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MaRS Market Insights

GOING GLOBAL

Market Information Report: Canada

Prepared for the Power Forward Challenge

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Natural Resources Canada | Ressources naturelles Canada

ADVANCED ENERGY CENTRE
MaRS Cleantech | Ontario, Canada

Country profile: Canada

COUNTRY SNAPSHOT	
Population[1]	37 million
Nominal GDP (CAD$)[1]	2.224 trillion
GDP per capita (CAD$)[2]	60,360
Major cities	Toronto, Montréal, Calgary, Vancouver
Official languages	English, French
Currency	Canadian dollar
Exchange rate[3]	C$1 = £0.59
Unemployment[1]	6%
Major exports[4]	Cars, Crude Petroleum, Vehicle Parts, Refined Petroleum, Sawn Wood
Export destinations	US, China, Japan, Mexico, UK
Major imports	Cars, Vehicle Parts, Delivery Trucks, Refined Petroleum, Crude Petroleum
Import destinations	US, China, Mexico, Germany, Japan

Executive Summary

This report is produced by MaRS Discovery District on behalf of Natural Resources Canada in parallel with the United Kingdom Government department for Business, Energy, and Industrial Strategy. The objective of this report is to provide a 360-degree view of the Canadian electricity market for UK and Canadian energy companies, to support the Power Forward Challenge. This is a Canada–U.K. led initiative to support breakthrough projects in smart grid and energy storage adoption designed to accelerate the transition to a low-carbon economy, whereby Canada will contribute C$10 million and the U.K. up to £6 million, totalling just over C$20 million. The report will examine the energy and electricity landscape specifically related to smart grid and energy storage opportunities as well as the business, social, political and legal frameworks and the country's macroeconomic drivers.

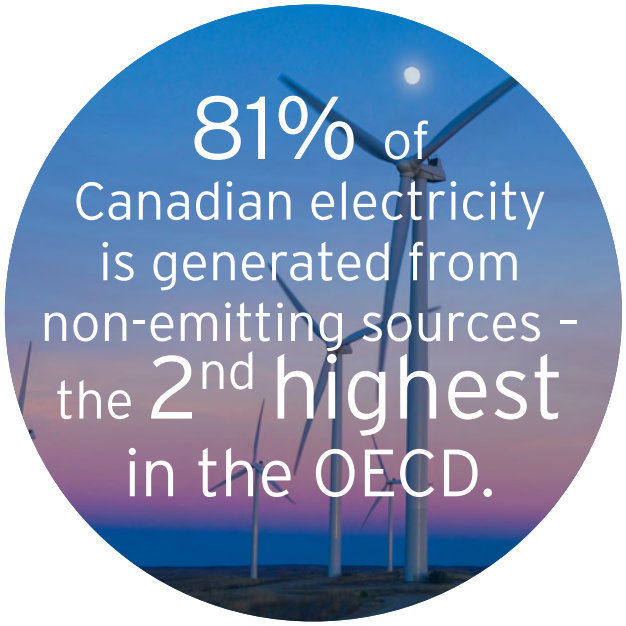
The analysis presented in this report is meant to help companies answer three key questions:

1. Are we a good fit for the market?
2. What are the opportunities and barriers for smart grid and energy storage solutions?
3. What are the opportunities and barriers to doing business, and do the former outweigh the latter?

In preparing this report, its authors examined a set of quantitative indicators adapted from third-party sources (the World Bank, the REN21, Bloomberg New Energy Finance, and Statistics Canada). These indicators measure key considerations for understanding opportunities and barriers for energy innovation in Canada, analyzing energy supply and demand, grid efficiency, sustainability and the business environment. In addition, the report identifies the scope of support for cleantech offered by national governments and organisations.

There are limitations to the insights this type of report can provide. The information presented is from secondary sources, and there are often details that can only be gathered from a physical presence in the market. The report is therefore intended to serve as an initial resource in understanding whether a market is suitable for your company. The report will prompt more specific questions and should be supplemented by a mission or visit to the market in question.

It is also important to note that within the cleantech market, the report focuses mainly on electricity and does not discuss technologies related to other cleantech subsectors (e.g. waste and water management).



1 Statistics Canada
2 OECD
3 Royal Bank of Canada
4 Observatory of Economic Complexity

Key findings

OPPORTUNITIES IN SMART GRIDS AND STORAGE

- Canada is pushing for grid modernization and decentralization to deliver renewable, reliable, and resilient supply.
- Market decentralization in some provinces has lead to reduced regulation and increased market competition.
- There is a significant opportunity in provinces that have phased out or will phase out coal and those with high renewable penetration.
- Energy storage is expected to be a fast-growing industry in Canada. This can be seen by increased deployment in the past year.
- Advanced Metering Infrastructure (AMI) has been deployed in all provinces and territories across Canada.
- Deployment of micro grid solutions, demand response and storage are still nascent in many provinces.

BARRIERS IN SMART GRIDS AND STORAGE

- The market is complex because of different provincial market structures and generation mixes. Demand is lower for storage and smart grid solutions in hydro-dominated provinces as they have greater grid flexibility and storage capacity.
- There is a strong desire for sustainable energy solutions in northern territories to replace expensive diesel generators but the commercial gain is limited because of the small and remote nature of these communities.

BUSINESS OPPORTUNITIES

- Canada has a conducive business environment for cleantech companies with low taxes, a reliable financial system, and access to top talent.
- Canada is seeing growth in its technology sector, attracting global tech companies and increasing foreign investments.
- Canada has a strong cleantech sector, ranking first in the G20 and fourth globally; Canada as a whole has an innovation focus.
- Recent federal budgets have announced a number of new programs to spur cleantech development and deployment, including initiatives focused on smart grid and energy storage.

BUSINESS BARRIERS

- Energy policies and decisions fall under the jurisdiction of provincial governments, consequently, they vary widely across the country.
- Energy is a political topic in Canada and can be captive to election cycles.
- Investments in clean energy are low compared to their peak in 2010–2015.
- Canada is attracting VC funding, but average investments and round size are considered small given the size of the country's economy, and there is a gap for later-staged companies.

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Methodology

This report looks at Canada from the standpoint of national energy indicators and measures the support for the adoption of innovative energy technologies within the Canadian government and major utilities. The purpose of this analysis is to help UK and Canadian cleantech companies identify potential opportunities and understand barriers to energy innovation in Canada.

The report assesses country indicators using technological, economic, social, environmental and regulatory data. To remove any subjectivity or bias in our depiction of the indicators, they are presented as raw data obtained from trusted third-party sources–including the World Bank, National Energy Board (NEB), and Statistics Canada. The analysis is represented visually and assessed qualitatively to demonstrate areas of opportunity, as well as barriers, in deploying smart grid and storage solutions in Canada.

Canada's Electricity Sector

OVERVIEW OF THE ELECTRICITY MARKET

Canada is the second-largest country in the world, and is made up of 10 provinces and 3 territories, which are interconnected by the North American Bulk Electricity System. In recent history, the Canadian electricity industry has been composed of integrated companies that own the entire electricity value chain. However, some integrated companies are unbundling to accommodate wholesale competition, such as Newfoundland and Labrador where one utility owns generation and transmission, while another owns distribution and retail. Ontario and Alberta are open competitive markets that unbundled in the early 2000s and are also seeing the emergence of independent power producers.[5]

Canada's energy mix is predominantly centralized generation in the form hydro, nuclear, and coal with hydro the dominant share (<85%) in five provinces and territories. This resulted in large-scale transmission lines being built to urban centres and towns to utilise centralized hydro resources. However, in the past decade, Canada has been pushing for grid modernization and decentralization to deliver renewable, reliable, and resilient electricity supply to consumers across the country.[5, 6, 7]

Key Electricity Market Indicators	
Installed generation capacity[6]	146.6 GW
Electricity generation[6]	652.4 TWh
Access to electricity[7]	100% of population
Electricity exports/imports[6]	62.8 TWh net exports
Main export market	United States

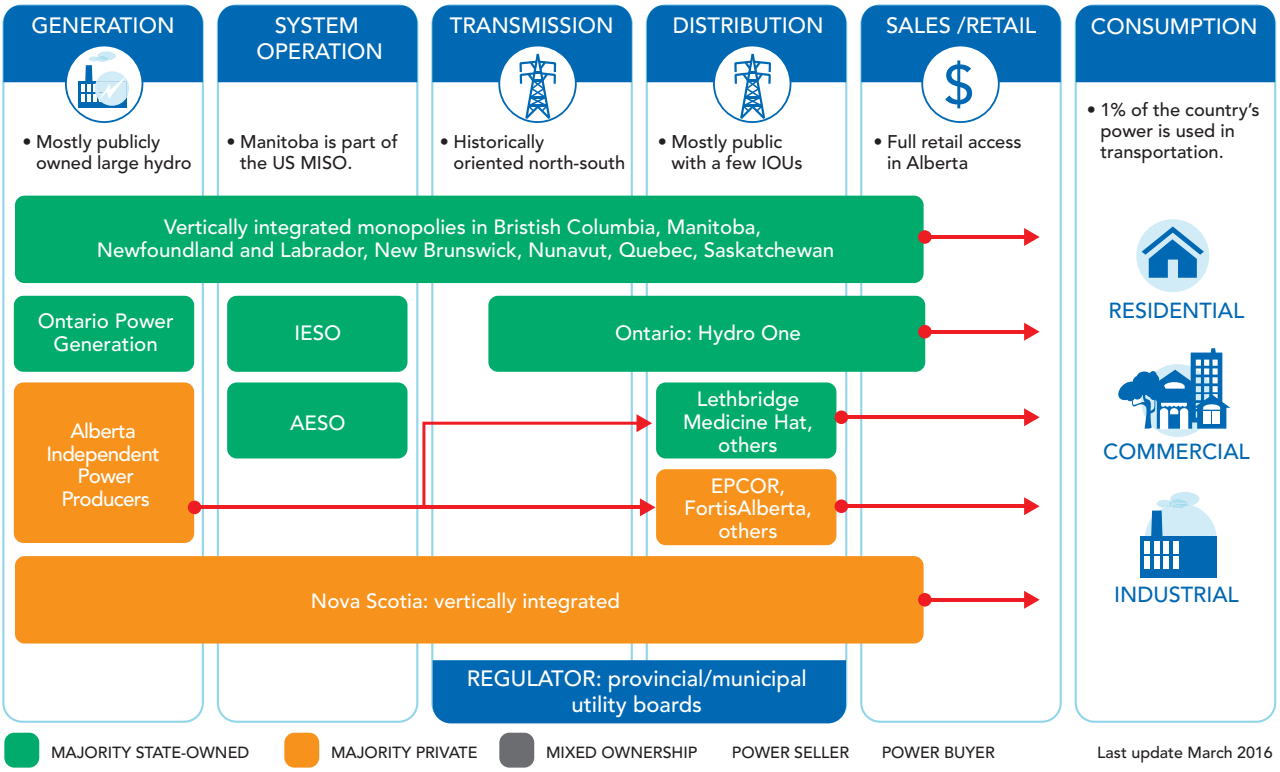
The market structure in each province can be broken into two categories as follows and is elaborated on below:

1. **Vertically integrated provinces** – British Columbia (B.C.), Manitoba (Man.), Quebec (Que.), Newfoundland and Labrador (Nfld.), Saskatchewan (Sask.), Nova Scotia (N.S.), New Brunswick (N.B.) and Prince Edward Island (P.E.I.)
2. **Restructured Provinces** – Alberta (Alta.) and Ontario (Ont.)

