The Darlington New Nuclear Project:

An Economic, Climate and Safety Analysis

August 1, 2023

ONTARIO CLEAN AIR ALLIANCE

Acknowledgments

The Ontario Clean Air Alliance Research gratefully acknowledges very helpful comments and suggestions from Gordon Edwards, Theresa McClenaghan and M.V. Ramana and the generous financial support from:

M.H. Brigham Foundation

Echo Foundation

Green Sanderson Family Foundation

Ivey Foundation

Merryweather Fund

Noor Cultural Centre

Taylor Irwin Family Foundation at the Toronto Foundation

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Introduction

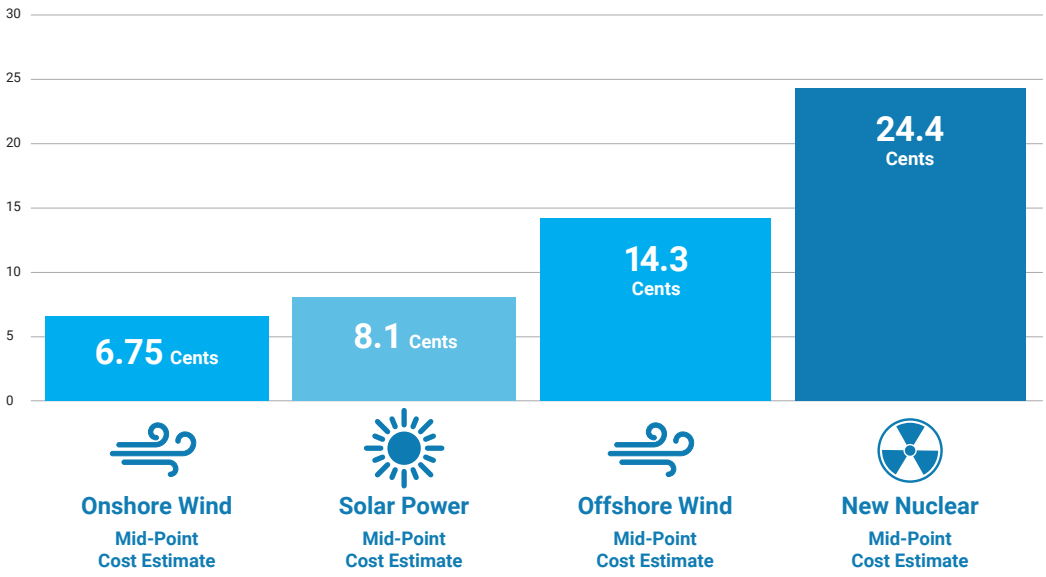
Ontario Power Generation (OPG), which is 100% owned by the Government of Ontario, is proposing to build a first of its kind GE-Hitachi 300 megawatt (MW) boiling water reactor at its Darlington Nuclear Station, east of Oshawa.

OPG has still not submitted GE-Hitachi's proposed reactor design to the Canadian Nuclear Safety Commission for review and potential approval, despite claiming that construction of the reactor will be completed by 2028.[1]

Cost Comparison

According to Lazard, one of the most respected names in global financial services, the cost of electricity from a new nuclear reactor is 1.7 times greater than the cost of offshore wind, three times greater than the cost of solar power, and 3.6 times greater than the cost of onshore wind. See Figure 1.

Figure 1 | **Ontario's Electricity Options: A Cost Comparison**[2]



Great Lakes wind power alone has the potential to provide Ontario with enough power to meet more than 100% of its electricity needs.[3]

According to the International Energy Agency, renewables will account for more than 90% of the world's new electricity supply capacity between 2022 and 2027.[4]

The cost of electricity from a new nuclear reactor is

1.7-3.6 x

greater than that from renewables

When the Wind Doesn't Blow and the Sun Doesn't Shine

Since the wind doesn't always blow and the sun doesn't always shine, wind and solar energy must be combined with storage options that can transform these intermittent energy sources into firm 24/7 sources of baseload electricity.

The Government of Ontario has announced its intention to procure up to 4,000 MW of storage from stationary storage options (e.g., large batteries) located in Ontario.[5] However, there are also lower cost storage options that Ontario should pursue.

