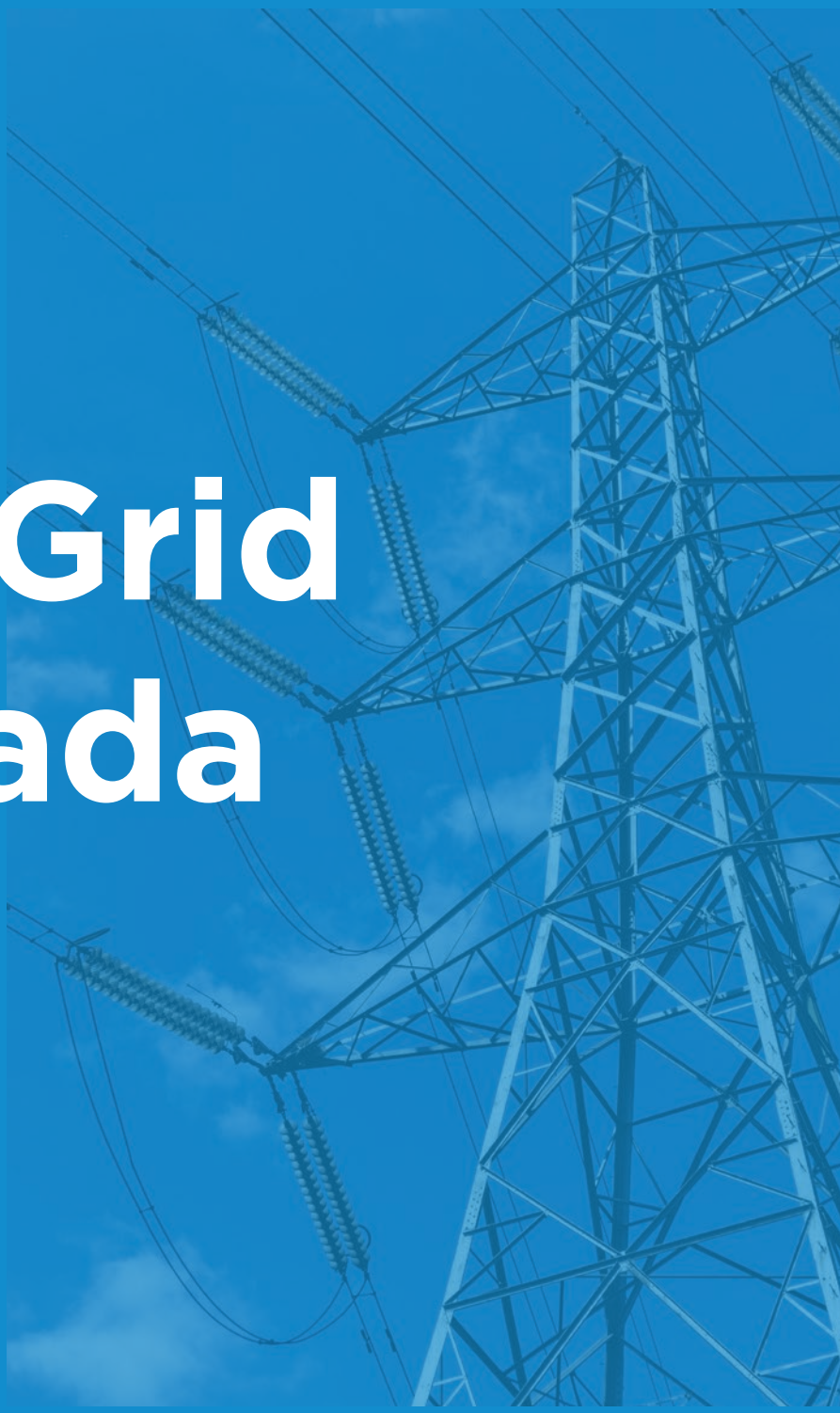
SMART GRID
INNOVATION NETWORK



Smart Grid in Canada

2020

About Us

The Smart Grid Innovation Network supports Canada's clean energy transition by advocating for the smart energy sector. Through education, policy, business model innovation, and smart technology, we are building a clean energy future for the benefit of all Canadians.

Author: David Beauvais, P.Eng.
For more information and questions about this report, please contact SGIN at **info@sgin.ca**.

Smart Grid in Canada

2020 EDITION

Smart energy technologies are enabling new ways to generate, distribute, and use electricity. It changes how Canadian utilities, communities, and companies collaborate toward a common goal: Transitioning to a low-carbon energy system.