The **vertically integrated provinces** as shown in Figure 1 are generally operated by publicly owned monopolies that own the electricity market and are dominated by hydropower or are highly dependent on fossil fuels. Hydro provinces such as British Colombia, Manitoba and Quebec are characterized by public ownership, low production costs and a dynamic export orientation and also have distinct business units for generation, transmission and distribution. They are reluctant to reform because of cheap abundant electricity, but have worked to become more competitive in export markets. The remaining vertically integrated provinces rely on fossil fuels and are a mix of publicly owned (Saskatchewan, New Brunswick, Newfoundland and Labrador) and private (Nova Scotia, Prince Edward Island) utilities.

The **restructured provinces** moved away from the centrally managed model through the creation of an independent system operator (ISO) to manage the transmission system and set wholesale market prices. The lack of hydropower potential means they rely much more on thermal and nuclear generation and are engaged in market reform to reduce regulation and increase market competition.[8]

5 *IISD Cities and Smart Grids in Canada*
6 *NEB Canada's Renewable Power Landscape 2017*
7 *World Bank Data 2016*
8 *Evolution of Global Electricity Markets, 2013*



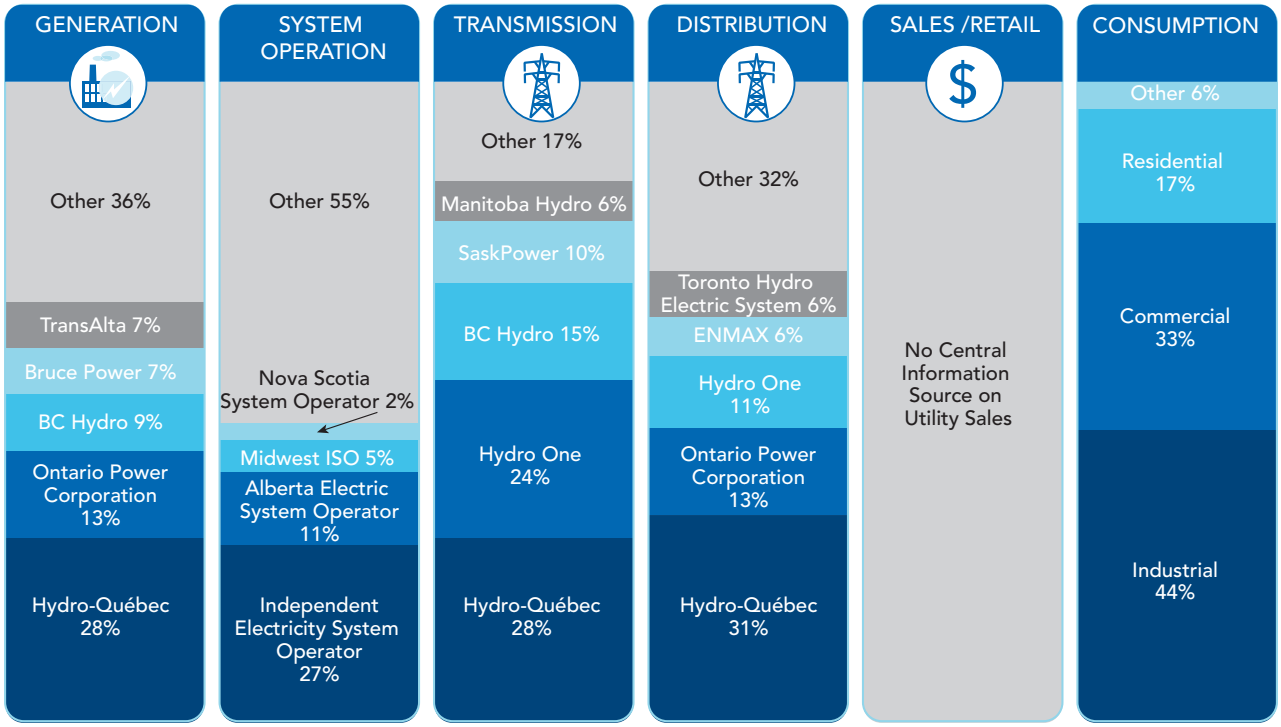


Figure 1 Canadian Electricity Market Structure[9]

9 *Bloomberg New Energy Finance*

ENERGY GENERATION

Provinces generally have open wholesale market access with varying degrees of competition and regulation. Vertically integrated provinces have open access wholesale markets that are dominated by provincial utilities such as BC Hydro and Hydro-Québec, but are also open to independent power producers (IPPs) who can sign PPAs with distribution companies.[10] Restructured provinces have competitive wholesale markets that vary in structure as Ontario has a hybrid regulation and competition model and Alberta has a mandatory power pool.[11] These wholesale markets are managed by the Ontario (IESO) and Alberta (AESO) independent system operators, respectively.

ENERGY TRANSMISSION

Canada, Mexico and the United States share an integrated electrical transmission network, which is referred to as the North American Bulk Electric System (BES). The BES includes approximately 430,000 kilometres of high voltage transmission lines in Canada, the United States, and Mexico, including 35 active transmission lines between Canada and the United States and 33 interprovincial lines within Canada.[12]

Every Canadian province along the US border is electrically interconnected with a neighbouring US state or states, with many provinces boasting multiple (or in the case of Ontario, more than a dozen) international interfaces.[13] Quebec and Ontario are the largest exporters of electricity to the US and delivered 23,532 GWh and 20,393 GWh of power, respectively in 2015.[12] The Ontario transmission system is predominantly managed by Hydro One, a transmission and distribution utility in Ontario, and operated by the Independent Electricity System Operator (IESO). It is one of largest in Canada, with 30,000km transmission length (≥115kV). Furthermore, Ontario has interconnections with Quebec, Manitoba, New York, Michigan and Minnesota with a maximum capacity of 29,600 MW.[14] Alberta's transmission network is managed by the Alberta Electricity System Operator (AESO), while in British Columbia and Quebec, the vertically integrated utilities manage generation, transmission and distribution.[15]

ENERGY DISTRIBUTION

Within the hydro-dominated provinces, the specific business units in the vertically integrated provincial utilities are responsible for distribution such as BC Hydro and Hydro Quebec Distribution, along with some municipal distribution companies. The restructured provinces have a distribution system managed by utilities or local distribution companies (LDCs), of which there are over 60 in Ontario. Prior to the restructuring of the sector in Ontario, more than 300 distribution utilities functioned as municipal departments, known as public utility commissions. This number was reduced greatly after consolidation of many LDCs through acquisitions and municipal amalgamation to achieve economies of scale.[16]

Major distribution utilities include ENMAX and EPCOR in Alberta, who have over 1 million customers collectively, and Toronto Hydro and Hydro One in Ontario with over 2 million.[17,18,19,20] These are among the largest utilities in Canada, but many local distribution companies operate at a much smaller scale in specific municipalities because of the large geographic area to cover in each province. The distribution grid is evolving in some provinces, where there was a push for decentralization and modernization to reduce the distance between generation points, adopt microgrids and support prosumers on the grid.[21]

COMMERCIALIZATION

Commercialisation has only taken place in the restructured provinces who have created competitive retail markets, while the vertically integrated provinces have had less impetus for reform. In hydro provinces, this is due to the historical low cost of generation and low cost-of-service rate regulation, meaning they have the lowest electricity rates in Canada. Market reform in the restructured provinces came about partly because of high electricity prices, but also because of a desire to reduce regulation and increase competition.[10] The key distinguishing feature is the presence of an ISO that sets a publicly available hourly reference price, known as "spot" market prices.

The retail market in Alberta has been open since 2001 and, as of 2012, 35% of Alberta residential consumers had switched retailers. Ontario opened its electricity market in 2002, which enabled more companies to operate in the market and allowed customers to choose between their regional distributor and an independent retailer. However, in Ontario, there is low competition because of price volatility and regulation, which limits retailers' price advantage and has reduced retail market share to 6%.[22] In New Brunswick, market reform in 2004 was reverted in 2011 with the reintegration of NB Power after high fossil fuel prices, delayed nuclear refurbishment and a failed takeover of NB Power by Hydro-Québec.[10]

There have been a number of key market developments in Ontario in recent years such as the integration of demand response, active participation of dispatchable loads, and the global adjustment charge (GAC) to cover the cost of providing adequate generating capacity and conservation programs for Ontario. GAC represents a component of the province's energy charge that covers the cost of building new electricity infrastructure, maintaining existing resources, as well as providing conservation and demand management programs, and can account for as much as 70% of C&I customer bills.[23, 24]

10 *Evolution of Global Electricity Markets, 2013*
11 *CEA - Electricity 101*
12 *NRCAN Electricity Infrastructure*
13 *CEA - North American Grid*
14 *IESO Ontario Transmission System 2017*
15 *NRCAN Electricity Infrastructure*
16 *The electricity distribution sector in Ontario: the slow road to consolidation*
17 *Hydro One 2009*
18 *ENMAX 2012*
19 *Toronto Hydro 2009*
20 *EPCOR 2009*
21 *IISD Cities and Smart Grids in Canada*
22 *Ontario's Retail Energy Sector: Market Evolution, Market Data and Consumer Protection, 2014*
23 *IESO Electricity Market Today*
24 *IESO Understanding Global Adjustment*

MARKET REGULATION

Key bodies within the Canadian electricity market include the Canadian Electricity Association (CEA), the National Energy Board (NEB), Natural Resources Canada and the North American Electric Reliability Corporation (NERC).[25]

Canada has a multi-jurisdictional regulatory environment within provinces and territories, and the regulation of provincial utilities falls under the responsibility of quasi-independent bodies, with the exception of Alberta and Ontario.[26, 27] Provincial governments manage energy resources, environmental impact, the electricity system, and conservation and demand response policies within provinces. The federal government manages nuclear safety, interprovincial and international trade, national environmental impacts, national policies and standards on conservation and demand.[27] Authority over electricity generation and transmission in Canada rests primarily with provincial governments. Not all jurisdictions have the necessary legal structures to name an electric reliability organization (ERO). However, all have recognized NERC as an electric reliability standards-setting organization and have committed to supporting NERC in its standards-setting and oversight role as the North American ERO.[27, 28]

The NEB is Canada's energy and safety regulator, and it operates under a variety of acts and regulations. It has jurisdiction over the construction, operation and abandonment of international power lines between Canada and the United States and designated interprovincial power lines.[29] Canada's energy sector is also regulated by provincial utility regulators that are responsible for facilities that lie completely within the borders of any single province. Some provincial utility regulators include Alberta Utilities Commission (AUC), British Columbia Utilities Commission (BCUC), Manitoba Public Utilities Board (MPUB), Ontario Energy Board (OEB), and the Régie de l'energie in Quebec.[30]

25 *Evolution of Global Electricity Markets, 2013*
26 *Bloomberg New Energy Finance*
27 *CEA - Electricity 101*
28 *NERC Canada*
29 *NRCAN Electricity Infrastructure*
30 *Enersource - Ontario's Electricity System*

Key Findings: Canada's Electricity Sector

- **The Canadian electricity market can be defined by two categories: vertically integrated provinces and restructured provinces.**
- **Canada is part of an integrated North American transmission network known as the Bulk Electricity System (BES) with 35 active transmission lines connected to the US.**
- **Restructured provinces Alberta and Ontario have independent system operators and present opportunities because of deregulation and greater competition.**
- **Canadian market entry can be challenging because of the different provincial market structures and regulation, which vary significantly in each jurisdiction.**