According to a Massachusetts Institute of Technology report, the lowest cost storage option for Ontario's electricity system is Quebec's hydro-electric reservoirs.[6] For example, when our wind power production is above average, our surplus wind energy can be exported to Quebec to keep the lights on in Montreal, and Hydro Quebec can store more water in its reservoirs. Conversely, when our wind power production is below average, Hydro Quebec can use the extra water in its reservoirs to produce electricity for export back to Ontario. In short, by integrating our wind generation with Hydro Quebec's reservoirs, we can convert intermittent wind energy into a firm 24/7 source of baseload electricity supply for Ontario.

The total storage capacity of Hydro Quebec's reservoirs (228 terawatt-hours[7]) is 1.6 times greater than Ontario's total annual electricity consumption in 2022 (137 terawatt-hours).

The Independent Electricity System Operator has identified how we can increase our access to Hydro Quebec's reservoirs by 7,500 MW by upgrading our transmission links with Quebec at Chats Falls (2,000 MW), Ottawa (2,000 MW), Beauharnois (2,000 MW) and Cornwall (1,500 MW).[8] All of these upgrades can use existing Hydro One transmission corridors.

Our electric vehicles' (EVs) batteries are also a low-cost storage option for wind and solar energy.[9] When combined with bi-directional chargers, our EVs can store surplus energy when renewable generation is high, and return power back to the grid when renewable generation is below average. **In 2030, the total capacity of our EVs' batteries will be more than double the capacity of our gas plants.**[10]

The lowest cost storage option for Ontario's electricity system is Quebec's hydro-electric reservoirs

Cost Overruns - Ontario

Every new nuclear project in Ontario's history has gone over budget.

1.3x Over Budget

In 1967 Ontario Hydro estimated that the 2,160 MW Pickering A Nuclear Generating Station would cost $527.65 million.[11] **The actual cost was 1.3 times higher** at $700 million.[12]

1.9x Over Budget

In 1969 Ontario Hydro estimated that the 3,200 MW Bruce A Nuclear Generating Station would cost $944 million.[13] **The actual cost was 1.9 times higher** at $1.8 billion.[14]

2.1x Over Budget

In 1975 Ontario Hydro estimated that the 2,160 MW Pickering B Nuclear Generating Station would cost $1.8 billion.[15] **The actual cost was 2.1 times higher** at $3.8 billion.[16]

2.2x Over Budget

In 1975 Ontario Hydro estimated that the cost of the 3,200 MW Bruce B Nuclear Generating Station would be $2.7 billion.[17] **The actual cost was 2.2 times higher** at 5.9 billion.[18]

4.5x Over Budget

In 1975 Ontario Hydro estimated that the cost of the 3,400 MW Darlington Nuclear Generating Station would be $3.2 billion.[19] The actual cost was 4.5 times higher at $14.319 billion.[20]

Since Ontario Hydro (a predecessor of OPG) was 100% owned by the Government of Ontario, all of its nuclear cost overruns were passed on to Ontario's electricity consumers and/or taxpayers.

In 1999, as a result of the cost overruns and poor performance of its nuclear reactors, Ontario Hydro was broken up into five companies. All of its generation assets were transferred to OPG. In order to keep OPG solvent, $19.4 billion of Ontario Hydro's debt or unfunded liabilities associated with electricity generation facilities was transferred to the Ontario Electricity Financial Corporation (an agency of the Government of Ontario) as "stranded debt" or "unfunded liability".[21]

All of Ontario Hydro's nuclear
cost overruns
were passed on to consumers and/or taxpayers

Cost Overruns - U.S.A.

The Vogtle Unit 3 nuclear reactor came into service this year and the Vogtle Unit 4 nuclear reactor is forecast to be in-service later this year. They are the first new nuclear reactors in the United States in 30 years. In 2013 their cost was estimated to be approximately $14 billion.[22] **Their actual cost is now estimated to be 2.1 times higher** at approximately $30 billion.[23]

Protecting Ontario Consumers and Taxpayers from Nuclear Cost Overruns

In 2008 the Ontario Ministry of Energy announced that Ontario was proceeding with a competitive procurement process for the construction of two new nuclear reactors at the Darlington Nuclear Station. The Ministry invited four companies to submit bids: Areva, Atomic Energy of Canada Limited (AECL), GE Hitachi Nuclear Energy and Westinghouse Electric Company.[24]

The procurement process required the companies to submit a **fixed price** bid. That is, the winning bidder would not be allowed to pass any of its capital cost overruns on to Ontario's electricity consumers.

