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SMART GRID IN CANADA -
OVERVIEW OF THE INDUSTRY IN 2010

Canada

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INTRODUCTION

The modernization of electrical infrastructure is underway in many countries around the world. Motivated by important drivers such as economic development, national security, and environmental and clean energy objectives, provinces, states and countries are prioritizing innovation in their electrical grids and striving to build a "smart grid".

In Canada, smart grids have been progressing for some time. During Industry Canada's Digital Economy Consultation in 2010, smart grids were identified as a core component of a digital economy. Over the last two years, activity has escalated, as related research has expanded and as greater numbers of applications are becoming commercially available. One important initiative is the Clean Energy Fund (CEF), which was announced by Natural Resources Canada on May 19, 2009 and included a demonstration component for Renewable and Clean Energy Technologies. Nineteen demonstration projects were announced in six technology areas, including energy storage and smart grids. These projects accounted for $146 million in CEF contributions.[1]

With greater smart grid activity across Canada, there is an increasing need for building awareness, sharing of knowledge and progress, and collaboration on both research and deployments. SmartGrid Canada has recently been formed as a not-for-profit alliance to foster that advancement. With a broad membership base including utilities, vendors, technology and service providers, academia, and other industry associations, SmartGrid Canada[2] intends to lead this sector for the benefit of all Canadians. Industry is also providing leadership through its participation in new initiatives, such as the Canadian Smart Microgrid Research Network and the Smart Grid Standards Task Force.

Canada has a great role to play in smart grid development in North America and around the world, by enhancing the innovative culture and the technical expertise that is already evident in many areas across the country. This paper will provide an overview of Canadian smart grid activities and initiatives by province, by utility and by the federal government.

Electricity in Canada

Comparing levels of smart grid development in Canada is a challenge. Canada is a federation of ten provinces and three territories. Electricity resource plans and economic regulation of transmission and distribution utilities are provincial responsibilities. Federal jurisdiction is limited to nuclear electricity generation, electricity exports, metering, telecommunications and research and development. Jurisdiction over environmental issues is shared between the provincial and federal governments.

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[1] CEF Projects, http://www.nrcan.gc.ca/eneene/science/renren-eng.php, November 15th, 2010 update.

[2] SmartGrid Canada (SGC) is a new national organization dedicated to promoting a more modern and efficient electricity grid for the benefit of all Canadians, www.sgcanada.org

Each province has a different mix of electrical energy sources, closely tied to local resources. Using electricity for heating and domestic hot water is dominant in hydro-powered provinces, while natural gas or fuel oil is used in other provinces. Canada is a land of many natural resources. The country is the world's largest producer of uranium, the second-largest producer of hydroelectricity and the third-largest producer of natural gas. In addition, it has the second-largest reserves of crude oil in the world. The energy sector is one of the main engines of Canada's economy; it accounts for about 6% of Canada's gross domestic product (GDP). The electricity sector alone generates about 2% of GDP. And both the energy sector in total and the electricity sector specifically are expected to play increasing roles in our economic future.

As presented in the picture below, Canada was a net exporter of electricity in 2009. Five provinces – Manitoba, Ontario, Newfoundland and Labrador, New Brunswick and Quebec – are net exporters of electricity, while five provinces are net importers. Electric power generated in Labrador flows through Quebec's transmission network.