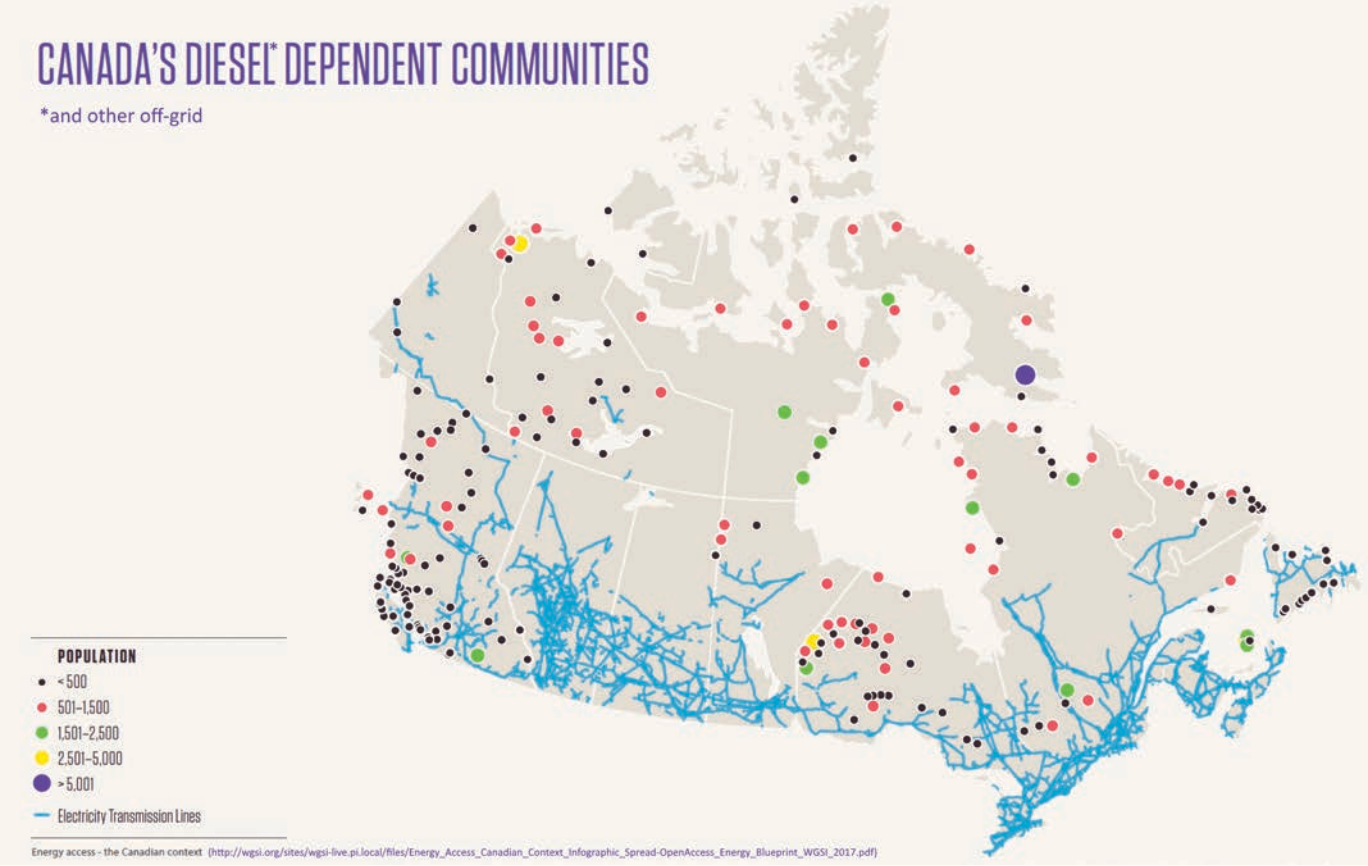
As the second-largest producer of hydropower in the world, the Canadian industry has always been recognized for its leadership in large construction projects and in the operation of transmission networks. While this sector is very alive, a nascent industry focused on distributed solutions is now growing and geared to meet the challenge of decarbonizing our economy. Together, the large, centralized generation and the local solutions are coming together to shape a more sustainable energy future for this country and for the planet.

This document provides an overview of the smart grid sector in 2020. It provides an outline of the status of smart grid deployment, a market review, the key drivers, and the role that smart grid will play to meet Canada's carbon neutrality objective for 2050.

