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Powering smart action on climate in Ontario

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A fiscally responsible climate-action strategy for electricity in Ontario

MAY 10, 2017

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Making smart choices

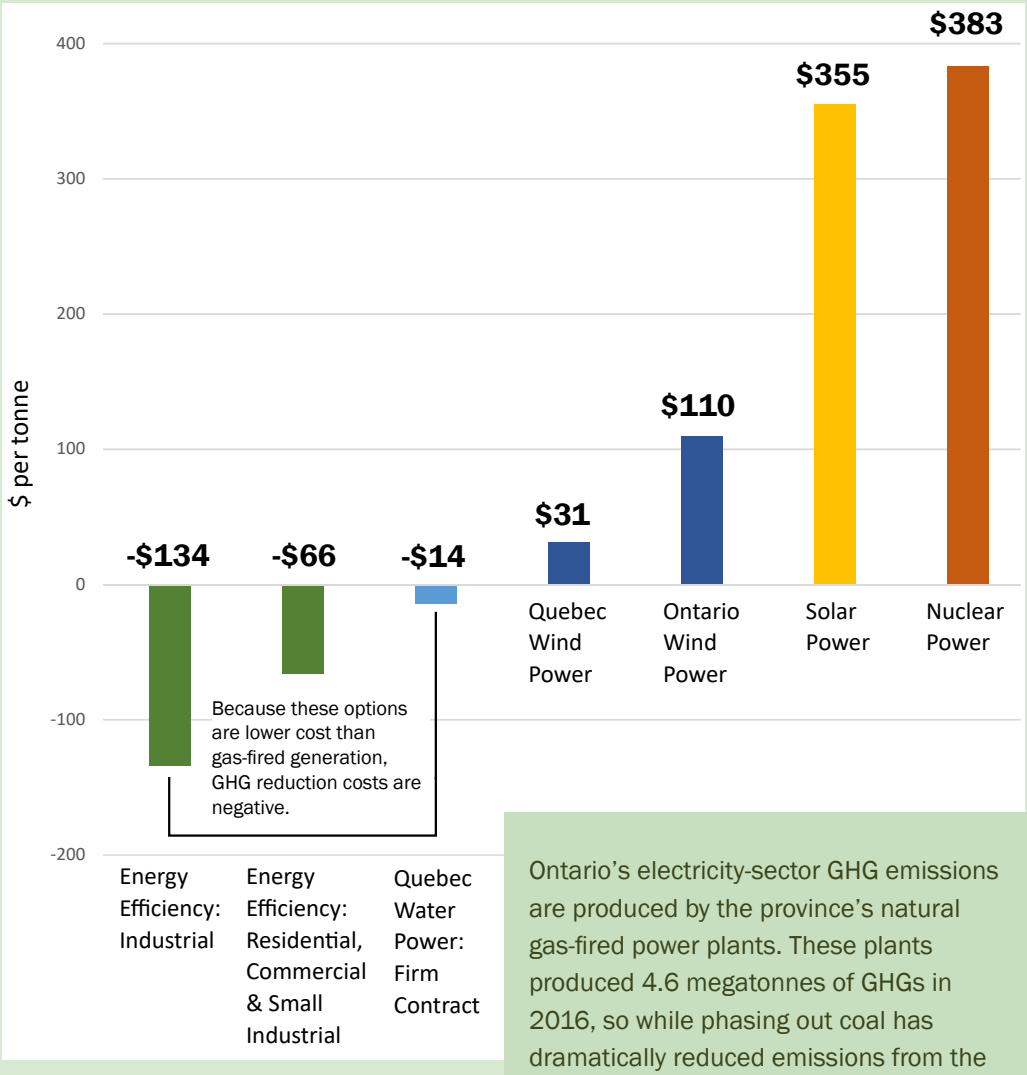
To help prevent dangerous climate change. the Government of Ontario is committed to reducing greenhouse gas (GHG) emissions by 80% by 2050. This is a very ambitious target, which will require a dramatic reduction in our consumption of fossil fuels and the electrification of our transportation and building systems. To maintain public support for these goals the government must adopt a climate action strategy that will enable Ontario to reduce its GHG emissions at the lowest possible cost by prioritizing actions that have the lowest cost per tonne for emission reductions.

Figure 1 shows cost per tonne for various options for reducing Ontario's electricity-related GHG emissions.