Supply and Demand Mix

Key Supply and Demand Indicators

Total Electricity Generation (TWh)[31]	652
Total Electricity Consumption (TWh)[32]	502
Renewable Generation Share[31]	66%
Renewable Generation Share (Excluding Hydro)[31]	7.2%
GDP Growth (2017)[33]	3%
Reserves (billion barrels)[34]	171
Net electricity imports (2017, billion kilowatt-hours)[35]	62.2
Electric network connectedness (low-high)	High

OVERVIEW

Canada ranks 4th in the world for renewable energy capacity, as electricity production is dominated by hydroelectricity, which represents about 59% of the country's generation mix. Conventional generation makes up another 37%, most of which comes from nuclear fuel at 14% and natural gas with around 10%. Eighty-one percent of Canadian electricity is generated from non-emitting sources, the 2nd highest in the OECD. This is due to Canada's large hydro and nuclear capacity with 80 GW and 14 GW respectively. Wind provides 5% of the total, with biofuels, biomass and solar totalling less than 3% as shown in Figure 2.[31]

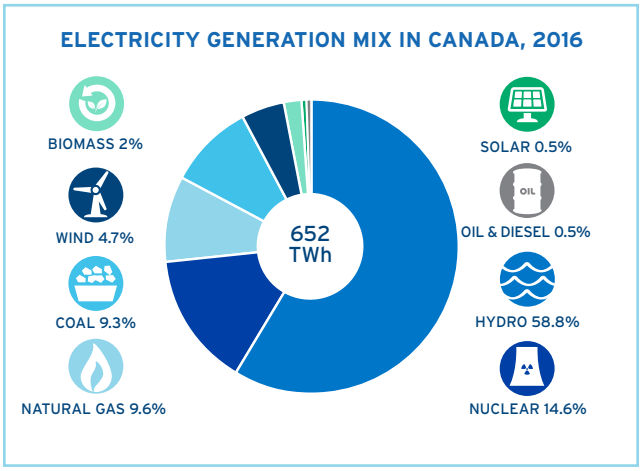


Figure 2 Canada's Generation Mix, 2016 [31]

31 *NEB - Canada's Renewable Power Landscape 2017*
32 *CEA - Electricity 101*
33 *World Bank Group*
34 *US Energy Information Administration Country Data*
35 *NEB Electricity Trade Summary*

Canada's Energy Facts[36, 37, 38]

- 2nd largest global producer of hydroelectricity (China 1st)
- 4th largest global producer of renewable energy (China 1st)
- 8th largest global producer of wind energy (China 1st)
- 6th largest producer of nuclear energy (US 1st)
- Worlds 4th largest oil producer (US 1st)
- Worlds 4th largest natural gas producer (US 1st)

SUPPLY

Canada is the 6th largest energy producer in the world, the fifth-largest net exporter and the 8th largest consumer. The amount of primary energy produced by Canada in 2015 is almost 17% more than was produced in 2005. The world, on average, has increased energy production by 19% in the same period.[39] Canada has a diverse abundance of energy resources including crude oil, coal, nuclear energy, renewable energy, natural gas and more. Electricity accounts for only 20% of overall energy use in Canada today, as shown in Figure 3. Fossil fuels and natural gas account for the largest use of energy in the country with 78%.[36]

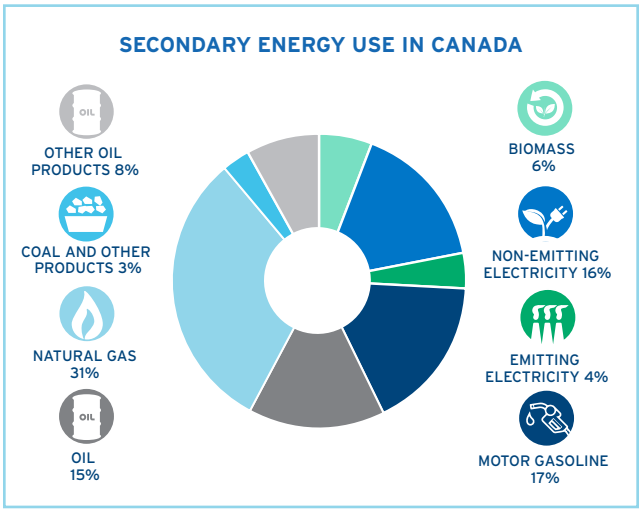


Figure 3 Secondary Energy Use Canada[36]

36 *The Generation Energy Council - Canada's Energy Transition*
37 *BP Statistical Review of World Energy 2018*
38 *IRENA Data and Statistics*
39 *NRCAN Energy and the Economy*

Canada ranks 4th in the world for renewable energy capacity with 97,317 MW, largely made of up hydroelectricity. Excluding hydro, renewable capacity is 16,914 MW which increased moderately from 65.6% to 66.4% in 2016, as thermal generation facilities were retired and the electricity sector continues to evolve a low-carbon future.[40] Canada's non-hydro renewable power capacity grew by 8.2% in 2016 with an added 1,293 MW of solar, biomass, and wind in Figure 4. Wind was the dominant source of new renewable capacity and in Ontario, Quebec, and Nova Scotia, it accounted for over half of net capacity additions. This increase in renewable capacity is driven by a shift away from fossil fuels in many provinces, and between 2005 and 2016, coal generation decreased from 16.1% to 9.3% of Canada's total generation, while natural gas increased from 6.8% to 9.6%.

The electricity supply mix varies largely across the different provinces and territories, with the largest generators being Quebec, Ontario and Alberta in that order, as shown in Figure 4.[40]

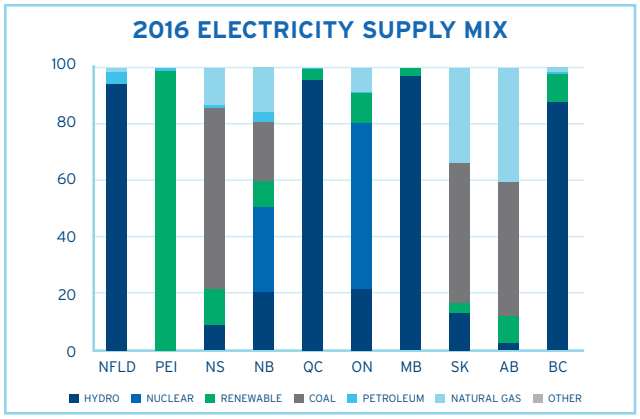


Figure 4 2016 Electricity Supply Mix [40]

Ontario's electricity system is dominated by nuclear power which accounted for 58% of generation in 2016. Coal was phased out in 2014, and this has been replaced by an increase in natural gas and renewable generation. Non-hydro renewables experienced strong growth under the feed-in-tariff program, implemented in 2006. As a result, wind, solar, and biomass increased from 0.7% in 2005 to 10.8% combined in 2016.

Quebec and British Columbia have a large hydro power generation share with 95% and 88%, respectively. Other provinces are heavily dependent on fossil fuels, such as Alberta, which generated 87% of electricity from coal and natural gas. There is a downward trend of coal in some provinces such as Alberta and Saskatchewan and is set to be phased out nationally by 2030. The diversity of Canada's electricity supply can be seen further in places such as Nova Scotia, which generated 64% of electricity from coal in 2016, and in remote northern communities, oil and diesel are the primary sources of power because of rural, disconnected, and remote areas. [40]

RENEWABLE GENERATION

Figure 5 shows the annual average solar photovoltaic (PV) generation potential in each province and territory in Canada, as well as select cities. Saskatchewan has the highest potential with 6.79 kWh/m over a month. On average, municipalities in Saskatchewan are exposed to the greatest amount of sunlight, followed by those in Manitoba, Alberta, Ontario, and Quebec. Canadian solar power generation in 2016 was almost 30 times that of solar power generation in 2010. Based on the current economic outlook, Canadian solar generation is expected to almost triple from 3.6 TWh in 2016 to almost 13.0 TWh by 2040. Over 98% of Canada's solar power generation capacity is currently located in Ontario, which has offered incentives for renewable-energy projects in the past.[41]

40 NEB - Canada's Renewable Power Landscape 2017

41 NEB 2018 - Market Snapshot: Which cities have the highest solar potential in Canada?

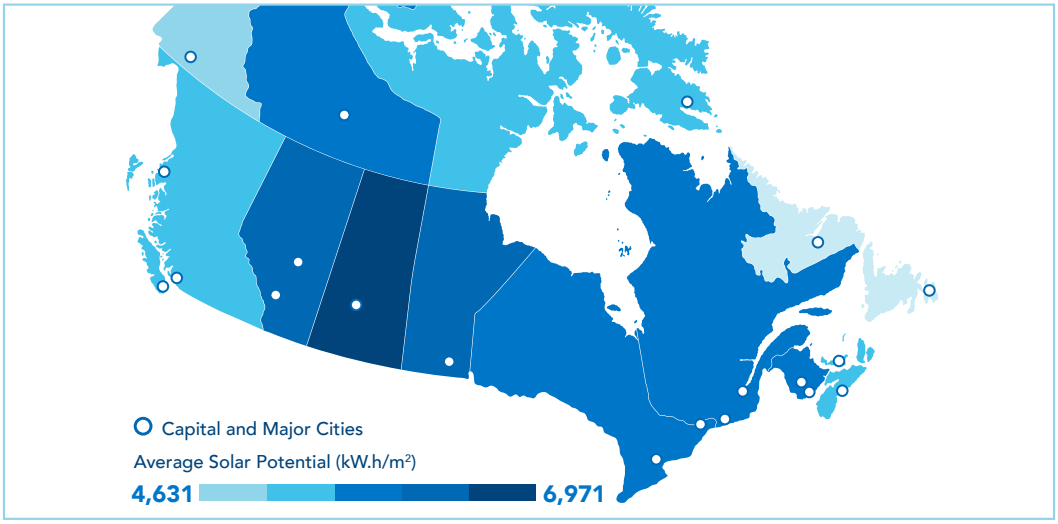
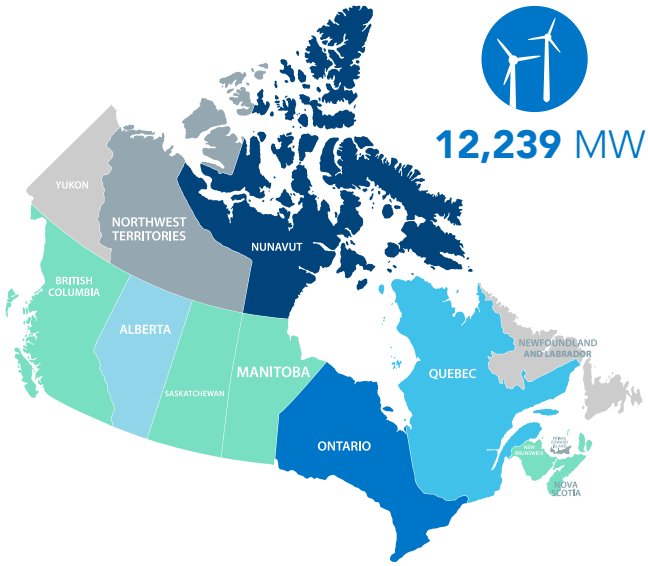


Figure 5 Photovoltaic Potential in Canada[42]

42 NEB 2018 - Market Snapshot: Which cities have the highest solar potential in Canada?



Province/Territory	Capacity
Yukon	0.8
Northwest Territories	9.2
Nunavut	0
British Columbia	698
Alberta	1,479
Saskatchewan	221
Manitoba	258
Ontario	4,900
Quebec	3,510
New Brunswick	294
Prince Edward Island	204
Nova Scotia	610
Newfoundland and Labrador	55