Electricity in Canada

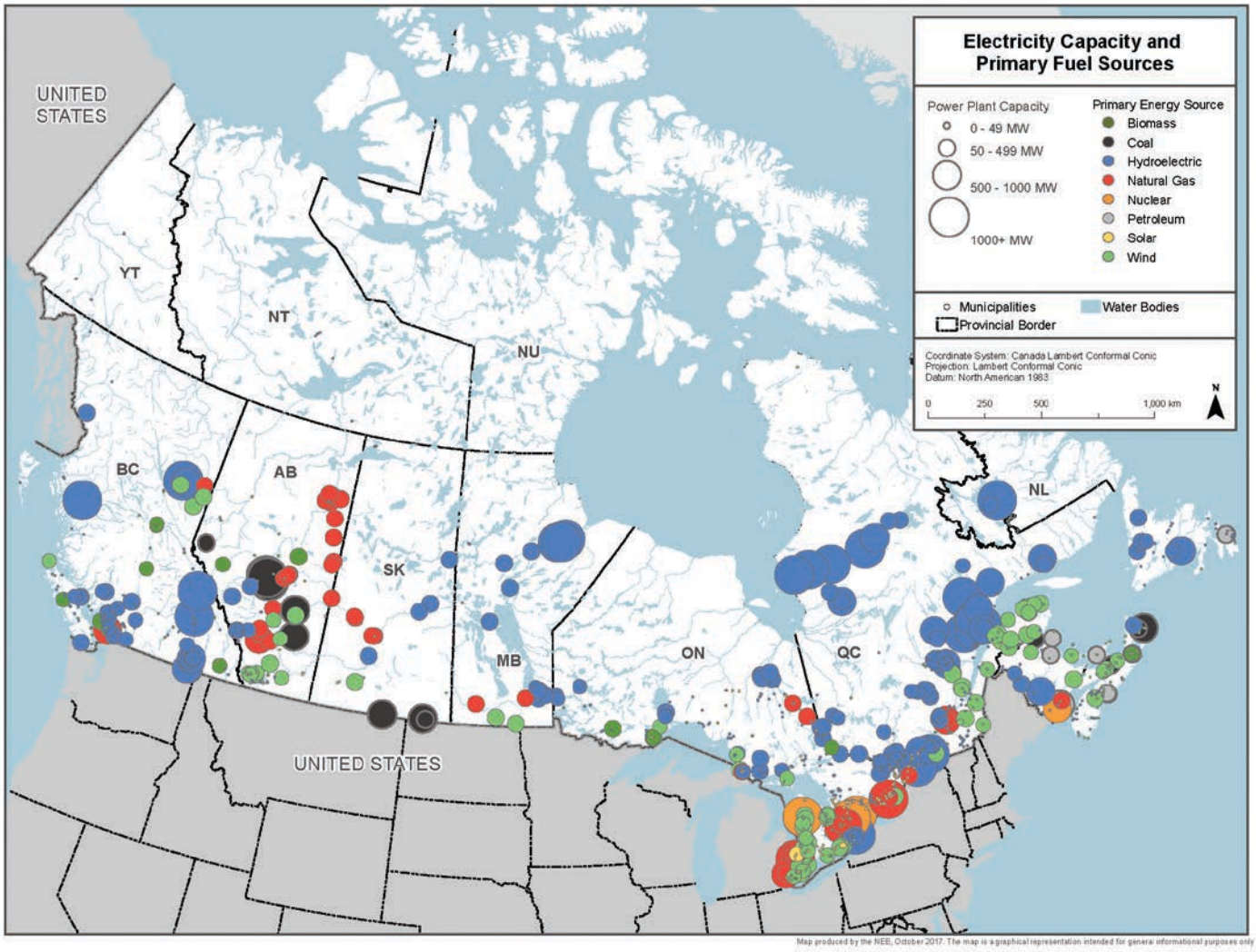
OVERVIEW

In Canada, the electricity markets and the environmental issues are a shared jurisdiction between the provinces (or territories), and the federal government. The ten provinces are connected to the North American electricity system and the three Canadian territories (Yukon, Nunavut and Northwest Territories) have more than 250 diesel-powered and remote microgrids.