A climate strategy, such as Ontario's, that calls for the electrification of building heat and transportation could also increase electricity demand. We will need to meet that demand with low or zero GHG power at the lowest possible cost given the impact of rising electricity rates on consumers and businesses in Ontario and the need to make this transition economically feasible.

Since energy efficiency and Quebec water power can keep our lights on at a lower cost than gas-fired generation, these options have a negative cost per tonne for emission reductions, meaning they simultaneously lower our electricity bills *and* our GHG emissions. On the other hand, the financial costs of wind, solar and nuclear energy are greater than those of gas-fired generation.

Fig. 1: Cost per Tonne of Greenhouse Gas Reductions



Ontario's electricity-sector GHG emissions are produced by the province's natural gas-fired power plants. These plants produced 4.6 megatonnes of GHGs in 2016, so while phasing out coal has dramatically reduced emissions from the electricity sector, it has not fully eliminated the sector's climate impact. See page 11 for more details on cost calculations.

To achieve our GHG emissions reductions at the lowest possible cost we must pursue all lower-cost options before moving on to higher-cost options such as nuclear. Figure 1 tells us that the hierarchy for selecting options to meet our electricity needs should be:

1. Energy Efficiency;
2. Quebec Water Power;
3. Quebec Wind Power;
4. Ontario Wind Power;
5. Ontario Solar Power; and
6. Nuclear Power.

The continued trend of steep declines in the cost of wind and solar energy — and rising nuclear costs — will only make this hierarchy more compelling over the next decade.

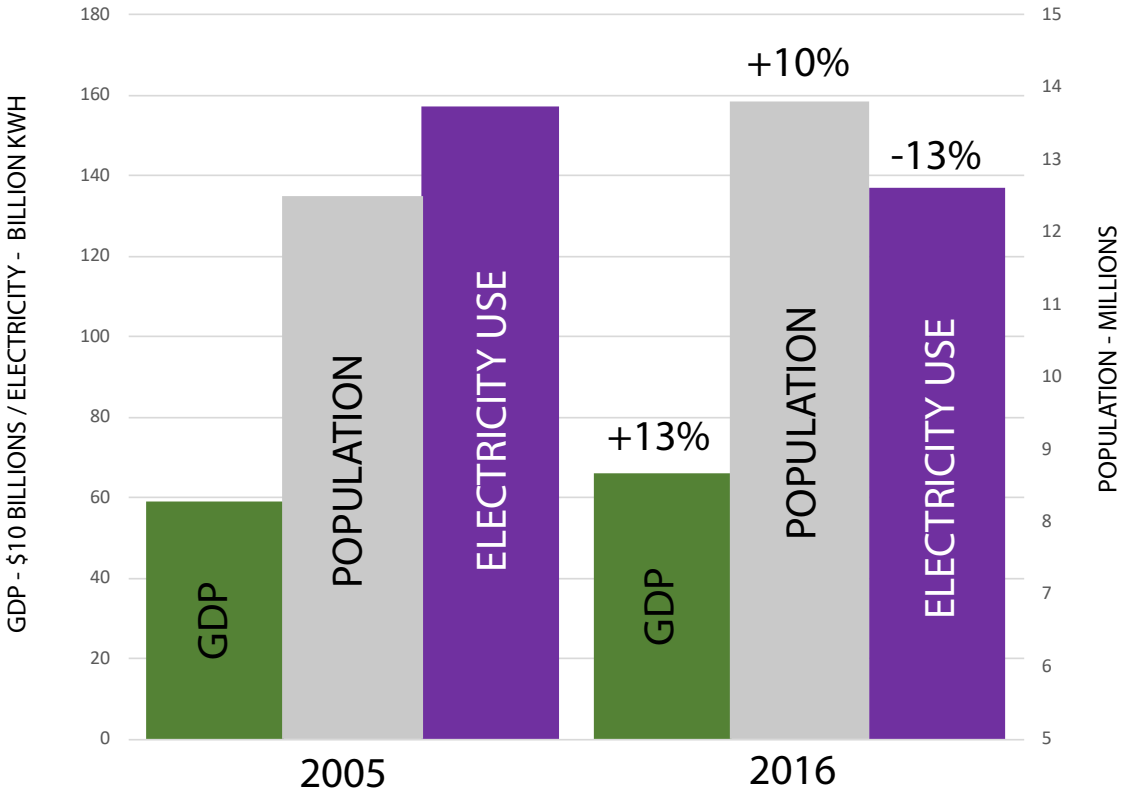
How much energy can the lowest cost options provide?