Figure 6 Wind Energy Capacity Canada, 2016[43]

Canada is global leader in wind energy as the 9th largest producer with 12,239 MW of installed capacity, enough to power 3.8 million homes. Wind power has been the largest source of new electricity generation for the last decade and has grown by 15% CAGR over the last 5 years, adding on average 1,159 MW/year. Ontario is the largest producer of wind power, as can be seen in Figure 6, followed by Quebec and Alberta.[43] As a result of rapidly falling costs for wind and solar power and a growing role for batteries in balancing electricity supply and demand, Canada's is well positioned to leverage its unparalleled wind resource in the future. This can be seen in Prince Edward Island, where roughly 98% of power generation is from wind farms.[44]

DEMAND

Total energy demand in Canada is dominated by the industrial (51%) and transport (23%) sectors, as can be seen in Figure 7 where the other two sectors are residential and commercial. This is largely due to provinces such as Alberta with significant industrial energy demand, whereas Quebec and Ontario have a higher share of energy demand for transport and residential sectors. Refined petroleum products were the largest fuel type consumed in Canada in 2015, accounting for 4,625 PJ or 41% of consumption. Natural gas and electricity accounted for 3,938 PJ (35%) and 1,879 PJ (17%), respectively.[45]

Electricity demand has remained relatively flat for the past 5 years, and in 2016 totaled 502 TWh. The majority of the demand came from the industrial and residential sectors, which accounted for 40% and 33%, respectively. Commercial and institutional demand was also a large consumer with 20%, but the remaining sectors of agriculture, public administration and transport accounted for only 6% of total demand.[46] Transport in particular remains small, although with increased adoption of electric vehicles, which has seen year-over-year growth of 214%, this could increase in the coming years.[47] Quebec ranked the highest for annual electricity consumption with 21.1 MWh per capita, 46% higher than the national average, while Nunavut ranked the lowest at 5.1 MWh per capita, 65% lower than average. Quebec's high demand is due to its low-cost electricity, which powers the aluminum industry and heats most residential homes.[45]

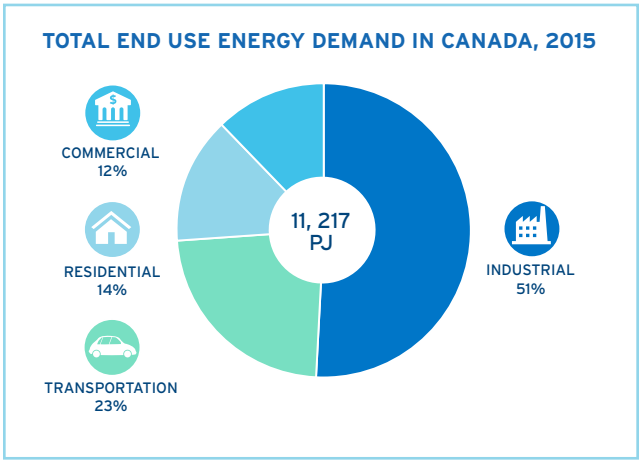


Figure 7 Total End Use Energy Demand in Canada, 2015[45]

43 CANWEA Installed Capacity
44 NEB - Prince Edward Island Energy Profile
45 NEB - Energy Profile Canada
46 CEA - Electricity 101
47 Electric Vehicles Sales Update Q2 2018, Canada

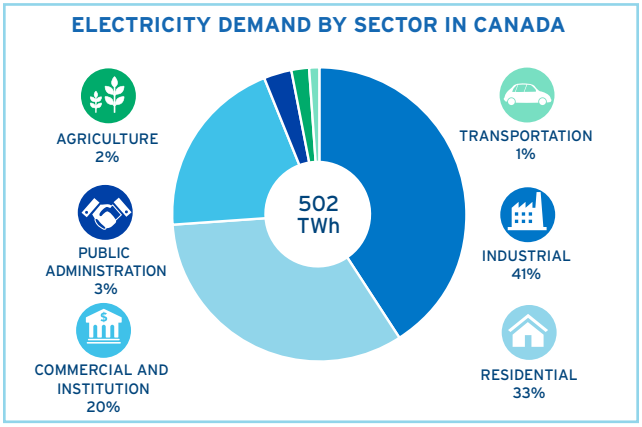


Figure 8 Electricity demand by sector in Canada, 2016[48]

Average daily electricity demand has fallen in Ontario considerably since 2002. The overall decrease in demand was primarily due to conservation efforts such as IESO's Save on Energy programs, as well as improvements in energy efficiency in appliances and light bulbs. The average day in 2002 saw peak demand of 19,500 MW, while the average day in 2016 only saw highs of 17,800 MW. Likewise, in 2002 daily average lows were 14,300 MW, whereas, 2016 lows only averaged 12,900 MW. The decrease in peak demand is due to an increase in solar capacity as self-generators reduce grid demand and also as Ontario industry has shifted since economic recession to service-based business instead of energy-intensive industries such as paper and pulp.[49]

48 *CEA - Electricity 101*
49 *NEB 2018 - Market Snapshot: Why is Ontario's electricity demand declining?*

ELECTRICITY IMPORTS AND TRADE

In 2017, electricity export volumes were the 2nd highest on record, after the record-breaking volumes exported in 2016. Net exports of 62.2 TWh, delivered significant trade value of C$2.7 billion, with 72.1 TWh of exports, and 9.9 TWh of imports.[50] In general, exports have increased between 2013 and 2017, with slight decreases in 2014 and 2017. Historically, provinces with significant hydro-based generation (British Columbia, Quebec, and Manitoba) have exported large amounts of power, and high export years usually coincide with high precipitation years. The US Northeast, a relatively small region, buys the majority of Canadian exports, the bulk of which is shared between the ISO-NE and NYISO markets, as can be seen in Figure 9. This is due to the extensive grid interconnection that exists with Quebec.[50]

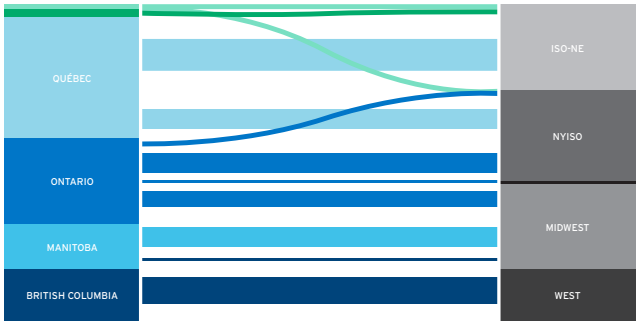


Figure 9 Annual Electricity Export Flow, 2017[50]

50 *NEB Electricity Trade Summary*

Key Findings: Supply and Demand Mix

- Canada's non-hydro renewable power capacity grew by 8.2% in 2016 with an added 1,293 MW of solar, biomass, and wind. Wind was the dominant source of new renewable capacity, and in Ontario, Quebec, and Nova Scotia, it accounted for over half of net capacity additions.
- There are increasing opportunities for renewable energy and storage to compete as fossil fuels are being phased out in provinces such as Alberta, Saskatchewan and Nova Scotia, where coal is a key part of the supply mix. Natural gas is also growing as an alternative form of supply.
- Wind power has been the largest source of new electricity generation for the last decade and presents an opportunity for storage and smart grid solutions in provinces with high growth such as Ontario, Nova Scotia and Alberta.
- Demand for smart grid solutions is high in provinces with high or growing renewable penetration. However there may be less demand for grid storage and flexibility in provinces with abundant hydro supply.
- Future demand in Canada will be impacted by electrification of heating and transport, and while demand in Ontario has decreased because of the reduction in industrial activity, demand in the transport sector will likely grow nationally because of the proliferation of EVs.

Quality, Efficiency and Resilience of the Electricity System

Key Quality, Efficiency and Resilience of Electricity Indicators	
Access to electricity (% of population)[51]	100%
Canadian Index of Reliability (2017)[52]	99.91%
Average monthly residential bill per 1,000 kWh (C$)[53]	$129
Average industrial price per kilowatt hour with 5,000 kW demand (C$)[53]	8.54c/kWh
Power transmission and distribution losses (% of output)[51]	8.87%

ELECTRICITY PRICES

Electricity prices vary significantly across different provinces as residential customers in Montréal, Winnipeg and Alberta pay the lowest in Canada, with Montréal the lowest at C$72 for a monthly consumption of 1,000 kWh. Comparatively, customers in Toronto, Ontario, pay on average C$178 per month, over two times higher than Montréal. Montréal, situated in Quebec, benefits from cheap electricity due to significant hydro capacity much like Winnipeg and Vancouver, which are among the top 5 cheapest cities.[54]

Hydro-dominated provinces have a historically low-cost generation portfolio and cost-of-service rate regulation. Ontario has seen high electricity rates since the market was restructured to incentivize competition and privatization, but this resulted in major price volatility in 2002 as wholesale and retail electricity prices were directly linked. After a rate freeze, a regulated price plan was introduced but prices remain high under this because of long-term supply contracts.[53, 55]

QUALITY AND RELIABILITY

The Canadian Index of Reliability, which measures the proportion of uninterrupted supply to customers, has remained consistently high over the past 10 years at over 99.9%. Major events such as hurricanes Igor and Earl in 2010 and the 2013 ice storm and flooding in Alberta and Toronto have impacted this score when widespread outages occurred. This shows the need for reliable electricity supply.[52]

Reliability, according to the North American Electric Reliability Corporation (NERC) is the ability to meet the electricity needs of end-use customers, even when unexpected equipment failures or other conditions reduce the amount of available power supply.[56] In Canada, regulatory oversight of electric reliability rests primarily within the jurisdiction of the provinces and territories. However, since the northeast blackout in 2003, Canadian and American authorities have worked collaboratively to implement a harmonized continental approach to mandatory reliability standards. The northeast blackout was the largest in North American history, as 61,800 MW of electric power was lost in Ontario, Ohio, Michigan, Pennsylvania, New York, Vermont, Massachusetts, Connecticut and New Jersey, affecting an estimated 50 million people and causing an estimated US$4 billion to US$10 billion in economic losses.[57]

51 *World Bank*
52 *CEA - Electricity 101*
53 *North American Electricity Prices - Hydro Quebec, 2017*
54 *NEB - Canada's Renewable Power Landscape 2017*
55 *Evolution of Global Electricity Markets, 2013*

56 *NERC State of Reliability 2018*
57 *After the Blackout: Implementation of Mandatory Electric Reliability Standards in Canada 2015*

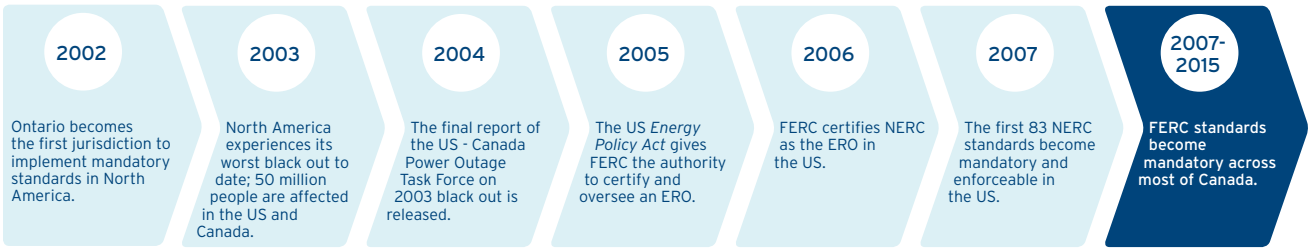


Figure 10 Timeline of major developments toward mandatory reliability standards in Canada[57]

