University of Alberta Future Energy Systems

Ontario Energy Market Profile

Measuring the Costs and Benefits of Energy Transitions

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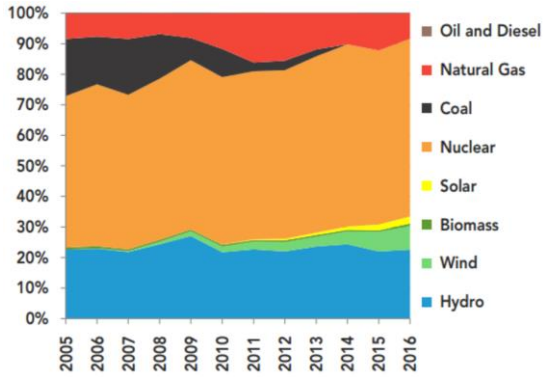
Context

Ontario's electricity comes from a mix of nuclear power, renewable sources, and some fossil fuels. In 2016, Ontario produced 156 TWh of electricity with a generating capacity of 40,215 MW. In 2016, Ontario's energy generation portfolio is as follows (NEB, nd):

- Nuclear: 58% (13,500 MW)
- Hydroelectricity: 23% (8,872 MW)
- Wind: 8% (4,826 MW)
- Solar: 2% (2,291 MW)
- Natural Gas: 9%
- Biomass and diesel: <1%



Electricity Generation by Source in Ontario
Source: NEB, 2017

Ontario uses a wholesale competitive market, similar to what is in place in Alberta. Under this format, private generators sell energy to the grid, who in turn sell it to large scale industrial users and local distribution companies, who provide it to residents and users. Consumers can choose to purchase energy from the local distribution company at a price reflective of market conditions based on demand and the price of production at that moment, or from an independent retailer, who may offer fixed or floating prices (IESO, nd). The Independent Energy System Operator (IESO) oversees and operates the electricity market. Using a mix of information, the IESO forecasts demand for times at points of the day. Generators and importers submit offers to supply a certain amount of energy at a certain price. The IESO accepts offers until the forecast demand is met (IESO, nd). However, Ontario has entered several contracts to purchase powers from certain producers. Hydro One, privatized in 2015, is the transmission and distribution service provider for the majority of Ontario (Hydro One, nd).

Average Consumption

In 2015, Ontario had the second lowest average electricity consumption per capita, consuming only 9.8 MWh per capita. Ontario is a net exporter of electricity, exporting 14.0 TWh in 2016. The residential sector is the largest consumer of electricity, followed by the commercial sector and industrial sectors. (NEB, nd). Ontario's average residential bill is higher than the national average. The City of Toronto had an average of $178 per 1,000 kWh compared to the Canadian mean of $129 per 1,000 KWh.

Ontario Demographics

- **Population:** 13,448,494 (4.6% increase from 2011)
- **Average Age:** 41.0
- **Working Age (15-64):** 8,988,865
- **Private Dwellings:** 5,598,391
- **Private Dwellings Occupied by Usual Residents:** 5,169,174

Statistics Canada (2016). Census Profile, 2016 Census.

Micro-Generation

The Feed-in Tariff (FIT) Program was intended to develop more renewable energy in Ontario. The FIT program has gone through several rounds, each with a procurement target. Through the program, energy generators are offered a guaranteed price per kWh produced, varying by energy type (IESO, nd*a*). Contracts are secured for 20 years except for hydroelectric power, which has a 40 year timeline. Ontario also offers the microFIT Program, which supports the development of small renewable energy projects with a capacity under 10 kW. Participants are paid a guaranteed price for the energy they sell to the grid over a 20 year term (IESO, nd*b*). Energy must be derived from biogas, biomass, landfill gas, solar, hydroelectricity, or wind. The FIT and microFIT programs were discontinued in 2016 and 2017 respectively, after procurement targets had been achieved (IESO, nd*a,* and IESO, nd*b*).

The Feed-In Tariffs offered the following prices (IESO, 2009):

- Solar: 80.2 ¢/kWh
- Wind: 13.5 ¢/kWh
- Hydroelectric: 13.1 ¢/kWh
- Biomass: 13.8 ¢/kWh
- Biogas: 16.0 ¢/kWh
- Landfill Gas: 11.1 ¢/kWh

As of 2009, the microFIT program added 8.6 MW of power, of which 8.38 MW came from solar photovoltaic projects (IESO, 2009).