In this section, we will look at the extent to which Ontario's electricity needs can be met by the lowest-cost options.

Energy efficiency

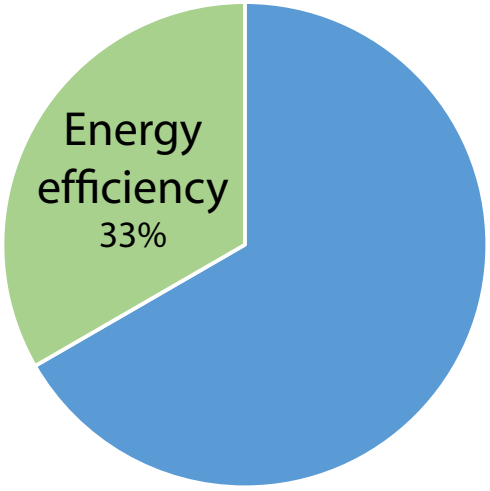
Ontario's electricity productivity (economic output per kWh of electricity used) has grown by 29% between 2005 and 2015.[1] As a result our electricity consumption has declined despite the fact that our population and our economy have grown (see Figure 2).

Fig. 2: Ontario's Population, Gross Provincial Product and Electricity Demand: 2005–2015 [2]



According to a report prepared for Ontario's Independent Electricity System Operator (IESO), energy efficiency investments can cost-effectively reduce the province's total electricity consumption by a further 45.4 billion kWh per year by 2035.[3] This is equivalent to 33% of Ontario's total annual electricity consumption.[4]

Fig. 3: Potential for Energy Efficiency to Meet Our Electricity Needs



Quebec export power

Phase 1 : Exporting current surplus

Ontario is very lucky to be located next door to Quebec, which is the fourth-largest producer of water power in the world[5]; has the lowest electricity rates in North America[6]; and has a large and growing supply of surplus power available for export.

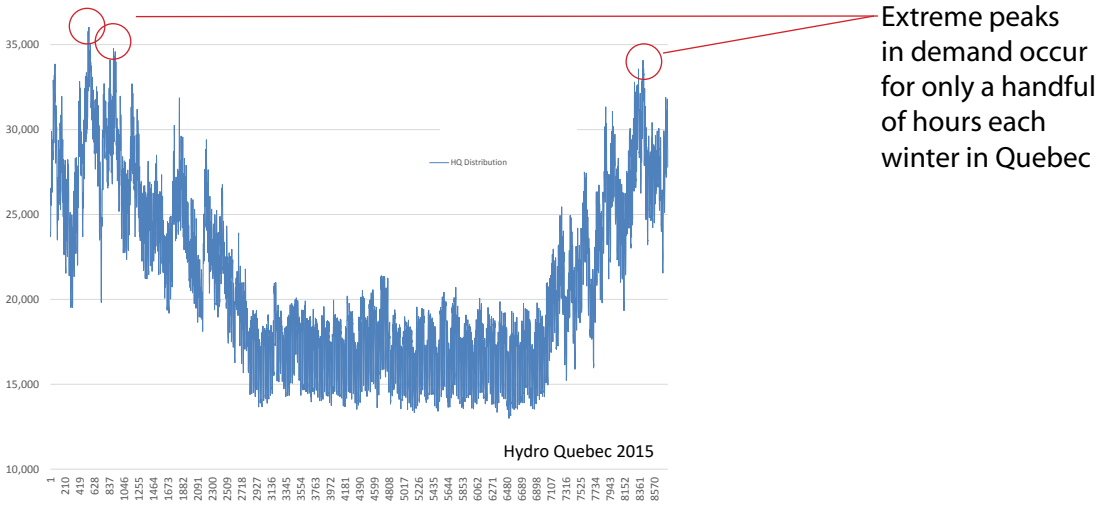
According to the Quebec Energy Commission, Hydro Quebec's supply of surplus electricity available for export will rise to 41.1 billion kWh by 2022.[9] This is equivalent to 30% of Ontario's total annual electricity consumption.