The blackout prompted a joint investigation by Canada and the US, resulting in the certification of NERC as the independent electric reliability organisation for North America, to implement mandatory reliability standards (Figure 10). The provinces of Ontario, Quebec, Nova Scotia, New Brunswick, Alberta, and Saskatchewan, as well as the NEB have MOUs with NERC, while British Columbia and Manitoba do not have MOUs but have adopted NERC reliability standards. NERC assures the effective and efficient reduction of reliability and security risks for the North American BES.[58]

SMART GRID DEVELOPMENT

A smart electrical grid is one that makes better use of existing generation, transmission and distribution assets, increases energy efficiency, ensures safer and more secure delivery of electricity and ultimately provides a higher quality of service for customers. By boosting the hosting capacity of renewable energy, increasing resiliency and improving energy efficiency and conservation, smart grids are a key enabler for greenhouse gas mitigation.[59] Canada is undergoing a modernization process, moving toward the integration of smart grid technology to address challenges arising from urban agglomeration trends and climate change, while seizing opportunities to reduce emissions and improve energy production, consumption and efficiency.[60] Other benefits of smart grids include facilitating microgrids and customer-owned generation, managing energy storage, autonomous demand response and increasing grid visibility.[59]

58 *After the Blackout: Implementation of Mandatory Electric Reliability Standards in Canada 2015*
59 *NRCan Smart Grid Program*
60 *IISD Cities and Smart Grids in Canada*

Smart Grid Deployment in Canada[61, 62, 63]

- Almost **70,000** EVs
- **8,708** charging stations
- **84%** of installed meters are smart meters

Smart grid deployments in Canada have increased significantly in recent years because of strong public funding programs and successful pilots of different smart grid technologies. Table 1 below shows the degree of adoption of smart grid technologies in each province with the following key for degree of adoption:

1. Under Study/Small Pilots ..... LOW
2. Partial/Ongoing Deployment ..... MEDIUM
3. Broad Deployment ..... HIGH

61 *Electric Vehicles Sales Update Q2 2018, Canada*
62 *Canadian Automobile Association*
63 *NRCan Smart Grid in Canada, 2016*

Table 1
Smart Grid Deployment in Canada, 2016[63]

	AMI	NRO	DR	DES	SHG	MG	VVC
Yukon							
Northwest Territories							
Nunavut							
British Columbia							
Alberta							
Saskatchewan							
Manitoba							
Ontario							
Quebec							
Newfoundland and Labrador							
Prince Edward Island							
Nova Scotia							
New Brunswick							

LEGEND LOW MEDIUM HIGH

AMI ADVANCED METERING INFRASTRUCTURE **NRO** NEW RATE OPTIONS **DR** DEMAND RESPONSE **DES** DISTRIBUTED ENERGY SOURCE
SHG SELF-HEALING GRID **MG** MICRO GRID **VVC** VOLT AND VAR CONTROL

In 2016 Natural Resources Canada identified about C$219 million of government support for demonstration or pilot projects worth C$647 million. A significant investment was for storage, micro grid, grid monitoring and automation, electric vehicle integration, and distributed energy resource management. There were a smaller number of demonstration projects related to demand side management, data management and communication, cybersecurity and customer enabling solutions.

Canada's vision for smart grid technologies, through the Pan-Canadian Framework on Clean Growth and Climate Change, is to evolve the grid into a modern system that delivers maximum value to customers while contributing to a low carbon economy by 2050. To achieve this, industry associations and businesses will aim to accelerate innovation and customer management of energy, implement financial instruments for carbon reduction, enable electric vehicles and expand collaboration across borders.[64]

ENERGY STORAGE

Several storage systems are being tested and commercialized in Canada such as flywheels, compressed air, hydrogen, batteries, thermal heat, and ice. The NEB estimated that over 50 MW of battery capacity would be operational in Canada by 2018, but this projection may prove to be conservative as the storage industry shows increased growth.[65] In Ontario, where the largest amount of storage projects in the country have been installed, with 15 in operation out of 22 in total, this is a result of Global Adjustment Charge (GAC). Because of the way the charge is designed, it represents a policy-driven economic opportunity for C&I storage companies to reduce peak demand. In the past year, there have also been a number of new behind-the-meter (BTM) projects announced in Ontario to mitigate this charge.[66, 67]

SELECT ENERGY STORAGE PROJECTS ACROSS CANADA

- **Stratford Lithium-ion Battery Storage:** Canada's largest operational energy storage project (8.8 MW/40.8 MWh) came on-line in April 2018. Owned by esVolta, a storage developer from California, this system provides grid reliability services to the IESO[67]
- **Drakes Landing-Solar Thermal Heating:** Located in Alberta and consisting of 52 houses, this is the first large-scale solar community in North America to use borehole thermal energy storage to heat homes. This 1.5 MW solar system has been providing well above 90 % of the space heating requirements[67]
- **Wind Energy Institute of Canada Wind R&D Park and Storage System for Innovation in Grid Integration:** This 1 MW sodium-nickel-chloride battery is being used to integrate electricity from the 10 MW Wind R&D Park located at the over 30 year old Wind Energy Institute of Canada facility in Prince Edward Island.[67]

TRANSMISSION AND DISTRIBUTION LOSSES

As severe weather events become increasingly common, preventing and responding to power outages is a top priority for Canadian utilities. The System Average Interruption Index (SAIDI) increased slightly in 2016 to 5.66 hours per customer, as did the System Average Interruption Frequency Index (SAIFI). This was due to a number of significant events, including two separate ice-storms, a lightning storm and the Fort McMurray fires. This can be seen in Figure 11 where the SAIDI* index that excludes extreme events remained relatively flat and shows that Canada's electricity system responds relatively well to interruptions and losses. Globally, European countries such as Germany tend to perform much better although data is not weighted to account for the size of the regional grid, while the US, Canada and Australia tend to sustain longer interruptions.[69, 70]

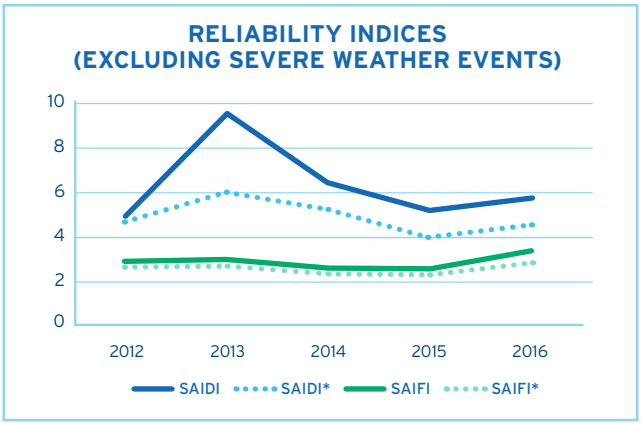


Figure 11. Canadian Reliability Indices[69]

Tree contacts remain the largest contributor to SAIDI in Canada, followed by equipment failure. Tree contacts contributed 2.0 hours of the total 5.66 SAIDI hours. Wildfires are also a major cause of transmission power losses in Canada, and caused 24 outages in one day in 2013. This was the highest incident of daily transmission loss across the entire North American BES between 2013 and 2017, 10 times the average daily transmission losses for that period.[71]

64 *Mission Innovation - Smart Grids Innovation Challenge Country Report 2017*
65 *Market Snapshot: Batteries Dominate Early Stage Testing for Energy Storage in Canada*
66 *Ontario C&I BTM Storage - Energy Storage News*
67 *US Department of Energy, Global Energy Storage Database*
68 *NRStor Godrich CAES Facility*
69 *CEA - Sustainable Electricity Annual Report, 2017*
70 *Clean Energy Wire, Germany's electricity grid stable amid energy transition*
71 *NERC State of Reliability 2018*

NETWORK CONNECTEDNESS – REMOTE COMMUNITIES

Remote and northern communities in Canada still lack access to safe and reliable power. The vast majority rely on expensive, imported diesel-fuel for meeting their basic energy needs.[72] Canada's vast and sparsely populated northern regions are not connected to integrated electricity grids and natural gas pipelines like the rest of North America, and there is little commercial incentive to build these connections because communities are small and widely dispersed. Geography poses a challenge for the broader use of renewables and as a result, northern Canada relies heavily on relatively expensive and carbon-intensive energy sources such as diesel generators.[73] These communities cannot benefit from the economies of scale that grid-connected communities receive and in addition, diesel generators have higher operational costs than most other generation technologies. Transportation and storage costs for diesel fuel are also high, especially for communities that lack road access.

To address this, the federal government announced the Clean Energy for Rural and Remote Communities Program this year, which will provide approximately $220 million in funding for initiatives to reduce reliance on diesel fuel in rural and remote communities, to drive clean growth and combat climate change in northern communities.[74]

72 *CEA - The Grid*
73 *NEB - Market Snapshot: Explaining the high cost of power in northern Canada*
74 *Canadians Living in Remote Communities Lack Access to Affordable and Reliable Electricity*

RESILIENCY AND EXPOSURE TO SEVERE WEATHER

Extreme weather events are becoming increasingly common, as events that used to happen every 40 years are now occurring every six years, and are expected to become more frequent and intense in the future. Canada has an aging infrastructure that was designed on a centralized model to utilize large-scale generation resources such as hydro, and most of Canada's transmission system is made up of a small number of long-distance transmission lines that run at extremely high capacity, connecting generation lines to consumers in urban centres. Increasing grid resiliency is paramount to secure many essential services to cities as well as to support reliability in electricity generation, transmission and distribution. In December 2013, an ice storm in Toronto left approximately 300,000 customers without power, while an ice storm in Quebec in 1998 still stands as a major example of the damage that can occur, leaving almost 1.5 million people without power. Grid resiliency is more important than ever as a result, and it is one of the primary factors in Canada's push in the last decade for grid modernization and decentralization in certain provinces. The need to modernize the electrical grid presents both challenges and opportunities for increasing reliability and resiliency to the grid, diversifying the electrical mix, and introducing technologies that will support low-carbon transition and strengthening of the electrical grid.[75]

75 *IISD Cities and Smart Grids in Canada*

Key Findings: Quality, Efficiency and Resilience of the Electricity System

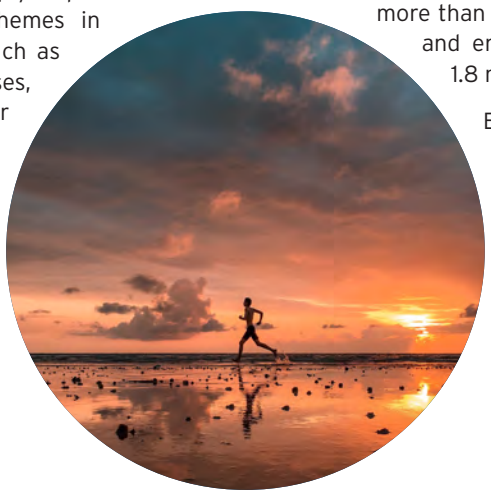
- **Electricity prices vary between provinces significantly with high prices in Ontario because of market unbundling and cheap abundant hydro power in Quebec and Manitoba.**
- **Reliability and resiliency have been prioritized in recent years in Canada because of increased impact of natural disasters and storms on Canada's large-scale transmission infrastructure, leading to adoption of smart grid and storage technologies.**
- **Storage development in Ontario has seen rapid growth to mitigate global adjustment charges for commercial and industrial customers and represents an attractive market opportunity for storage companies.**
- **Smart grid deployment has matured across many provinces such as Ontario, Quebec and British Columbia with broad deployment of AMI and new rate options, but deployment of micro grid solutions, demand response, and storage is still nascent.**
- **Northern territories present an opportunity to provide clean power solutions in place of expensive and dirty diesel generators but the commercial gain is limited because of small and remote nature of these communities.**