Source: Waterloo Global Science Initiative (WGSI)

Electricity in Canada



Source: Canada Energy Regulator (CER)

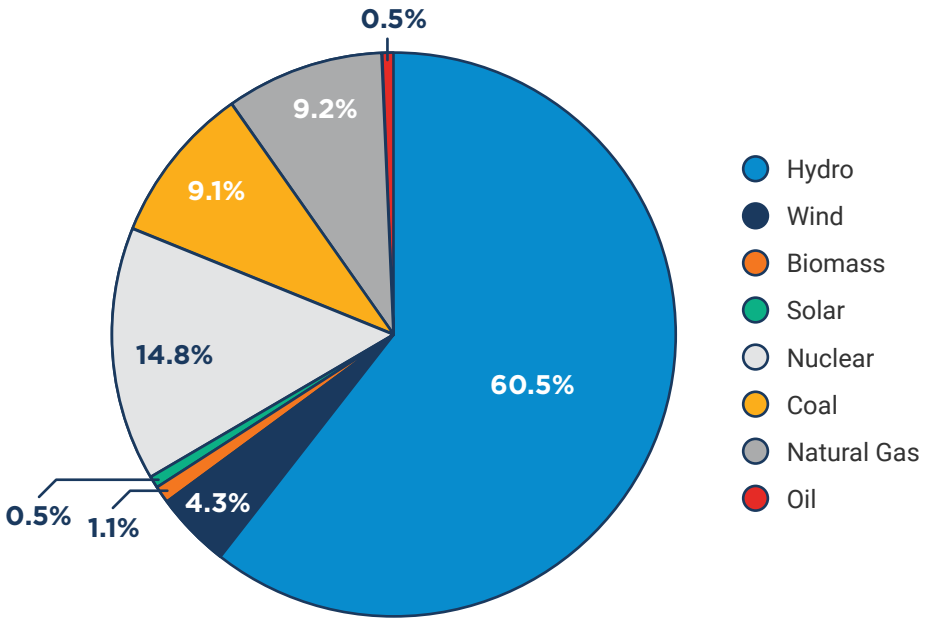
Northern Canada Remote grids are primarily diesel-powered and heat is being provided using heating oil furnaces.

In southern parts of Canada, hydroelectricity contributes 60% of the electricity supply mix, with 15% from nuclear, 9% each for coal and natural gas. Canadian homes are heated primarily using natural gas (48%) and electricity (27%). The cost of electricity and the proportion of renewable energy is very different across provinces, as presented in the following summary table:

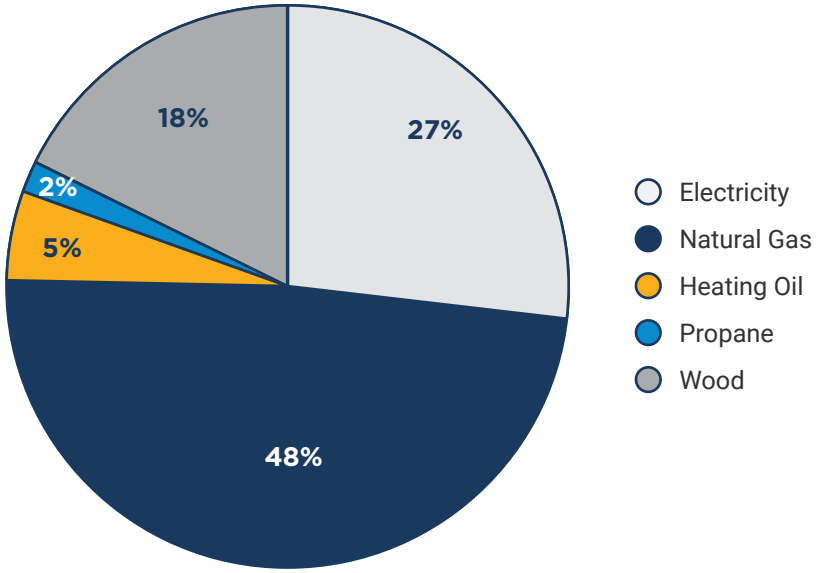
Province	Average Residential Cost in c/kWh	Renewable Penetration
AB	14.8	8.3%
BC	11.5	97.8%
MB	9.6	99.9%
NB	13.4	31.4%
NL	13.6	95.5%
NS	16.9	24.6%
NT	38.7	73.9%
NU	37.5	0.0%
ON	10.3	36.9%
PEI	16.8	99.5%
QC	7.3	99.7%
SK	16.5	16%
YK	14.5	94%

Table: Cost of electricity and renewable energy penetration per Canadian province.
Source: Canada Energy Regulator (CER) Hydro-Quebec
www.energyhub.org

Electricity Generation per resource in Canada in 2017



Resources for space heating for residential sector in Canada in 2017



Source: Canada Energy Regulator (CER)

While the electricity regulation is a shared jurisdiction, the main decisions impacting the smart grid development are mostly made by provincial jurisdictions. Each province or territory has the right to decide on the structure of its electricity wholesale or consumer market, to set the electricity cost, to adopt the building code, and the labor laws. The provincial legislators determine the overall utility business design within their region. Typical models include a single vertically integrated utility or an Independent System Operator with an electricity market with regionally operated utilities. In Canada, the vertically integrated model is dominant, with only two provinces opening, at various degrees, their wholesale or retail electricity market to competition.