In 2016, Quebec was paid 5 cents per kWh on average for its export power.[7] In contrast, Ontario Power Generation (OPG) is seeking permission to raise the price it is paid for nuclear power to 16.5 cents per kWh.[8]

Figure 4 plots Quebec's demand for electricity during each hour of 2013. It reveals three key facts:

1. Quebec's demand for electricity spikes on cold winter days.
2. These spikes in demand are needle peaks that only last for brief periods.
3. Quebec's annual *peak hour* demand for electricity is more than 80% greater than its *average* annual hourly demand.[10] In other words, Quebec has significant surplus power available outside of these few brief periods when domestic demand spikes.

Fig. 4: Hydro Quebec's 2013 Hourly Demand for Electricity[11]



While Quebec may not be in a position to export electricity to Ontario on very cold winter days, it has surplus generation available during 99% of the hours of the year. During the 1% of the year when Quebec water power may not be available, Ontario could meet its electricity needs by increasing the output of its natural gas-fired power plants. Ontario wind power gen-

eration also peaks in winter, meaning that it would combine well with Quebec water power imports. As the IESO has noted, "Ontario . . . is a summer-peaking province, which means the province has spare capacity in the winter."[12]

It is important to remember that nuclear generating stations are also *not* available for 100% of the hours in a year, only more so. For example, the Pickering Nuclear Station is forecast to be out-of-service for approximately 30% of the hours of the year between 2017 and 2021.[13]

Therefore, Ontario's electricity needs can be met at a lower environmental cost with an integrated combination of water power from Quebec (99%) and natural gas-fired generation (1%) than by combining the Pickering Nuclear Station (70%) and natural gas-fired generation (30%).

Phase 2: Making more water power available for export by investing in energy efficiency

Quebec's electricity consumption per person is the highest in the world.[14] As a consequence, Quebec could export even more low-cost water power by investing in low-cost energy efficiency measures, which would reduce the electricity bills of its domestic customers and free up even more of its existing heritage water power capacity for export.

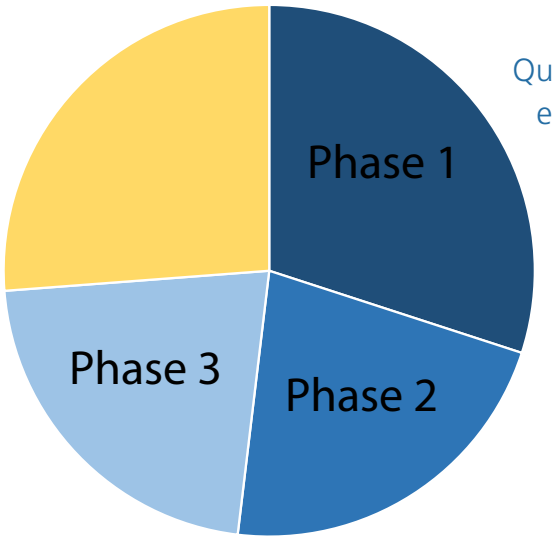
According to Professor Pierre-Olivier Pineau of the University of Montreal, cost-effective energy efficiency investments could increase Quebec's export potential by approximately an additional 30 billion kWh per year.[15]

Phase 3: Making more water power available for export by investing in solar energy

The cost of solar electricity will also drop dramatically within the next 10-20 years. Bloomberg New Energy Finance is forecasting that the price of solar electricity will fall to 4 cents per kWh by 2040.[18]

Eric Martel, the CEO of Hydro Quebec, predicts that Hydro Quebec's domestic sales could fall by up to 30 billion kWh per year as its customers become increasingly self-sufficient by investing in on-site solar electricity. As Mr. Martel noted in his speech to the Canadian Club on February 15, 2017, this will increase Hydro Quebec's supply of power available for export by up to 30 billion kWh per year. [19]

Fig. 5: Proportion of Ontario electricity demand that could be met by Quebec water power



Quebec can meet more than two-thirds of Ontario's electricity supply needs by exporting surplus water power, increasing its surplus by improving efficiency, and having its citizens meet some of their needs with solar power. It can increase its export potential even further by developing its massive wind power potential (which is not included here).