As part of the *Green Energy and Green Economy Act* (2009), the Ontario government announced their intention to have Indigenous and Metis groups participate in renewable energy generation. The Indigenous Energy Program (IEP) was introduced to provide funding support for the development of First Nations and First Nations partnerships for renewable energy. The IEP offers a maximum of $150,000 for project development, $25,000 for feasibility studies, and $50,000 for partnership projects (IEP, 2018).

Ontario Power Generation

While there are numerous private corporations who own and operate renewable projects in Ontario, approximately half of the energy produced in the province is owned by the Ontario Power Generation Inc. (OPG), a publicly owned corporation (OPG, nd). The OPG operates 54 hydroelectricity generating stations, as well as being responsible for the Pickering and Darlington Nuclear Generating Stations. Like all industry participants, the OPG is subject to Ontario Energy Board Regulation (OPG, nd*a*).

Goals

Ontario's goals for energy generation is provided through *Ontario's Long Term Energy Plan* (2017). One of the clear goals includes improving the reliability and affordability of electricity (Government of Ontario, 2017). From 2017 to 2021, residential electricity bills will be cut by an average of 25% and will hold any increase consistent with the rate of inflation. This plan also involves deferring the construction and refurbishing of nuclear reactors at the Darlington facility and Bruce Nuclear Station, as well as suspending another round of the renewable procurement process.

The Long Term Energy Plan (Government of Ontario, 2017) also establishes the goals of supporting more net metering, encouraging greater participation of renewable energy generation, and encouraging more renewable sources to replace natural gas.

Ontario is undergoing a Market Renewal, which will provide greater stability and security in the future. This is meant to resolve the challenges around the currently faulty two schedule system. In this system, the IESO determines the dispatch of resources via a constrained optimization algorithm, which accounts for transmission limitations and losses and other realistic constraints, whereas the generation settlements use prices based on an unconstrained transmission system, which does not account for physical feasibility. This leads to discrepancies in price and inefficiencies. The IESO makes uplift payments to compensate suppliers for the costs that were not reflected in the unconstrained algorithm (Pfeifenberger et al., 2017).

Rising Energy Prices

Ontario has seen significant increases in electricity prices in the last decade, spurring public discord and political will to rectify the energy market. These rising prices can be attributed to actions taken in the early millennium that continue to affect the energy market. At the time, Ontario was experiencing a generation shortfall (Fremeth, Holburn, Loudermilk, & Schaufele, 2017). To rectify this, the Government made numerous investments into the infrastructure of energy generation and transmission. These capital costs are contributing to the high prices of energy (Morrow & Cardoso, 2018)

Additionally, the Province entered into a number of long-term energy contracts with generators, which established a fixed unit rate for energy. A **global adjustment** was offered to generators, which offset the difference between the market wholesale price and the price promised under the contract (Fremeth, Holburn, Loudermilk, & Schaufele, 2017). Thousands of megawatts were added to the generation portfolio, with a contract unit rate that varies based on the energy type. However, demand for energy actually fell due to efficiency gains, a recession, and the decline of the industrial-manufacturing sector. The surplus of suppliers and falling demand have led to a low wholesale market price (Fremeth, Holburn, Loudermilk, & Schaufele, 2017). However, the global adjustment has accounted for the difference between wholesale and contracted price. This also allowed generators to manipulate the market, offering energy at ludicrous prices while knowing they would be guaranteed the contract price (Fremeth, Holburn, Loudermilk, & Schaufele, 2017). In 2008, the global adjustment was only 11% of the cost per kilowatt hour; in 2016, the global adjustment reached 85% of the cost per kilowatt hour (Jackson, Stedman, Aliabari, & Green, 2017). As part of the 2009 Green Energy Act, the Feed-In Tariff program was approved, allowing renewable energy producers to receive a long-term guarantee of above market rates of power. In an annual report by Ontario's Auditor General, the guaranteed price promised to wind producers was double market price, and the guaranteed prove for solar was nearly three and a half times market price (Jackson, Stedman, Aliabari, & Green, 2017).

The oversupply of energy also results in energy being exported at a loss or generators not producing, for which they are paid for curtailing production (Jackson, Stedman, Aliabari, & Green, 2017). Under the contract structure, generators still receive payment even if their capacity is not necessary.

An additional element as to why the annual price is higher than necessary goes back to the duration of these power purchase agreements. These agreements are typically in place for 20 years, with the

exception of hydro projects, which are 40 years. However, these time horizons are far shorter than the operational lifespan of each project, thus the project is amortized in 20 years for a potentially 40 year lifespan (Fremeth, Holburn, Loudermilk, & Schaufele, 2017). These amortization costs are added to the variable costs of generation.