Electricity market structures

In Alberta and Ontario, the electricity market is competitive, with more wholesale generation and energy rates options for customers. There is also a greater presence of municipal utilities distributing electricity. In those provinces, the electricity wholesale price is set by an hourly market.

In 2003, coal represented approximately 25%, or 7,560 MW, of Ontario's supply mix. In 2014, the phasing-out of coal generation was completed. During this period, Ontario started a major green energy plan, with initiatives to increase penetration of wind and solar and deploy smart meters to reduce the peak. The majority of customers were moved to a time-of-use rate. The Independent System Operator of Ontario plans for reliability and system adequacy, using regional planning working groups. The Ontario energy board has implemented a performance-based approach to utility rate-making.

In Alberta, the province is operated by the Alberta Electricity System Operator (AESO) and the wholesale price is set through an hourly market. The current generation in the province is primarily fossil-fuel-based, however, in contradiction to this, the province has one of the best solar and wind regimes in Canada. The province took the path to deregulate the retail market to give more choices of pricing or green energy supply for their customers.

In British Columbia, Quebec, Saskatchewan, Manitoba, Newfoundland, and New Brunswick, the main electric utility is owned by the provincial government. In Nova Scotia, Saskatchewan, and Prince-Edward Island, the primary electricity providers are publicly-traded companies, usually headquarter in their province. Municipal-owned utilities remain in most of those provinces. Rates are set by the government legislated energy commission or regulatory board based on a return on asset model. Time-of-use rates are usually not available in those provinces, where a high penetration of electric heating and a winter peaking system makes the case for shifting energy usage more challenging for utilities and consumers.

The role of the federal government

While the major decisions about the electricity market in Canada are made by the provincial or territorial governments, the federal government played a leadership role in building smart grid in Canada since the inception of this concept in 2000. As an outcome of the Paris Accord, the Federal government through its Pan Canadian commitment set environmental targets and required that all provinces and territories have a carbon pricing mechanism in place for 2019. Using its shared jurisdiction over international or interprovincial transmission lines, the Canadian Government enables the sharing of renewable inside and outside the country, supporting generation and transmission investments. Finally, the federal government finances most of the research on nuclear energy, energy efficiency, oversees revenue grade metering and telecommunications, and providing most of the funding for the demonstration of smart grid technologies.

Supplying electricity to more than 250 remotes and indigenous communities in territories is a federal responsibility, but the federal government delegates the operation of remote diesel grid to provincial utilities or to a territorial entity.

New markets

Across every jurisdiction in Canada, new businesses are being set up to support customers in their energy transition projects, provide technology, rates, and incentives bundles.

Canadian utilities are exploring or sometimes actively involved in new business ventures to finance, sell and install, solar, battery, energy, or peak demand reduction technologies to their customers. Utilities would offer those new services internally, generating new revenue or create a subsidiary. This shift in the role of utilities shows a strong desire to be more customer-centric and to play a more significant role in supporting customers in their effort to conserve energy or to reduce the peak.

Key drivers for Smart Grid Solutions in Canada

Canadian utilities started modernizing their electricity networks a long time ago to improve the reliability and the carrying capacity of electricity transmission over long distances. Significant innovation has happened in the past 50 years with the development of Flexible AC Transmission Systems (FACTS) and HVDC transmission technology to carry renewable energy from remote hydro-generation dams to main consumption centers.

Since 2000, the discussion of grid modernization has evolved, with a greater focus on distributed solutions.

The first generation of smart meters were used to implement time-of-use rates and to reduce the system peak. Distribution automation programs were launched to improve the reliability of long distribution feeders. 2010 has seen the emergence of new connected technologies, advanced smart meters, and battery storage, accelerating the focus on distributed solutions, but also, on demand-side management.

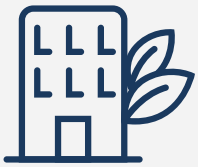
As climate change policies are being implemented in the country, smart grid investments were selected for funding and tailored to enable a positive contribution toward climate change. In December 2018, Canada announced regulations to phase-out traditional coal-fired electricity by 2030 as well as greenhouse gas regulations for natural gas-fired electricity. In September 2020, the Federal government announced significant funding to support the energy transition agenda. Most of the funding aligns with the electrification and enablement of clean, digital solutions.