Quebec Wind Power

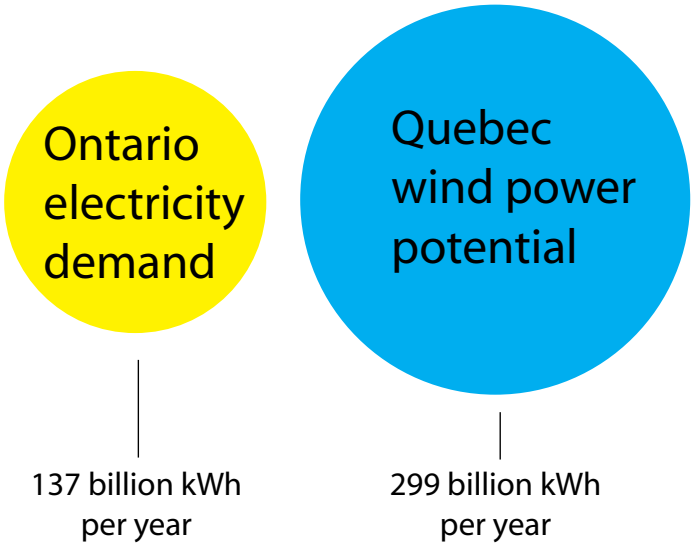
Quebec also has a huge untapped supply of wind energy. Specifically, Quebec has the potential to produce 299 billion kWh of wind energy from sites that are within 25 km of Hydro Quebec's existing transmission lines.[16] This is more than double Ontario's total annual electricity consumption.

In a 2014 competitive procurement for wind energy, Quebec signed contracts for an average price of 6.3 cents per kWh, an extremely attractive price that most likely will fall further for future projects.

Furthermore, by combining Quebec's wind energy with its huge hydro-electric reservoirs — which can serve as a giant battery — Quebec's variable wind energy can be converted into a firm 24/7 supply of base-load renewable electricity for export to Ontario.

The Government of Quebec strongly supports the development of its wind power potential to supply export markets.[17]

Fig. 6: Comparison of Ontario electricity demand and Quebec wind power potential



What these projections show is that Quebec will have more than enough power to serve both Ontario and other export markets well into the future without building any new dams. A combination of efficiency, solar and wind can massively increase the power Quebec has available for export and add up to an export capacity that is many times what is needed to replace costly nuclear in Ontario.

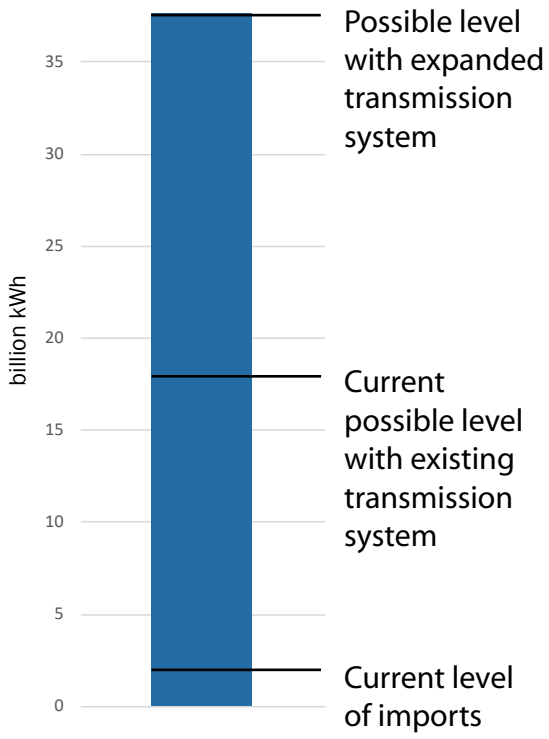
Ontario-Quebec transmission links

In October 2016, Ontario signed an agreement with Hydro Quebec to import 2 billion kWh of water power per year at a price of 5 cents per kWh for seven years.[20]

Fortunately, with our existing transmission lines, we can import much more power from Quebec. According to the IESO, we can currently import 16.5 to 18.5 billion kWh per year from Quebec.[21] This is greater than the Pickering Nuclear Station's forecast annual production for domestic consumption[22] (a significant portion of Pickering's output is surplus to Ontario's needs and is exported to the U.S. at a loss).

According to the IESO, with upgrades to the Hydro One transmission system costing approximately $2 billion we could import 37.6 billion kWh per year from Quebec[23] — the equivalent of 27% of Ontario's annual electricity consumption. The cost of these transmission upgrades would add less than one cent per kWh to the cost of importing power from Quebec, making Quebec power still significantly cheaper than nuclear.

Fig. 7: Potential for power imports



Achieving our climate targets and lowering our electricity bills

Currently, nuclear power provides 60% of Ontario's electricity supply, water power 24%, wind 8%, gas 6% and solar 2%.[24] However, all of our aging nuclear reactors will come to the end of their operational lives during the next 10 years.

