacity (MW)	Connection Cost ($M)*	Bulk Transmission Cost ($M)	Total Cost ($M)
Little Jackfish	80	330-385	-	330-385
Severn-Windigo	20	15-25	-	15-25
Moose River Basin	640	400-490	1,895-2,400	2,295-2,890
Albany-Attawapiskat	680	780-955	-**	780-955
Total	**1,420**	**1,525-1,855***	**1,895-2,400**	**3,420-4,255**

*Note that these costs are provided for completeness. OPG has included an estimate of connection costs in its generator development costs as previously noted.

**In combination with the Moose River Basin bulk transmission cost

5. System Value Assessment

The value of an electricity system resource is dependent on system needs, its performance and cost characteristics and other resource alternatives, all while considered in the context of prudent electricity system planning and relevant government policy (e.g. emissions policy).

Hydroelectric supply is characterized as high capital/low operating cost, long lived, non-emitting and with the ability to provide sustained levels of capacity and energy. Depending on topography and the cost to implement, some hydroelectric facilities can provide daily to seasonal energy storage, shifting electricity to periods when it is needed most, increasing operating flexibility and facility value.

The following sections discuss the value of hydroelectric facilities in the context of the 2021 APO, and more generally in IESO's evolving Pathways to Decarbonization Study.

5.1 2021 Annual Planning Outlook

The 2021 APO identifies a sustained capacity need emerging in the mid 2020s, with more significant energy needs emerging in the mid 2030s. These needs assume the continued availability of existing resources, with shortfalls addressed by a proxy resource that mimics the fixed costs and performance of a simple cycle gas turbine (SCGT), but priced as the highest marginal cost resource for dispatch.

The economic assessment of the proposed hydro facilities, with approach per Section 1.2, found that by 2042 system benefits amounted to between 30% and 50% of revenue requirement, depending on the facility. Recognizing that hydroelectric facilities are long lived and that the need and value of energy will continue to grow, system benefits increase to between 80% and 120% of revenue requirement, depending on the facility, when considering the full lifetime of the asset (90 years).

Note that this assessment does not include any allocation of cost for necessary transmission build-out or reinforcement. In addition, much has changed since the early development of the 2021 APO, with further perspective in the following section.

5.2 Pathways to Decarbonization

Leading up to the publication of the Natural Gas Phase-Out Study and since then, it's clear that industry, communities and individuals are concerned about provincial emissions, with a desire to electrify the economy using a zero emissions electricity grid. The IESO is responding to a Minister of Energy letter in this respect, tasked to assess a moratorium on new natural gas-fired facilities as well as develop a pathway to achieve zero emissions in the province's electricity system.

Ontario's resource mix is well diversified, and with additional hydroelectric potential, a resource not available to a number of other decarbonizing jurisdictions, there's opportunity for it to play a key role as we address future needs, maintaining this diversity. The IESO anticipates this role may include providing sustained levels of capacity and energy, peak shaving and system flexibility (e.g. ramping). For the latter two, some hydroelectric facilities can shift electricity and achieve this by storing water, while others can provide reliable off-peak charging of storage resources (e.g. batteries) with operation to the same effect. To the extent these storage resources do not exist already, the cost of these facilities needs to be considered in the value proposition if paired as such. In any case, hydroelectric facilities need to be economic versus alternatives, alternatives that no longer include natural gas-fired generation. This point is important, as the IESO expects the Pathways to Decarbonization Study will provide insight into a new resource, or portfolio of resources, to be used as an economic capacity benchmark in replacement of SCGT for assessments, as applicable.

Lastly, the IESO also expects the Pathways to Decarbonization Study will provide insight into the timing of need and how resource selection is impacted by lead times for resource in-service. In order to preserve opportunity and mitigate lead time risk, it may be prudent to advance design work, environmental approvals and consultation to shorten development timelines for hydroelectric supply.

6. Conclusion

The Minister of Energy asked OPG to examine opportunities for new hydroelectric development in northern Ontario. As part of the request, the IESO was asked to identify: 1) the value these facilities provide to the system; and, 2) the transmission costs associated with enabling these new hydroelectric facilities, should they be built. This report is an input to OPG's study and will be further considered as part of the IESO's Pathways to Decarbonization Study. The assessment provided an indication of the system value and the scope of what would be required from a transmission perspective. If any of the 21 hydroelectric facilities were to become projects, they will be subject to existing IESO rules and grid connection requirements.

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