Environmental Sustainability and Policy

Key Environmental Sustainability and Policy Indicators	
Fine Particulate Matter PM2.5 Pollution[76]	1,606 kilotonnes
GHG Emission Reduction Target 2050[77]	80% below 2005 levels
GHG Intensity from Electricity[78]	140g GHG/kWh

CLIMATE TARGETS AND POLICY

Although Canada has national climate targets, provinces independently set targets and actions to achieve the national target. In 2017, the federal government announced a new target to reduce greenhouse gas (GHG) emissions by 80% by 2050, relative to 2005 levels, as part of its renewal and expansion of greening government operations.[79] According to a recent report by the Canadian auditors-general, Canada will not meet their 2020 targets and will require substantial efforts and actions beyond those currently planned in order to meet their commitment of 40% by 2030.[80] Only 5 of 13 provinces and territories have targets for 2020, of which only New Brunswick and Nova Scotia are on track to meet goals with domestic reductions. Quebec and Ontario have a cap-and-trade program that includes emissions reductions from outside of the province, and the program is currently under review in Ontario. Consequently, the federal government is introducing a carbon tax, which will apply to provinces that don't have carbon-reduction schemes in place.[81] Changes to climate policies, such as new carbon taxes, will affect businesses, but may also present opportunities for cleantech and clean energy solutions. Revenues from Quebec's cap-and-trade go to the Quebec Green Fund, which are earmarked for financing GHG reduction initiatives outlined in the 2013-2020 Climate Change Action Plan.[82]



CLEAN ENERGY POLICIES

Energy falls under provincial purview. The federal government has indicated its intention to support deployment of renewable generation across the country through the Pan-Canadian Framework on Clean Growth and Climate Change–Canada's climate framework, first established in 2016. However, it is really the provincial level where renewable energy (RE) policies and incentives take place.

Most provinces have set a RE target, each using different strategies (see Figure 12 below for a summary of renewable targets and policies). For example, 47% of Alberta's generation is coal-fired. In 2015, the province announced plans to phase out coal-fired generation by 2030, replacing one third of generation capacity with renewables. In comparison, New Brunswick plans to meet 40% of energy demands with renewables by 2020. The province plans to meet this goal through eligible renewable energy imports from other provinces and buying power from local producers and customers.[83] Nova Scotia has the same renewable targets, but has implemented feed-in tariffs (FIT) and a commercial renewables program among other initiatives.[84]

Provinces adopted FIT programs to accelerate the adoption of renewable energy in the early 2000s. Under Ontario's *Green Energy Act* and *Economy Act*, the province introduced its FIT program in 2009, which was one of North America's first comprehensive guaranteed pricing structures for renewable generation under long-term contracts. According to the Ontario Ministry of Energy, Northern Development and Mines, the *Green Energy Act* and FIT program have created more than 20,000 jobs, $20 billion of investment, and enough electricity generation to power 1.8 million homes.[85]

Every province has also implemented a net-metering regulation. Net metering frameworks give businesses and consumers more opportunities to generate and store renewable electricity.

76 Government of Canada
77 Bloomberg New Energy Finance
78 NEB - Canada's Renewable Power Landscape 2017
79 Government of Canada sets ambitious GHG reduction targets for federal operations
80 Most provinces not on track to meet emission-reduction targets: auditors
81 Understanding the federal government's changes to its carbon tax plan, and why you should care
82 A brief look at the Quebec cap-and-trade system for emissions
83 Canada's Renewable Power Landscape 2016 – Energy Market Analysis: New Brunswick
84 Canada's Renewable Power Landscape 2016 – Energy Market Analysis: Nova Scotia
85 Ontario energy minister admits mistake with green energy program

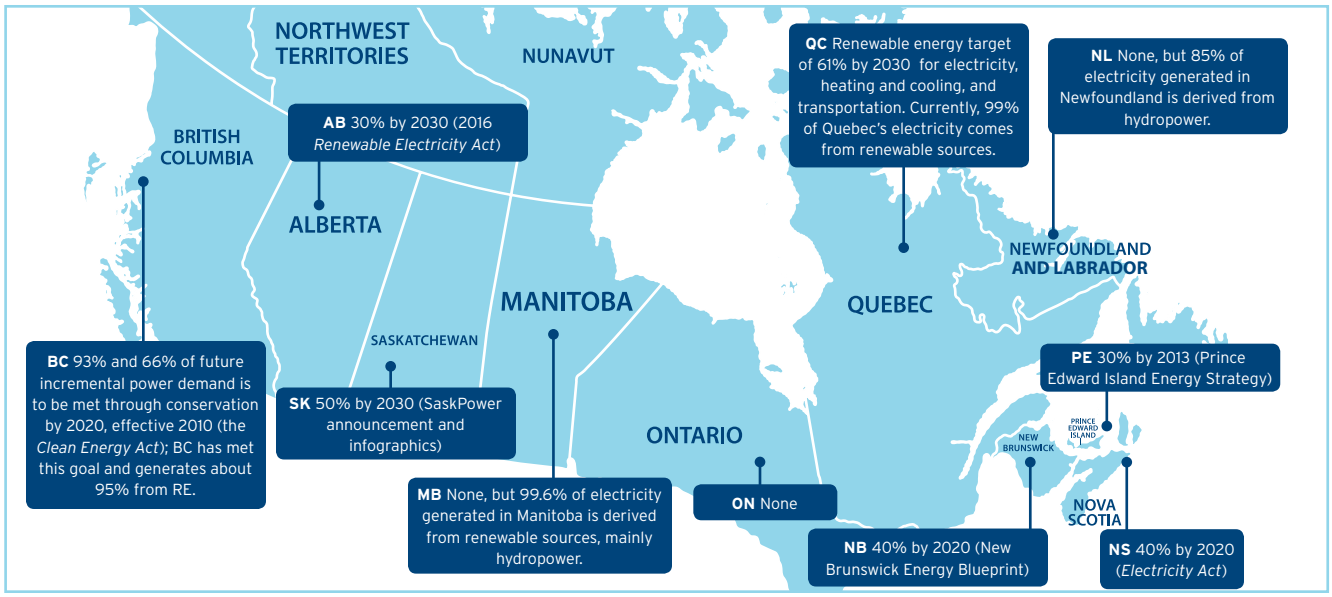


Figure 12: List of provinces with a renewable energy target (renewable portfolio standard)[86]

Table 2.
Provincial FiT and Net-Metering Policies

Provincial Policy	Feed-in Tariffs	Net-metering
British Columbia		Yes
Alberta		Yes
Manitoba		Yes
Saskatchewan		Yes
Ontario	Yes	Yes
Quebec		Yes
Nova Scotia	Yes	Yes
Prince Edward Island	Yes	Yes
New Brunswick		Yes
Newfoundland and Labrador		Yes

CLEAN ENERGY SUBSIDIES AND TAX INCENTIVES

Canada has a number of tax incentives to encourage investments in qualifying clean energy and conservation projects. Both the accelerated capital cost allowance (CCA) and Canadian renewable conservation expense (CRCE) enables tax deferrals for equipment and development-related expenses, respectively, while the Atlantic investment tax credit provides a 10% credit on the cost of prescribed properties.[87]

FITs were popular in the early 2000s and offered stable pricing under long-term contracts for renewable energy projects. As the price of renewables has come down, FIT programs have been phased out or cancelled. However, to continue to action on lowering carbon emissions, governments are spurring the development and deployment of cleantech through programs and funding (see Table 3 and Section 5. Cleantech Business Environment).

Table 3 summarizes the types of government support available to cleantech companies, which includes financial incentives (FI), public financing (PF), and regulatory policy (RP).

Table 3.
Measuring Government Support for Cleantech

Indicator	Canada
National strategy for renewables	Sub-national
RP: FIT	Sub-national
RP: Utility quota obligation	Sub-national
RP: Net metering	Sub-national
RP: Obligation and mandate	Yes
RP: Tradable renewable energy certificates	No
FI: Capital subsidy, grant or rebate	Sub-national
FI: Tax incentives	Yes
FI: Energy production payment	No
PF: Public investment, loans	Yes
PF: Public competitive bidding	Sub-national

86 *Advanced Energy Centre - MaRS Discovery District*
87 *Income Tax Folio S3-F8-C2, Tax Incentives for Clean Energy Equipment*

CLEAN ENERGY PROGRAMS

Canada offers a number of renewable and clean energy programs at all levels of government. Programs support initiatives across conservation, energy efficiency, smart buildings, smart grids, transportation, and clean energy for rural and remote communities. At the federal level, Natural Resources Canada (NRCan) is primarily responsible for energy-related programs. In 2017, NRCan launched a $155 million Clean Growth Program that aims to build a clean growth economy alongside provinces and territories with a focus on reducing GHG emissions, improving waste management, advanced materials, energy efficiency, and water reduction.[88]

Because of differences in electricity systems and energy access, the Canadian government also has a number of energy programs that specifically focus on rural and remote communities.[89] Rural and remote communities not connected to the electricity grid rely on costly and GHG-emitting diesel energy. Consequently, there are programs in place to reduce reliance on diesel and support communities in transitioning to clean energy. This includes NRCan's Clean Energy for Rural and Remote Communities Program, which was launched in early 2018. The program has two tracks for community building and technology demonstration and deployment.[90] Under the latter track, there are streams to address biomass heating, to create innovative demonstrations to reduce diesel use, and to deploy renewable energy. Innovative demonstrations include novel renewable energy, energy efficiency, energy storage, and smart-grid technologies and applications.

CLEANTECH PROGRAMS

As part of the Cleantech Growth Program mentioned above, the Canadian government has put together the Clean Growth Hub, which is a dedicated cleantech resource focused on supporting companies and projects, coordinating programs, and tracking results.[91] The Clean Growth Hub provides a summary of cleantech programs across various stages, including R&D and demonstrations, growth, exports, and adoption.

Canada also has a strong record of supporting small and medium-sized enterprises through their funding programs, Sustainable Development Technology Canada (SDTC) and the Industrial Research Assistance Program (IRAP).[92] Export Development Canada (EDC) and the Canadian Trade Commissioner Service (TCS) also offer programs and assistance to support Canadian companies looking to export globally. These programs and organizations are valuable resources for companies looking to tap into regional networks and connect with the right people and/or organizations.