$1.5B for zero emission buses

To expand and accelerate the adoptions of zero emission buses which will modernize bus fleets, reduce greenhouse gases and reduce operating costs over the long-term. This supports the government's goal of 5,000 new zero emission buses.

$2.5B for clean power

To facilitate interprovincial electricity transmission or interties, clean power and storage. This step will support clean power, reduce greenhouse gas emissions and help Canada in its 2030 and 2050 emissions reductions targets.



$2B for energy efficient building retrofits

To improve the energy efficiency of existing buildings and help large real estate owners, both public and private, modernize their assets. Improved energy efficiency will reduce greenhouse gas emissions and operating expenses.

$2B for large scale broadband

To develop large projects with significant connectivity gains for Canadians in underserved communities. The CIB will drive projects forward which connect a substantial number of households and businesses.

At the same time, the federal government announced the reinforcement of the interconnection to facilitate the flow of electricity in the eastern part of the country. The project called "Atlantic Loop" would facilitate the decommissioning of coal power plants and the export of hydroelectricity to the three Maritimes provinces.

With those new policies, investments, and technologies always more accessible, the smart grid deployment drivers in 2020 can be described as follow:

1

Saving energy and reducing the peak with smart meters: With over 80% of meters in Canada classified as smart meters, there is considerable opportunity for utilities to be able to interact more efficiently with customers, but also to increase the grid flexibility with load management. In September 2020, new smart meter deployment was announced in the Maritimes provinces to better inform customers of their energy usage, to drive conservation projects, and to save utility operation costs.

2

Reducing GHG with the electrification of heating and transportation: With an abundance of hydropower in several jurisdictions of Canada, electrification is on the rise. Electrifying oil, propane, and natural gas furnaces would help reduce greenhouse gases, but also provide power system flexibility with smart grid enabled technologies. The potential for load management and thermal storage of space and water heating is significant in all sectors. The same goes for the electrification of transportation. Electric vehicle adoption is on an upward trend in Canada and offers great potential for further smart grid flexibility. Furthering the deployment of EVs will be one of the largest contributors to reducing greenhouse gas emissions in Canada.

3

Reducing GHG and empowering communities with renewable energy in diesel power systems: More than 250 communities, mostly in northern parts of Canada are still powered exclusively with diesel for both heating and electricity generation. Opportunities to reduce the cost, reduce emissions, and empower local aboriginal communities to manage the power system are driving investment in this area. Canadian mining companies are also experimenting with the integration of renewable energy into their private diesel-powered systems.

4

Increasing reliability with distribution automation and microgrids: The reliability of the electricity system varies greatly between urban and rural areas. Due to the long distances to serve the population in certain regions, Canadian customers experience unequal service reliability. Automating distribution systems, adding battery storage to existing distributed generation to form a micro-grid is a key driver for smart grid development. Flexible storage helps utility improve the reliability of remote communities and better prepare the country for extended outage durations due to climate hazards.

The next section provides information about the status of smart grid deployment in Canada.

Status of Smart Grid deployment in Canada

The smart grid is not made of a single product. It is a set of technologies that automates the flow of electricity and information between consumers and suppliers.

There are more than 14 million electricity meters in Canada, more than 120 utilities, and 3,000 distribution substations. On those networks, different sensors, automations, and information systems are being used and modernized that could be coined as "smart grids". However, a single technology does not make the system smart.

However, some technologies, like smart meters, play a pivotal role in changing the way utilities and consumers manage energy. The country now has more than 80% of smart meters deployed and two provinces are planning to replace existing meters with newer, smarter versions. Smart meters reduce O&M costs, but also allow data to be automatically shared with the consumer or third-party companies. It facilitates the deployment of solar roof-top and demand response programs.

Distribution automation and storage equipment are also key technologies for customers and utilities that want to better integrate renewables on the system. By adding storage and advanced protection equipment to distributed generators (solar, wind, small hydro), utilities and large customers can create a microgrid that keeps the lights on when the main system is down. This smart grid capability makes communities more resilient in front of climate change hazards but is also very complex to implement and operate. It requires expensive battery storage and load management technologies, standards for planned islanding, and operational practices to protect utility workers and equipments.

The level of deployment of smart grid in Canada is contingent on enabling technologies, but also policies for data sharing, rate making, and network operations.