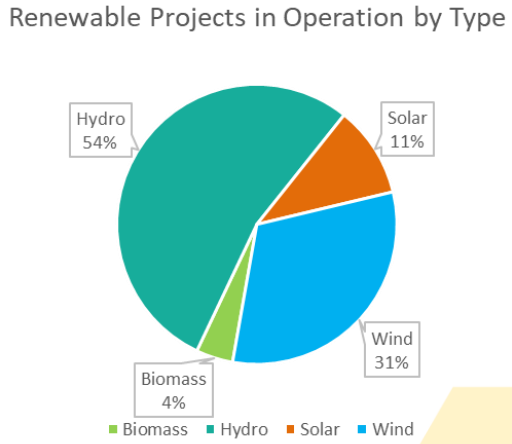
New Provincial Direction

Since the election of the Progressive Conservative party in 2018, the province has started to take steps away from encouraging renewable projects. In July of 2018, Energy Minister Greg Rickford announced the cancellation of 758 renewable energy contracts, claimed to be a cost-saving method to reduce Ontario's higher than average bills (Jeffords, 2018). Additionally, the government has announced a repeal of the existing cap and trade system for emissions, ending subsidies for electric vehicles, and removing a program that supports energy efficiency retrofits for homes, demonstrating an effort to move away from a green economy (Winfield, 2018).

Opposition parties and industry stakeholders have come out against the move, claiming it will harm small businesses and residents attempting to use microgeneration to cut their costs and the move will not save any money, as the contracts have not involved a transfer of money from the government. Additionally, employment in renewable project development will fall and the province has opened itself up to lawsuits (Jeffords, 2018). Furthermore, the federal government has earmarked $420 million in funding for Ontario under the Low Carbon Economy Leadership fund, which may be rescinded following the repeal of the cap and trade program. Ontario will now be forced to comply with a federal carbon tax coming into effect in 2019 (Rabson, 2018).

Renewable projects

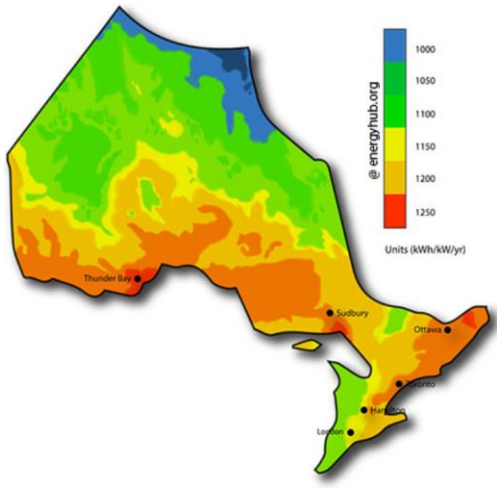
Ontario has hundred of renewable projects throughout the province, in a mix of private projects, municipal public projects, and public projects owned by Ontario Power Generation. 16,773.31 MW of renewable capacity is operational, with an additional 1,097.05 MW in development. This does not include many projects with less than 1 MW of capacity, as these smaller projects have not been inventoried. However, given recent statements made by the provincial government, it is unknown how many of these projects in development will make it to the operations stage. Of operational projects, the majority of energy is from hydroelectric sources, followed by wind energy. The figure adjacent demonstrates the makeup of the renewable energy portfolio in Ontario in 2018.



Renewable Energy Potential

Solar

Ontario is the fourth sunniest province in Canada (Solar Panel Power, 2018), with potentials higher in the south than the north. The FIT and microFIT programs provided financial guarantees for solar projects, which are calculated to offset the capital cost of installation, but are now closed. The GreenON Rebate program was planned to launch in summer of 2018, which has since been cancelled by the progressive conservative government (Solar Panel Power, 2018).

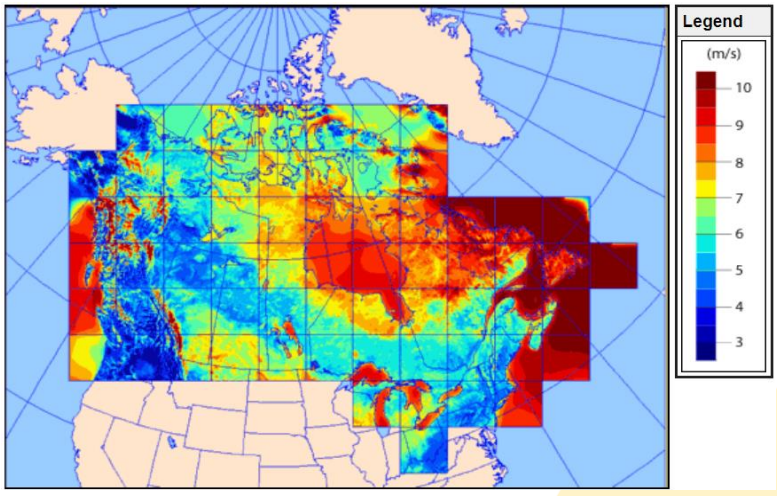


Solar Power Feasibility in Ontario
Source: https://solarpanelpower.ca/solar-power-maps-canada/