88 NRCan - Clean Growth Program
89 Reducing diesel energy in rural and remote communities
90 Green Infrastructure programs
91 Clean Growth Hub
92 Other Federal Funding Sources

SMART GRID AND ENERGY STORAGE PROGRAMS

Canada is making efforts to invest more in smart grids and energy storage, indicating both support in these areas as well as resources for relevant research and businesses. As part of funding in Budget 2017, the federal government invested $100 million in utility-led smart grid projects across Canada and is supporting Mission Innovation's Smart Grids Innovation Challenge.[93, 94]

At the provincial level, many provinces have installed smart meters and are investing in research labs focused on smart grids and related technologies.[95] Ontario is recognized internationally for its leadership in developing and deploying smart grid technologies.[96] The Ontario Ministry of Energy, Northern Development and Mines has a dedicated Smart Grid Fund (SGF) to support innovators in developing new technologies: proactive consumers, data analytics, EV integration, energy storage, grid automation, micro grids, and building local capacity. Since 2011, the SGF has funded $200 million for 45 projects.[97] Ontario also launched a province-wide Green Button initiative in 2012 to standardize and provide customers with timely energy data, which has since been mandated and is expected to come into effect with compliance by electricity and natural gas utilities by 2020.[98] Accordingly, Ontario has a more sophisticated market for smart grid technologies, but opportunities are emerging in other provinces as they look to make their grids smarter. Notably, a number of provinces, including British Columbia and Saskatchewan, have had issues with smart meters in recent years, recalling hardware and pausing programs.

The National Research Council (NRC) and NRCan's ENERGY Innovation Program initiated a multi-year (2016–2021) energy storage (ES) road map for Canada.[99] The project aims to understand the market potential, roadblocks and actions required at the planning, procurement, rate treatment, interconnection, market, and regulation steps for adopting ES technologies in Canada by 2021. In addition, the NRC runs an Energy Storage for Grid Security and Modernization program, which aims to address obstacles in adopting ES technologies, such as durability, cost, and risk. The program brings together key stakeholders to share knowledge and expertise, as well as offer a range of research services and facilities on a fee-for-service basis.[100]

Provincially, Alberta and Ontario have been making efforts to expand ES deployment. In 2014, Alberta Innovates issued a call-for-proposals and announced $1.5 million in funding for ES projects.[101] On behalf of the province, the AESO recently undertook an assessment of the potential benefits of dispatchable renewables and storage as it aims to meet its renewable targets. Following this, the AESO will propose new regulations, policies, and programs to the

93 Smart Grid Program
94 Mission Innovation
95 Faculty of Engineering, University of Alberta
96 Canmet Smart Grid in Canada, 2014
97 Projects funded by the Smart Grid Fund
98 Regulatory Proposal for Province-Wide Implementation of Green Button
99 Canadian Energy Storage Roadmap
100 Energy Storage for Grid Security and Modernization program
101 AI-EES Invests $1.5 Million in Game-Changing Energy Storage Technology Projects

Government of Alberta. In contrast, the IESO first procured energy storage resources in 2012 and initiated a competitive energy storage procurement framework in 2014 for 50 MW.[102] The Long-Term Energy Plan, Ontario's 20-year road map, noted the legislative barriers that are disadvantageous to ES development.[103] Accordingly, the IESO, OEB, and province have committed toward addressing some of these challenges through updated regulations and new initiatives.[104] However, it is unclear how the new Ontario government and policies may change moving forward. Despite government and policy changes, there are opportunities for ES projects in both Alberta and Ontario given the better understanding and acceptance of storage technologies through the abovementioned programs.

Other Cleantech Supporting Organizations

- Leading cleantech industry organizations across Canada started the CanadaCleantech Alliance in 2016 to "identify and crowdsource issues, obtain guidance, and mobilize change" for key stakeholders in the cleantech sector.[105] Co-founding groups include the Alberta Clean Technology Industry Alliance (ACTia), BC Cleantech CEO Alliance, Ecotech Quebec, and MaRS Cleantech in Ontario. The alliance has since expanded to more than 200 cleantech CEOs and provincial/territorial organizations.
- SmartGrid Canada[106] and Energy Storage Canada[107] are other national organizations advancing opportunities and market opportunities for smart grid and energy storage, respectively.

102 *IESO, Energy Storage*
103 *2017 Long-Term Energy Plan: Delivering fairness and choice*
104 *2018: Energy Storage Developments in the Last Twelve Months*

105 *Canada Cleantech Alliance*
106 *Smart Grid Canada*
107 *Energy Storage Canada*

Key Findings: Environmental Sustainability and Policy

- Canada sets national climate targets, but policy and actions occur at the provincial level. There will be opportunities as federal and provincial governments establish carbon-based policies and funding programs.
- Energy policies and decisions fall under the jurisdiction of provincial governments. Consequently, they vary widely across the country.
- Recent federal budgets have announced a number of new programs to spur cleantech development and deployment, including initiatives focused on smart grid and energy storage.
- Canada has a strong cleantech sector with many support programs for cleantech companies.

Cleantech Business Environment

Key Cleantech Business Environment Indicators	
Ease of doing business ranking[108] (2017)	18th
Foreign Direct Investment[108] (2017) (USD)	$27,525 million
Political Stability[109] (Score -2.5 to 2.5)	1.24
Regulatory Quality[109] (Score -2.5 to 2.5)	1.74
Rule of Law[109] (Score -2.5 to 2.5)	1.84

Table 4
Ease of Doing Business Indicators[110]

Topics	**2018 Rank** (out of 190)
Overall	18
Starting a Business	2
Dealing with Construction Permits	54
Getting Electricity	105
Registering Property	33
Getting Credit	12
Protecting Minority Investors	8
Paying Taxes	16
Trading across Borders	46
Enforcing Contracts	114
Resolving Insolvency	11

QUALITY OF BUSINESS ENVIRONMENT

Overall, Canada has an enabling business environment for cleantech companies. It has a market that is open for business, investment, and trade, and benefits from a reliable financial system, low taxes and business costs, and a federal government that is supportive of a clean growth economy.

The ease of doing business index ranks countries on how the regulatory environment is conducive to business operations; a higher rank means that the regulations are simpler. The World Economic Forum's Global Competitiveness Report ranks Canada as 14 out of 137 for global competitiveness.[111] In the same report, Canada's banking system was ranked second globally and remains one of the world's safest having been ranked first place for eight consecutive years. Canada is also one of the most tax competitive countries for businesses globally in all sectors based on KPMG research.[112,113] Companies operating in Canada have preferential access to more than 40 countries, representing over 1.2 billion consumers and US$43.6 trillion.[114] Canada also has access to top talent and a dynamic workforce.

Canada's talent pool is ranked first of 34 OCED countries, with more than half of its population aged 25-64 attaining a tertiary-level education.[115] Challenges that have been noted relate to the macroeconomic environment (e.g. interest rates, government debt), where Canada fell six places in the Global Competitiveness Report.

The Global Entrepreneurship Index ranks Canada's entrepreneurship ecosystem as second in the G7 and third among 137 countries.[116] Notably, Toronto, has been emerging as a major tech hub, comparable to cities like San Francisco, Seattle, and Washington (see Table 4). In recent news, Toronto has created more jobs than the three American cities combined.[117] According to CBRE Group's Annual Survey, Toronto has created 28,900 tech jobs in 2017, increasing 52% in the last five years. Toronto also ranked 4th out of 50 North American cities in terms of "tech talent," which measures talent supply, concentration, education, cost, and outlooks for job and rent growth of offices and apartments.

CANADA'S GROWING TECH SECTOR

Canada has a growing technology sector, with employment and output growth exceeding 5%.[118] Despite Statistics Canada reporting that foreign direct investment dropped 26% in 2017 to $33.8 billion,[119] there is significant investment activity happening in the tech sector. Toronto attracted over $1.4 billion in international investment, ranging from global tech giants to local startups, in September, 2018 alone.[120]

- Big tech companies, Microsoft, Shopify, Amazon, are expanding their Canadian offices and/or looking to locate their headquarters in Canada.[121,122,123,124]
- A unit of Alphabet (Google's parent company), Sidewalk Labs has partnered with Waterfront Toronto to develop a smart city community – "an urban district that is built around information technology and uses data."[125]
- Uber Technologies Inc. will be investing over $200 million in Toronto to expand operations and open an engineering lab.[126]

CLEANTECH INNOVATION

108 World Bank Group
109 World Bank Worldwide Governance Indicators (2016)
110 The World Bank - Doing Business in Canada
111 What happened to Canada's economic competitiveness?
112 KPMG, Focus on Tax, 2016
113 Finance Canada
114 IMF World Economic Outlook, April 2018.
115 OECD, Education at a Glance, September 2017.
116 Global Entrepreneurship Index, 2018.
117 Who Just Beat the Bay Area in Tech Jobs? Toronto
118 Tech boom a reason to be bullish on the Canadian economy
119 Foreign Direct Investment in Canada Plunges on Oil Exodus
120 September brought over $1.4 billion in international investment for Toronto's tech ecosystem
121 Microsoft Announces New Toronto Headquarters and $570 Million in Investments
122 Shopify will invest up to $500-million in new Toronto office
123 Toronto only Canadian city to make shortlist for Amazon's new headquarters HQ2
124 Amazon bringing 3,000 new tech jobs to Vancouver
125 Google's Sidewalk Labs signs deal for 'smart city' makeover of Toronto's waterfront
126 Lane change: Uber boosts Toronto R&D to speed up strategic shift

According to the Global Cleantech Innovation Index 2017, Canada ranked first in the G20 and fourth globally, with strong scores for emerging clean technology.[127] Canada has a strong cleantech sector and is poised as a leading growth industry. However, research shows that Canada does fairly well at research and development, but poorly at the commercialization and deployment stages, which are where most of the wealth and jobs are created, and makes them vulnerable for foreign takeover.[128] Furthermore, competition is intensifying as other countries look to grow their cleantech sectors. Canada currently owns 1.4% of the global cleantech market, but that has fallen 12% over the last decade.[129]

Canada's Cleantech Sector[130]

Canada's cleantech industry contributed **$59.3** billion to GDP in 2016.

Canada's cleantech industry employs an estimated **274,000** Canadians.

Nearly 80% of Canadian cleantech firms are exporters, and together they generated **$11.5** billion in exports in 2016.

Public and private sectors in Canada are working towards addressing these challenges. All levels of the Canadian government have begun to make progress on clean innovation policies. Examples include the Pan-Canadian Framework on Clean Growth and Climate Change and recent federal budgets that outline a series of new policies, programs, and investments aimed at supporting low-carbon innovation.[131]

CLEAN ENERGY INVESTMENT

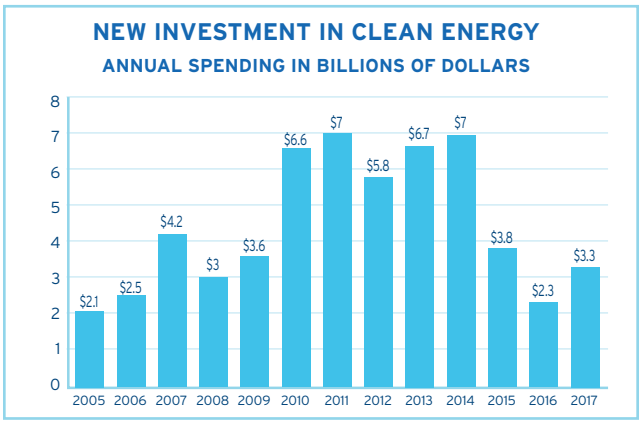


Figure 13: New Investment in Clean Energy[132]

Canada received $3.3 billion in clean energy investments last year, up from US$2.3 billion in the previous year.[132] Investments are low compared to its peak in 2010–2015, which were spurred by a number provincial and federal renewable energy programs that have since been wound down. In general, Canada has a very supportive federal environment that offers investments in the form of grants, loans, and access to growth capital. Recent federal budgets have announced increased funding in cleantech as shown in Figure 13.