To date, Premier Wynne has been committed to maintaining our heavy dependence on high-cost nuclear power. Specifically, in December 2015, the Government of Ontario signed a deal with Bruce Power to finance the re-building of six of the reactors at the Bruce Nuclear Station. And in January 2016, Premier Wynne endorsed Ontario Power Generation's (OPG) proposal to extend the life of the Pickering Nuclear Station to 2024 and to re-build the Darlington Nuclear Station.

OPG is now proposing to raise its price of nuclear power from 5.9 to 16.5 cents per kWh by 2025 (a 180% price increase) to pay for the Pickering life extension and the Darlington Re-Build.[25] If the Darlington Re-Build goes over budget, the price of nuclear power will rise by more than 180%.

This means that nuclear energy is a costly way to reduce greenhouse gas emissions. Within a decade, nuclear power will cost more than three times what we could be paying for Quebec power today and up to 10 times as much as what we could pay for energy efficiency improvements that reduce the need to generate electricity in the first place.

As outlined in this report, Quebec has significant low-cost power available for export today and the potential to vastly increase its export power supplies through efficiency improvements and wind and solar power development. By the time work on the Darlington Station is forecast to be complete, Quebec will be well positioned to supply a significant share of Ontario's electricity needs while also meeting the needs of its U.S. customers. Of course, many of Hydro Quebec's customers (e.g., New York State) are also investing aggressively in solar and wind energy and energy efficiency, which helps to explain Quebec's strong interest in diversifying its export markets.

The Government of Ontario can achieve our climate goals at the lowest possible cost to electricity consumers by taking the following actions:

1. Importing sufficient water power from Quebec to permit the closure of the high-cost Pickering Nuclear Station in 2018 when its licence expires.
2. Directing the IESO to partner with municipalities, co-ops, First Nations communities, electric and gas utilities, district energy companies, energy-efficient appliance and equipment manufacturers and distributors and other corporations to pursue all of our energy conservation and efficiency options that can meet our electricity needs at a lower cost than the Darlington Re-Build Project.
3. Directing Hydro One to upgrade its transmission system to enable Ontario to import up to 37.6 billion kWh of wind and water power from Quebec each year.
4. Directing the IESO to negotiate electricity supply agreements with Hydro Quebec that will enable Ontario to cancel the Darlington Re-Build Project.
5. Directing the Ontario Energy Board to review the benefits and costs of cancelling the Bruce Power contract before the first reactor re-build commences in 2020.
6. Directing OPG to immediately decommission and dismantle its nuclear reactors as soon as they are closed. This will ensure a just transition for workers in the nuclear industry. For example, the immediate decommissioning and dismantling of the Pickering Nuclear Station could create 32,000 person-years of direct and indirect employment between now and 2030.[26]

The Cap Chat wind farm in Quebec. Quebec's wind power potential dwarfs Ontario's electricity demand and can be combined with its reservoir system to make power available 24/7.

Ensuring GHG reductions at the lowest cost

The government's goal of reducing GHG emissions by 80% by 2050 is an ambitious but appropriate target given the high costs of not acting to curb our climate impact. However, it also means that we cannot afford to squander resources on high-cost actions, such as rebuilding 30-40-year-old nuclear reactors instead of investing in energy efficiency and securing lower cost renewable energy, particularly low-cost water power from Quebec. The solution to reducing electricity sector emissions at the lowest cost is on our doorstep. We simply need to plug in.

Endnotes

1 Our real gross provincial product per kWh of electricity consumption has risen from $3.74 to $4.82 per kWh between 2005 and 2015, measured in 2007 dollars. Statistics Canada Table 384-0038 and http://www.ieso.ca/power-data/demand-overview/historical-demand.

2 Statistics Canada Table 051-0001 and Table 384-0038; and http://www.ieso.ca/power-data/demand-overview/historical-demand.

3 Nexant, *Achievable Potential Study: Long Term Analysis*, (June 30, 2016), page 4.

4 In 2016 Ontario's total electricity consumption was 137 billion kWh. Independent Electricity System Operator (IESO), *News Releases*, "Ontario's Independent Electricity System Operator Releases 2016 Electricity Data", (January 18, 2017).