The table below shows the status of smart meter and smart grid deployment in Canada for the following categories:

1	**Smart Meter Deployment (Hourly data measurement)**
2	**Automated Data Sharing, using protocols like Green Button for energy consumption diagnostics**
3	**Demand Response Programs, of different sorts (rates, incentives, load management)**
4	**Solar net-metering, for solar owners to receive a solar generation payment or credits**
5	**Microgrid Capability (Distributed Generation Planned Islanding Standard)**

Province	Smart Meter	"Automated data sharing (Green Button)"	Demand Response	Solar net-metering	Microgrid (DG Planned Islanding Standard)
AB	C&I		Industrial	Net Billing	
BC	Completed		Testing R	Yes	Yes
MB			Industrial	Yes	
NB	Planned		Testing R, C&I	Yes	Pilot
NL			C&I	Yes	
NS	Planned		R	Yes	Pilot
NT			No	Yes	
NU			No	Yes	
ON	Completed	Proposal	R, C&I	Yes	Pilot
PEI			No	Yes	
QC	Completed		R, C&I	Yes	Pilot
SK	C&I		C&I	Yes	
YK			R	Yes	

Table prepared by SGIN
***C&I**: Commercial and Industrial, **R**: Residential

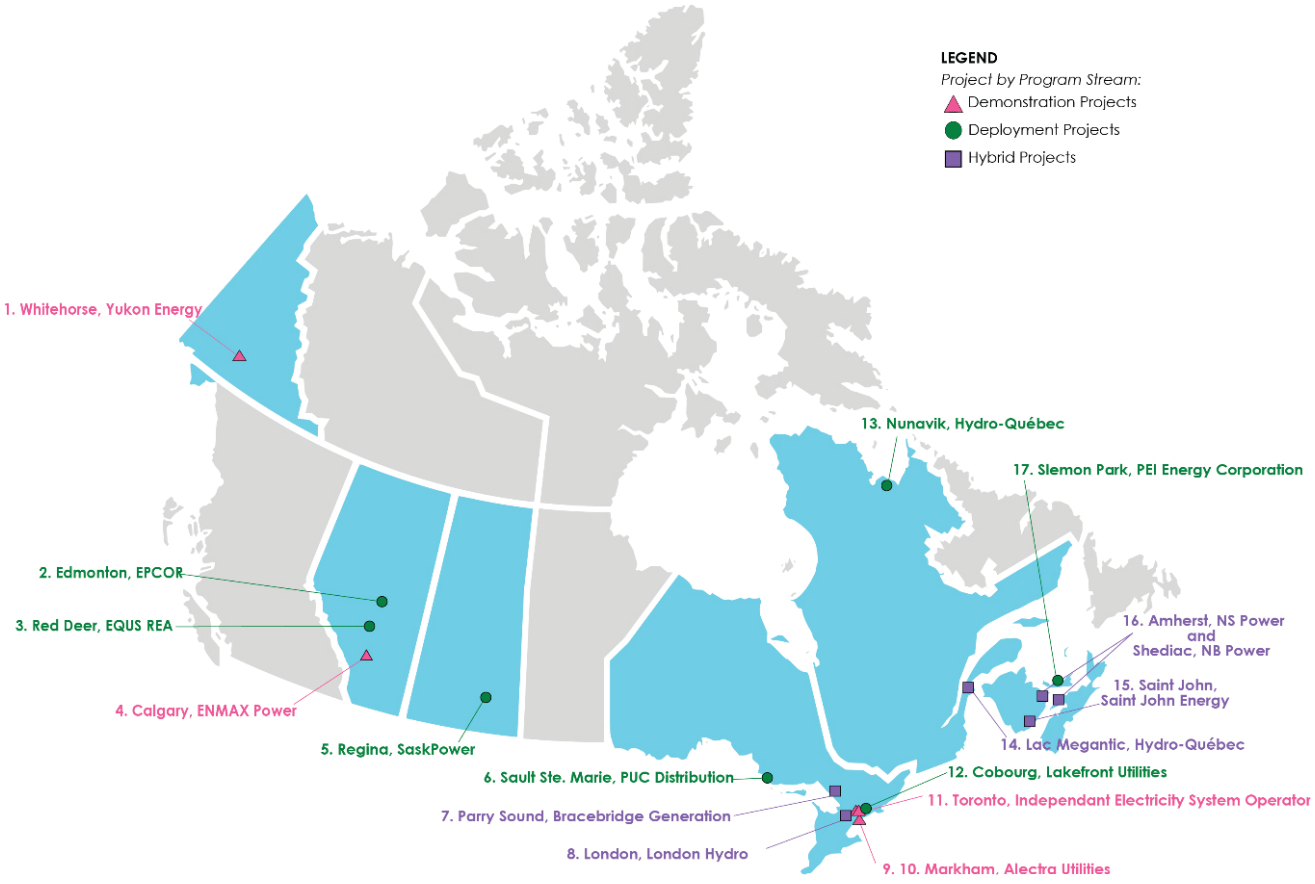
For a closer view of the smart grid projects in Canada, check the **Smart Grid in Canada 2018** publication from CanmetEnergy.