Barrington-Leigh & Ouliaris (2015) examined the feasibility of utility-scale solar farms in Canada, using the areas in the nation that are the most suitable for solar farms, after removing lands more suitable for wind energy development. Under these parameters, solar farms can produce 132 TWh per year, meeting 18% of the total energy demand in Ontario, 698 TWh per year.

Wind

Mean wind speed at a height of 80 m is provided in the map below. Areas with the highest speeds are more feasible for wind power development. The greatest wind speeds appear to be in the northern parts of the province.



Mean Wind Speed in Canada at 80 m Height
Source: http://www.windatlas.ca/maps-en.php

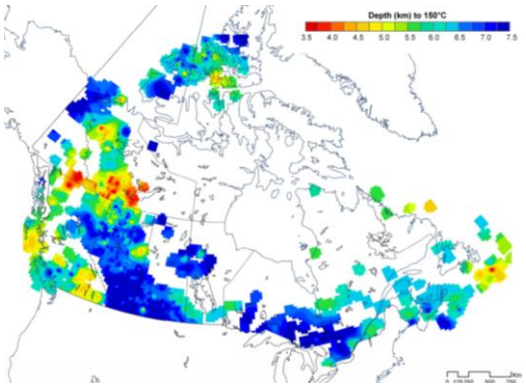
In a 2015 national study by Barrington-Leigh & Ouliaris, wind potentials across the nation were measured to determine the feasible generation. Using GIS, high wind potentials were identified using wind speeds of 7 m/s at a height of 80 m. The study excluded protected lands, inland water bodies, First Nations land, and a 5 km buffer around population centres. The remaining lands were then amended to only include lands near transmission lines (Barrington-Leigh & Ouliaris, 2015). Assuming that 25% of the remaining high potential areas are utilised, which accounts for competing land uses, Ontario could generate 30 TWh per year. Of Ontario's total 2015 energy demand

of 698 TWh per year, wind energy could account for 4% of Ontario's total energy generation (Barrington-Leigh & Ouliaris, 2015).

Ontario also has some potential for offshore wind energy in the Great Lakes. Barrington-Leigh & Ouliaris (2015) evaluated the potential for offshore wind across the nation. Offshore wind benefits from higher wind speeds, but is challenged by higher construction costs, higher maintenance costs due to seawater corrosion, and higher transmission costs (Barrington-Leigh & Ouliaris, 2015). When examining feasible lands for offshore wind, areas near the shore and water bodies near population centres or transmission lines were considered feasible. Areas with high potential were off the coast of British Columbia, on the Great Lakes, on the Gulf of St. Lawrence, and Bay of Fundy. In the Ontario context, the feasibility of wind development on the Great Lakes was considered. High potential sites do not account for shipping lanes and environmentally sensitive areas. Assuming a 50% utilization of high potential areas, it was determined that offshore wind farms on the Great Lakes could produce 182 TWh per year, meeting 26% of the total energy demand in Ontario of 698 TWh per year (Barrington-Leigh & Ouliaris, 2015).

Geothermal

Geothermal thermal has limited potential in Ontario. The following map provides the depth to reach a temperature of 150°C, suitable for geothermal electricity production (Grasby et al., 2012). Ontario is one of the least feasible provinces for geothermal energy production.



Depths at which temperatures of 150°C occur.
Source: Grasby et al., 2012

Hydroelectric

Barrington-Leigh & Ouliaris (2015) used the technical feasibility of hydroelectric resources and assumed a 60% capacity to generation ratio and 60% of feasible sites are developed to determine the feasibility of energy generation from hydroelectric sources. Ontario could produce 65 TWh per year, which could meet 9% of the total 698 TWh per year demand.

Bioenergy

Barrington-Leigh & Ouliaris (2015) summarised a study by Layzell, Stephen, and Wood (2006) that evaluated the bioenergy potential in Ontario, finding that Ontario could produce 86.5 TWh per year, accounting for 12.4% of the 698 TWh per year energy demand in Ontario.

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