AECL was the only bidder that "met the province's demand that the vendors assume all the risk for cost overruns."[25] However, AECL's price for building the new nuclear reactors, $10,800 per kW, was 3.7 times higher than the Ontario Power Authority's forecast of $2,900 per kW.[26] As a result, on June 29, 2009 the Government of Ontario suspended its procurement process and the proposed new nuclear reactors were never built.[27]

Ontario's Independent Electricity System Operator (IESO) has more than 30,000 contracts for renewable electricity (wind, water and solar) with individuals, First Nations communities and private corporations.[28] None of these renewable electricity contracts allow capital cost overruns to be passed on to Ontario's electricity consumers.

A fixed price bid stipulation would
protect taxpayers
from inevitable cost overruns

Construction Times

According to Lazard, the construction times for renewable electricity technologies are three months to one year. See Table 1 below.

Table 1 | Construction Times for Solar and Wind[29]

Residential Rooftop Solar PV	3 months
Utility-Scale Solar PV	9 months
Onshore Wind	12 months
Offshore Wind	12 months

The Vogtle Units 3 & 4 reactors began construction in 2013 and were originally forecast to be completed in 2017 and 2018 respectively.[30] Unit 3 was completed this year and Unit 4 is now forecast to be completed by the end of 2023.[31]

As the Independent Electricity System Operator has noted, new nuclear reactors can take 10 to 15 years to build.[32]

Speed is of the essence. According to the Intergovernmental Panel on Climate Change, the world needs to reduce its greenhouse gas pollution by almost half by 2030 to limit temperature rise to 1.5 degrees Celsius.[33] According to the Secretary-General of the UN, wealthy countries such as Canada should be moving the fastest on decarbonization and should have zero carbon electricity systems by 2035 at the latest.[34]

New nuclear reactors can take 10 to 15 years to build and where climate change is concerned speed is of the essence

Storage of Nuclear Wastes

According to the Nuclear Waste Management Organization (NWMO), which is owned by Canada's nuclear power companies, radioactive nuclear wastes must be fully isolated from people and the environment for one million years or more.[35]

OPG is proposing three sequential methods for the storage of the new reactor's wastes: a) wet storage; b) dry storage; and c) off-site storage in a deep geological repository.

Wet Storage

Freshly discharged spent nuclear fuel is so hot that it must be put in wet storage pools to cool down.[36]

If the storage pool loses water due to a terrorist attack or other disruption (e.g., earthquake) the nuclear spent fuel rods could catch on fire and release radiation to the atmosphere.[37]

According to the U.S. Nuclear Regulatory Commission, a fire in a densely packed U.S. spent-fuel pool could release 100 times as much radiation into the air as was released by the Fukushima accident. This could require the evacuation of millions of people and cause 20,000 cancer deaths.[38]

Fortunately, the adverse consequences of a pool fire can be dramatically reduced by transferring the spent fuel rods to dry storage when they have cooled enough to do so.[39]

According to GE-Hitachi, the new reactor's spent fuel rods can be transferred to dry storage after they have been in a wet storage pool for 2.5 years.[40]

More than 50% of the spent fuel rods at the Pickering Nuclear Station have been in wet storage for more than 10 years.[41]

Dry Storage

According to the U.S. National Research Council, dry storage is safer than wet storage for two reasons:

1. It is a passive system that relies on natural air circulation for cooling; and
2. it divides the inventory of that spent fuel among a large number of discrete, robust containers. These factors make it more difficult to attack a large amount of spent fuel at one time and also reduce the consequences of such attacks.[42]

Currently, the dry storage containers at the Pickering, Darlington and Bruce Nuclear Stations are housed in **conventional warehouse buildings** on the edge of Lakes Ontario and Huron.