The deployment of forward-looking, smart grid pilot projects in Canada is a telling sign of what the future of smart grid will look like in the country. The next section captures the most recent demonstration project.

Funding programs supporting Smart Grid Solutions in Canada

This shift of paradigm from centralized to distributed solution creates opportunities for several utilities, mostly municipal, to save operation and peak demand costs. However, deploying new technologies requires further testing, especially when the success of such technology is dependent on customer engagement and participation.

In 2009, the smart grid concept was put on the agenda of the Canada-US Dialogue and since then, the federal government started playing a more active role in providing demonstration funding, convening provinces, utilities, and vendors, and fostering collaboration between provinces. The table below presents a sample of the active smart grid demonstration projects.



Source: Natural Resources Canada

Project Title	Lead Proponent	Total Project Cost
West 5 Smart Grid Project	London Hydro	$10.9M
Lac Mégantic Microgrid	Hydro-Québec	$8.46M
Interoperability and Non-Wires Alternative Demonstration	Independent Electricity System Operator (IESO)	$11M
Smart, Proactive, Enabled, Energy Distribution; Intelligent, Efficiently, Responsive (SPEEDIER) project	Bracebridge Generation Ltd.	$9.48M
Power.House Hybrid: Minimizing GHGs and Maximizing Grid Benefits	Alectra Utilities Corporation	$2.53M
The Transactive Grid – Enabling an End-To-End Market Services Framework Using Blockchain	Alectra Utilities Corporation	$4.01M
MiGen Transactive Grid	Hydro Ottawa Limited	$15.1M
Collaborative Grid Innovation for Atlantic Smart Energy Communities	NB Power Corporation, Nova Scotia Power	$37.4M
Residential Demand Response Program	Yukon Energy Corporation	$1.3M
Integrated Dispatchable Resource Network for Local Electric Distribution Utility	The City of Saint John (Saint John Energy)	$11.8M
EPCOR Smart Grid System	EPCOR	$44.2M

For more information about Smart Grid Demonstration Projects in Canada, please refer to the Natural Resources Canada **website**, where you can find more details about each active or completed projects.

The demonstration project showcases the strengths of the Canadian software, hardware, and service industry in those four main areas:

Electric Heating Technologies

As the second-largest electric heating market in the world, many Canadian companies have developed expertise in system design and the technology used for the electrification of heating across industrial, residential, and commercial sectors. Thermostat, thermal storage, heating systems are engineered and built in the country.

Electrification of Transportation

There is significant expertise in the electrification of transportation in Canada. The country has several companies developing electric buses and trucks, but also and electric motors, drivetrains, and other technologies to electrify and convert diesel and gasoline fleets to electricity. The country also has leaders in EV charging infrastructure and large conglomerates to manufacture transformers and substations dedicated to the electrification of public transportation.

Storage

The country has considerable expertise in fundamental and applied research related to material and hardware for energy storage technologies. Several labs and universities have patented technologies and are making a global contribution to the research in this area.

Enterprise Software

The country has a strong IT sector specialized in energy and in cybersecurity for critical infrastructure protection (CIP). Solutions for distributed energy, storage, or load management are developed by small and large companies. Several power system simulators used globally by utilities and engineering firms are developed in Canada.

CONCLUSION

How Smart Grid helps Canada reach its Climate Change Goal

The current government of Canada has set an ambitious target to become carbon-neutral by 2050. While this challenge requires a massive coordination of political and economic forces and a large spectrum of technologies beyond smart grids, the role played by the clean electricity industry is prominent.

The abundance of electricity will likely drive a major electrification effort and ensure the energy autonomy of the country. The smart grid technologies will allow this electrification to be beneficial and not require extensive expenditure in network capacity. In preparation for climate changed hazards caused by wind and snowstorms, microgrid solutions can help provide back-up power and heat to communities.

The reduction of greenhouse gases is an international effort from all the sectors of the green energy economy. The smart grid industry in Canada is up to the challenge to decarbonize the economy and enable a more sustainable future for all living things on the planet.