5 Jean-Thomas Bernard & Jean-Yves Duclos, *Quebec's Green Future : The Lowest-Cost Route to Greenhouse Gas Reductions*, C.D. Howe Institute Backgrounder No. 118, (October 2009), page 2.

6 Hydro Quebec, *Comparison of Electricity Prices in Major North American Cities: Rates in effect April 1, 2016.*

7 Hydro Quebec, *Annual Report 2016*, page 76.

8 Ontario Energy Board Docket No. EB-2016-0152, Exhibit N3, Tab 1, Schedule 1, Attachment 2, Table 14.

9 Commission sur les enjeux energetiques du Quebec, *Maitriser Notre Avenir Energetique*, (2 fevrier 2014), page 183.

10 Hydro Quebec, *Annual Report 2014*, page 2.

11 Pierre-Olivier Pineau, Professor, HEC Montreal, "Can Ontario and Quebec benefit from more electricity market integration? A long-term perspective", Power Point Presentation for York University Conference, January 9, 2015.

12 IESO, *Review of Ontario Interties*, (October, 2014), page 22.

13 Ontario Energy Board Docket No. EB-2016-0152, Exhibit A1, Tab 4, Schedule 3, page 2; and Exhibit E2, Tab 1, Schedule 1, Table 1.

14 *Quebec's Green Future*, page 2.

15 Chaire de gestion du secteur de l'energie, HEC Montreal, *2016 Etat De L'Energie Au Quebec*, page 28.

16 Helimax Energie Inc., *Etude sur l'evaluation du potential eolien, de son prix de revient et des retombees economiques pouvant en decouler au Quebec,* (2004), page vi.

17 Government of Quebec, *Energy in Quebec: A Source of Growth: The 2030 Energy Policy*, (2016), page 48.

18 Bloomberg New Energy Finance, *New Energy Outlook 2016 : Executive Summary*, (June 2016).

19 http://www.mediaevents.ca/canadianclub/20170215/

20 Denis Lessard, "Hydro-Quebec signe un contrat ferme avec l'Ontario", *La Presse*, (October 21, 2016).

21 Email from Jordan Penic, IESO to Jack Gibbons, Ontario Clean Air Alliance, (November 21, 2014).

22 Ontario Energy Board Docket No. EB-2016-0152, Exhibit L, Tab 6.5, Schedule 7 ED-028, page 3; and Undertaking JT1.17, Attachment G, page 2.

23 IESO, *Review of Ontario Interties*, (October 2014), pages 22 – 26 and Appendix F; and Ontario Clean Air Alliance Research, *Ontario's Long-Term Energy Plan: A One Year Review*, (November 10, 2014), page 5.

24 Ontario Energy Board, *Regulated Price Plan Price Report: May 1, 2017 to April 30, 2018,* (April 20, 2017), page 21.

25 Ontario Energy Board Docket No. EB-2016-0152, Exhibit N3, Tab 1, Schedule 1, Attachment 2, Table 14.

26 Torrie Smith Associates, D*irect Decommissioning of the Pickering Nuclear Station: Economic and Other Benefits*, (March 2016), page 6.

Notes for cost calculations in Figure 1 (see page 12 for data sources)

Ontario's electricity-related greenhouse gas (GHG) emissions are produced by its natural gas-fired power plants. According to the Ontario Power Authority, the GHG emission rate of a combined-cycle natural gas-fired power plant is 290 grams/kWh. According to the Independent Electricity System Operator, assuming a 95% annual capacity utilization rate and a commodity cost of gas of $5.50/MMBtu (2014$) at the Dawn Hub near Sarnia, the cost of natural gas-fired generation in 2020 will be 5.4 cents per kWh.[1] Therefore to calculate the cost of reducing our GHGs by switching to alternative electricity resource options, one must compare their costs per kWh to that of natural gas-fired generation.

Energy Efficiency – Industrial: The IESO has a $500 million budget to reduce the electricity consumption of Ontario's large-volume industrial customers by 1.7 billion kWh per year in 2020. The IESO assumes that these savings will persist for 20 years. Therefore, the average cost per kWh saved is 1.5 cents.[2] This means that reducing our natural gas-related GHG emissions (290 grams per kWh) by investing in industrial energy efficiency measures will cost –3.9 cents per kWh (1.5 cents per kWh – 5.4 cents per kWh). That is –0.0134 cents per gram (–3.9/290) or –$134 per tonne.