In Germany, six nuclear reactors have **on-site, above-ground, attack-resistant, reinforced concrete vaults** for the storage of their nuclear wastes. The concrete walls and roofs of these vaults are approximately 1.2 and 1.3 metres thick respectively.[43]

The International Joint Commission's Great Lakes Water Quality Board is calling for OPG's interim on-site storage facilities to be "**hardened**" to protect them from terrorist attacks; and **located away from shorelines** to prevent them from being compromised by flooding and erosion.[44]

According to a report prepared for OPG, the total capital cost of building above-ground, attack-resistant, reinforced concrete vaults at the Darlington Nuclear Station would be approximately $400 million.[45]

Radioactive waste is currently housed in

conventional warehouse buildings

on the edges of Lakes Huron and Ontario

Deep Geological Repository

In the long-term, OPG is hoping that its nuclear wastes can be transferred off-site to a permanent storage facility, on First Nations' traditional territories, where they would be placed in caverns 500 to 1,000 metres below ground.

There is no deep geological repository (DGR) facility for high-level nuclear fuel wastes currently operating anywhere in the world despite decades of effort on the part of the nuclear industry to establish such a facility. In Canada, after almost 50 years of trying to solve the long-term radioactive waste problem, there is still no site selected or accepted by a "host" community and there is no completed design for the DGR itself. In addition, the used-fuel transfer facility is still in the conceptual stage, as is the transportation system for getting waste from nuclear stations to the DGR.

According to the NWMO, if a radioactive release occurs in a DGR "it may be difficult for a future generation to detect the breach in a timely way and take corrective action."[46]

As a consequence, the high-level nuclear wastes at the Bruce, Darlington and Pickering Nuclear Stations may remain on-site far into the future.

The high-level nuclear wastes may remain on-site far into the future

Decommissioning

According to the International Atomic Energy Agency, immediate dismantling is the "preferred decommissioning strategy" for nuclear plants.[47] Nuclear operators in the U.S., Germany, France, Italy and Spain have followed this advice and have completely dismantled closed nuclear stations in as little as a decade.

Nevertheless, OPG is planning to defer the dismantling of its existing nuclear reactors, and its proposed new reactor, for up to 30 years after they cease producing electricity.[48]

On January 27, 2020 the Pickering City Council unanimously passed a resolution calling for the Pickering Nuclear Station to be dismantled as "expeditiously as possible" after it is shut down in keeping with the recommendations of the International Atomic Energy Agency.[49]

Conclusions and Recommendations

1 The cost of electricity from a new nuclear reactor is 1.7 times greater than the cost of offshore wind, three times greater than the cost of solar power, and 3.6 times greater than the cost of onshore wind. It doesn't make sense to build a new nuclear reactor at Darlington when renewable electricity can keep our lights on at much lower cost without creating a toxic legacy of deadly radioactive nuclear wastes that future generations will be required to safeguard for a million years, something the human race has zero experience doing.

2 Ontario's Independent Electricity System Operator should establish annual competitive procurement processes for new renewable electricity supplies (solar, waterpower, onshore wind and offshore wind power) to help Ontario move to net zero greenhouse gas pollution as soon as possible and at the lowest possible cost.

3 If the Government of Ontario believes that building a new nuclear reactor is in the public interest it should require OPG to:

- **a** find a third-party (e.g., GE-Hitachi, Aecon) to build the reactor pursuant to a fixed price contract to protect Ontario's electricity consumers and taxpayers from cost overruns;
- **b** transfer the reactor's spent nuclear fuel rods from wet to dry storage after 2.5 years unless GE-Hitachi produces an analysis to show that a longer period for wet storage is safe;
- **c** build above-ground, attack-resistant, reinforced concrete vaults, away from the Lake Ontario shoreline, at the Darlington Nuclear Station for the dry storage of the reactor's spent nuclear fuel as per the recommendation of the International Joint Commission's Great Lakes Water Quality Board; and
- **d** immediately dismantle the nuclear reactor after it ceases to produce electricity as per the recommendation of the International Atomic Energy Agency.

It doesn't make sense to build a new nuclear reactor at Darlington when renewable electricity can keep our lights on at a lower cost

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Notes

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