Although Canada is attracting more venture capitalist (VC) investment, the average investments and round size are about half of that in the US based on relative economy sizes. Canada also has a gap in VC funding for later-staged companies. As such, Budget 2017 announced the Venture Capital Catalyst Initiative, which will provide Business Development Canada with $400 million to invest in growth stage companies, which expects to leverage more than $1 billion in the private sector.[129]

There are funding and investment opportunities for cleantech companies, but these may be more favourable to Canadian-based companies as many are attributed to government programs. Notably, there may be additional opportunities in Alberta as the province opened up bids to the private sector to install 600 MW and 700 MW in 2017 and 2018, respectively through its Renewable Electricity Program.[133]

127 *The Global Cleantech Innovation Index, 2017*
128 *Canada's clean tech sector falling behind competition, says report*
129 *Canada's Next Edge: Why Clean Innovation is Critical to Canada's Economy and How We Get It Right*
130 *The Generation Energy Council - Canada's Energy Transition*
131 *Accelerating Clean Innovation in Canada*
132 *Bloomberg New Energy Finance*
133 *AESO, Renewable Electricity Program*

INVESTMENT IN CANADIAN CLEANTECH[134]

$12M CLEAN GROWTH HUB

Whole-of-government focal point for clean technology program coordination and stakeholder engagement.

$75M IMPACT CANADA CLEAN TECH

Innovative funding approaches (e.g., prizes, co-creation) to solving Canada's big challenges.

$2B LOW-CARBON ECONOMY FUND

Will leverage investments in projects that will generate clean growth and reduce greenhouse gas emissions toward meeting or exceeding commitments under the Paris Agreement

$300M IMPACT CANADA SMART CITIES

Innovative funding approaches (e.g. prizes, co-creation) targeted at communities to solve tough problems

$1.26B STRATEGIC INNOVATION FUND

Supports firms of all sizes across all sectors through four streams: R&D; growth and expansion; attracting and retaining large scale investments; and advanced industrial research

$1.4B NEW FUNDING

For equity financing, growth capital and project financing for promising clean technology firms through the Business Development Bank of Canada (BDC) and Export Development Canada (EDC)

$429M CLEAN TECHNOLOGY IN NATURAL RESOURCES, CLEAN ENERGY AND CLEAN TRANSPORTATION INVESTMENTS

Support for clean technology RD&D in national laboratories and with external participants, including in the energy, mining, forestry, agriculture and fisheries/ aquaculture sectors.

$400M SUSTAINABLE DEVELOPMENT TECHNOLOGY CANADA (SDTC)

Recapitalization of the SD Tech Fund that supports the development and demonstration of pre- commercial clean technology.

$21.9B INVESTMENTS IN GREEN INFRASTRUCTURE

Includes $822M for clean energy infrastructure across five streams: smart grids, renewables, reducing diesel in rural and remote communities, electric vehicle infrastructure, and energy efficient buildings

134 *Clean Technology - Canada's Competitive Advantages*

RECENT CLEANTECH INVESTMENT SUCCESSES 2017/2018

ecobee

ECOBEE
$125M
Amazon, Relay Ventures, Thomvest, BDC and CDBQ

MTI Metamaterial Technologies Inc. Mastering Light

METAMATERIAL TECHNOLOGIES
$22M
Radar Capital, Lockheed Martin, SDTC, ACOA

GHGSat GLOBAL EMISSIONS MONITORING

GHGSAT
US$10M
OGCI Climate Investments

CARBON CURE

CARBONCURE
US$11M
Gates & Bezos-backed Breakthrough Energy Ventures

minesense

MINESENSE
$42.5M
Prelude Ventures, Caterpillar, and ABB Technology Ventures

MIREXUS NANO BY NATURE

MIREXUS BIOTECHNOLOGIES
$12M
led by GEL Canada

xpertSea

XPERTSEA
$10M
Obvious Ventures, Aqua-Spark and Real Ventures

CANVASS

CANVASS ANALYTICS
US$5M
led by Gradient Ventures, the Google AI fund

Canadian cleantech companies are seeing traction with the investment community given its strong reputation in the sector. Notably in energy innovation, ecobee, best known for its smart thermostat, raised US$61 million in its latest series C, with funding from Amazon. Since the company was founded in 2007, it has raised over $146 million, earned 35% of the smart thermostat market share competing with the likes of Honeywell and Google, and has partnered with tech giants, Amazon and Apple, to distribute its product.

INTERNATIONAL TRADE

Trade is significant to Canada's economy as it represents 64% of the country's GDP.[135] Canada has 13 free trade agreements, of which the North America Free Trade Agreement (NAFTA) with the US and Mexico is the most important. In 2016, the US received 73% of Canada's total exports, valued at $454 million.[136] Canada was also noted as the top market for 32 of 50 US states. Recently, Canada, the US, and Mexico have announced a new trilateral trade deal, the United States-Mexico-Canada Agreement (USMCA), which will be ratified by each respective government in the coming months.[137] In late 2017, Canada signed the Canada-EU Comprehensive Economic and Trade Agreement (CETA), which is the biggest agreement since NAFTA. Since coming into effect, CETA has increased trade by 10%, or $100 billion.[138]

Positive international trade relations are particularly important as 80% of Canadian cleantech companies export to other countries. According to EDC, the EU represents a cleantech market of $148 billion, China's total cleantech spending could reach $2 trillion by 2020, and India is looking to triple renewable capacity by 2022. Given Canada's strong cleantech reputation, there are significant international opportunities as countries look to Canadian solutions.

Key Findings: Cleantech Business Environment

- **Canada has a conducive business environment for cleantech companies with low taxes, a reliable financial system, and access to top talent.**
- **Canada is seeing growth in its technology sector, attracting global tech companies and increasing foreign investments.**
- **Canada has a strong cleantech sector, ranking first in the G20 and fourth globally.**
- **Investments in clean energy are low compared to its peak in 2010–2015, noting that peak investments were attributed to provincial and federal renewable energy programs that have been since wound down.**
- **Canada is attracting VC funding, but average investments and round size are considered small given the size of the country's economy, and there is a gap for later-staged companies.**
- **Canada is well-positioned in global markets given its strong cleantech reputation and positive international relationships.**

135 *The World Bank, Trade (% of GDP)*
136 *EDC, What are the benefits of Canada's trade agreements?*
137 *Canada, US have reached a NAFTA deal – now called the USMCA*
138 *Canada and EU celebrate one year of free trade despite lingering opposition*

Appendix

INSTITUTIONS IN THE ELECTRICITY SECTOR

Organisation	Description	Website
Alberta Clean Technology Industry Alliance (ACTIA)	ACTia is a multi-stakeholder, province-wide and industry-focused group working to support Albertans developing clean technology ("cleantech") – products and services that improve economic performance and reduce environmental footprint	https://www.actia.ca
Alberta Electricity System Operator (AESO)	AESO manages and operates the provincial power grid.	https://www.aeso.ca
BC Cleantech CEO Alliance	The BC Cleantech CEO Alliance is a group of innovative entrepreneurs and leaders who are committed to achieving the economic and environmental benefits of resource efficiency through the commercialization of advanced technologies in clean energy, water, agriculture and built environment.	https://bccleantech.com
Business Development Canada (BDC)	BDC is a federal Crown corporation wholly owned by the Government of Canada. Its mandate is to help create and develop Canadian businesses through financing, growth and transition capital, venture capital and advisory services, with a focus on small and medium-sized enterprises.	www.bdc.ca
Canadian Electricity Association (CEA)	CEA is the national forum and voice of the evolving electricity business in Canada. The Association contributes to the regional, national, and international success of its members.	https://electricity.ca
Canadian Wind Energy Association (CanWEA)	CanWEA is the voice of Canada's wind energy industry, actively promoting the responsible and sustainable growth of wind energy.	https://canwea.ca
Clean Growth Hub	The Clean Growth Hub is a Canadian Government focal point for clean technology focused on supporting companies and projects, coordinating programs and tracking results.	https://www.ic.gc.ca
Cleantech Canada Alliance	CanadaCleantech Alliance coordinates regional clusters, associations and hubs to identify and crowdsource issues, obtain guidance and mobilize for change.	https://www.canadacleantechalliance.ca
Ecotech Quebec	Ecotech Québec brings together all of Québec's industry stakeholders from across the province, including innovative companies, R&D and technology transfer centres, major end-user companies, the financial community, education and training institutions, labour confederations and associations working in the clean technology sector.	http://www.ecotechquebec.com
Energy Storage Canada (ESC)	ESC is an industry association in Canada that focuses on advancing opportunities and building the market for energy storage.	http://energystorage-canada.org
Export Development Canada (EDC)	EDC is Canada's export credit agency. They support and develop Canada's export trade by helping Canadian companies respond to international business opportunities. They are a Crown corporation that operates at arm's length from the Government.	https://www.edc.ca
Impact Canada	Announced in Budget 2017, the Impact Canada Initiative is a Government of Canada-wide effort that will help departments accelerate the adoption of innovative funding approaches to deliver meaningful results to Canadians.	https://impact.canada.ca
Independent Electricity System Operator (Ontario) (IESO)	IESO is the Crown corporation responsible for operating the electricity market and directing the operation of the bulk electrical system in the province of Ontario	http://www.ieso.ca

Organisation	Description	Website
Industrial Research Assistance Program (IRAP)	The National Research Council-Industrial Research Assistance Program (NRC-IRAP) is Canada's premier innovation assistance program for small and medium-sized enterprises (SMEs).	https://www.nrc-cnrc.gc.ca/eng/irap/
MaRS Cleantech	MaRS's Cleantech Venture Services team works with high-growth ventures that are addressing a range of complex global challenges—from improving energy storage, generation and distribution to defining the future of transportation.	https://www.marsdd.com/our-sectors/cleantech/
National Energy Board (NEB)	The NEB is an independent economic regulatory agency created in 1959 by the Government of Canada to oversee "international and inter-provincial aspects of the oil, gas and electric utility industries."	https://www.neb-one.gc.ca
North American Energy Reliability Corporation (NERC)	North American Electric Reliability Corporation (NERC) is an institution that oversees and regulates the reliability of the North American electrical grids.	https://www.nerc.com
National Research Council (NRC)	NRC is the Government of Canada's largest research organization supporting industrial innovation, the advancement of knowledge and technology development, and fulfilling government mandates.	https://www.nrc-cnrc.gc.ca/eng/
Natural Resources Canada (NRCan)	NRCan is the ministry of the government of Canada responsible for natural resources, energy, minerals and metals, forests, earth sciences, mapping and remote sensing.	https://www.nrcan.gc.ca/home
Ontario Energy Board (OEB)	The OEB regulates the province's electricity and natural gas sectors in the public interest.	https://www.oeb.ca
SmartGrid Canada	SmartGrid Canada is a national organization dedicated to promoting a more modern and efficient electricity grid for the benefit of all Canadians.	www.sgcanada.org/
Sustainable Development Technology Canada (SDTC)	SDTC is a foundation created by the Government of Canada to support Canadian companies with the potential to become world leaders in their efforts to develop and demonstrate new environmental technologies that address climate change, clean air, clean water and clean soil.	https://www.sdtc.ca/en/
Trade Commissioner Service (TCS)	TCS helps companies navigate international markets.	http://www.tradecommissioner.gc.ca/trade_commissioners-delegues_commerciaux/index.aspx?lang=eng

marsdd.com/aec

The Advanced Energy Centre's Going Global Series is developed in line with its mission to foster the adoption of innovative energy technologies in Ontario and Canada and to leverage those successes and experiences into international markets.

The information provided in this report is presented in summary form, is general in nature, current only as of the date of publication and is provided for informational purposes only.

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