Energy Efficiency – Residential, Commercial & Small Industrial: According to the Ontario Power Authority, the average cost of residential, commercial & small industrial energy efficiency programs is 3.5 cents per kWh.[3] Therefore the cost of reducing our natural gas-related GHG emissions (290 grams per kWh) by investing in residential, commercial & small industrial energy efficiency measures is –1.9 per kWh (3.5 cents per kWh – 5.4 cents per kWh). That is –0.0066 cents per gram (–1.9/290) or –$66 per tonne.

Quebec Water Power - Firm Contract: In October 2016, Ontario concluded an agreement with Hydro Quebec to purchase 2 billion kWh of water power per year at a price of 5 cents per kWh for seven years.[4] Therefore the cost of reducing our natural gas-related GHG emissions (290 grams per kWh) by importing water power from Quebec is –0.4 per kWh (5 cents per kWh – 5.4 cents per kWh). That is –.0014 cents per gram (–0.4/290) or –$14 per tonne.

Quebec Wind Power: In 2014, Hydro Quebec used a competitive procurement process to contract for wind power at an average generation cost of 6.3 cents per kWh.[5] Therefore the cost of reducing our natural gas-related GHG emissions (290 grams per kWh) by importing wind power from Quebec is 0.9 per kWh (6.3 cents per kWh – 5.4 cents per kWh). That is 0.0031 cents per gram (0.9/290) or $31 per tonne.

Ontario Wind Power: In March 2016 the IESO procured new wind power supplies at an average cost of 8.59 cents per kWh.[6] Therefore the cost of reducing our natural gas-related GHG emissions (290 grams per kWh) by investing in wind power is 3.19 per kWh (8.59 cents per kWh – 5.4 cents per kWh). That is, 0.011 cents per gram (3.19/290) or $110 per tonne.

Solar Power: In March 2016 the IESO procured new solar power supplies at an average cost of 15.7 cents per kWh.[7] Therefore the cost of reducing our natural gas-related GHG emissions (290 grams per kWh) by investing in solar power is 10.3 per kWh (15.7 cents per kWh – 5.4 cents per kWh). That is, 0.0355 cents per gram (10.3/290) or $335 per tonne.

Nuclear Power: Ontario Power Generation (OPG) is seeking permission from the Ontario Energy Board to raise its price of nuclear electricity by 180% to 16.5 cents per kWh in 2025. According to OPG, the price increase is needed to finance the continued operation of the Pickering Nuclear Station and the re-building of the Darlington Nuclear Station.[8] Therefore the cost of reducing our natural gas-related GHG emissions (290 grams per kWh) by investing in nuclear power is 11.1 per kWh (16.5 cents per kWh – 5.4 cents per kWh). That is, 0.0383 cents per gram (11.4/290) or $383 per tonne.

Sources for Figure 1:

1 Ontario Power Authority, *Supply Mix Analysis Report*, Volume 2, (December 2005), page 213; Independent Electricity System Operator (IESO), *Conservation & Demand Management Energy Efficiency Cost Effectiveness Guide*, (March 2015), pages 57 & 58; email from Terry Young, Vice President, IESO to Jack Gibbons, Ontario Clean Air Alliance, (October 20, 2015); and email from Chuck Farmer, Director, Stakeholder & Public Affairs, IESO to Jack Gibbons (Feb. 6, 2017).

2 Email from Terry Young, IESO to Jack Gibbons (July 13, 2015).

3 Ontario Power Authority, *Conservation First Framework Update: Presentation to SAC,* (June 24, 2014), pages 7 & 8.

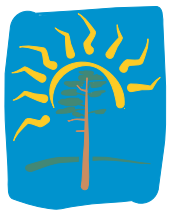
4 Denis Lessard, "Hydro-Quebec signe un contract ferme avec l'Ontario", *La Presse*, (October 21, 2016)

5 Hydro Quebec, *Press Release,* "Calls for tenders for the purchase of 450 MW of wind power: Hydro-Quebec Distribution accepts 3 bids totalling 446.4 MW", (December 16, 2014)

6 IESO, *News Release*, "IESO Announces Results of Competitive Bids for Large Renewable Projects", (March 10, 2016).

7 IESO, *News Release*, "IESO Announces Results of Competitive Bids for Large Renewable Projects", (March 10, 2016).

8 Ontario Energy Board Docket No. EB-2016-0152, Exhibit N3, Tab 1, Schedule 1, Attachment 2, Table 14.



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