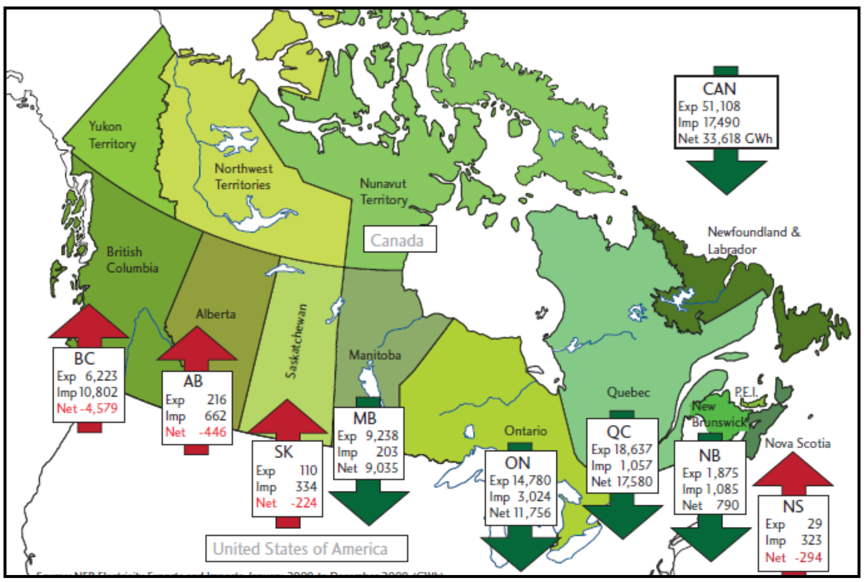

Figure 1: NEB Electricity Exports and Imports, January 2009 to December 2009 (GWh)[3]

The illustration below shows that a large proportion of the electricity produced in Canada is generated by hydroelectric and nuclear plants. Over 75% of the electric power generated in Canada involves no or few greenhouse gases emissions. Our high hydroelectric output accounts also for the low cost of electricity in several provinces. However, such a high share of renewable and non-emitting energy does not reflect regional disparities. Certain provinces are dealing with the increasing cost of electricity related mainly to the use of oil and gas as the primary fuel for power generation.

[3] National Energy Board, *www.neb-one.gc.ca*

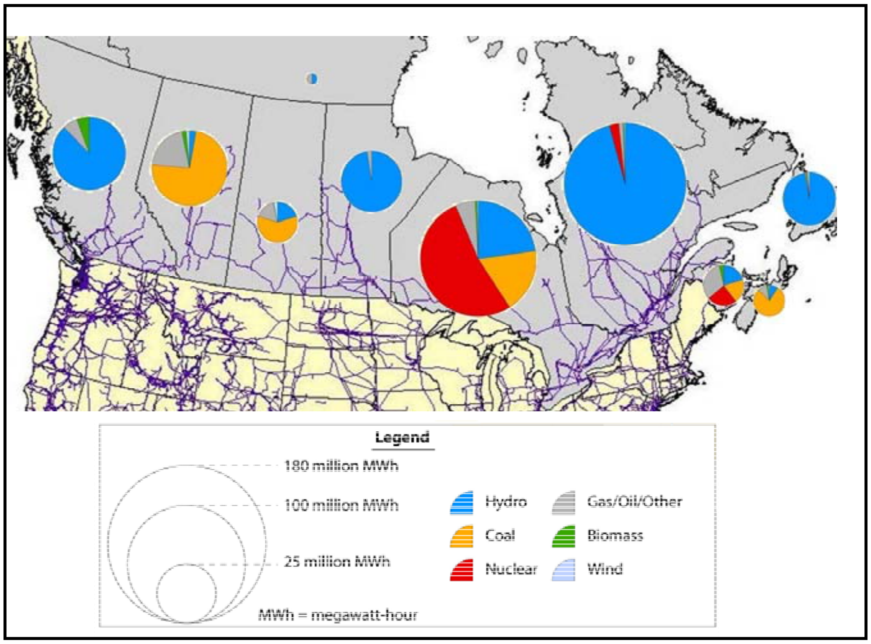

Figure 2: Electricity generation and supply mix in Canada[4]

While some provinces have been very proactive in developing green energy policies to support smart grid development, many are still considering an appropriate course of action. In several provinces, the industry is playing a leadership role with a number of utilities, vendors and academics working on smart grid initiatives.

A table can be downloaded that provides an overview of the smart grid applications being planned or tested in Canada at the CanmetENERGY website[5]. This includes projects funded by utilities and the CEF demonstration programs. Developments in intelligent buildings, community energy systems, distributed generation and electrical recharging infrastructures, which are often part of a broader smart grid roadmap or vision, are not represented in this table.

To provide a better sense of the diversity of smart grid developments in Canada, several different Canadian contexts will be presented to describe the evolution of the regional electricity markets.

[4] Statistical Source: NRCan (provincial electricity supply); North American Electric Reliability Council (NERC, grid)
Map Source: Global Energy Network Institute (GENI)

[5] An updated version of this table could also be found at the following address : http://canmetenergy-canmetenergie.nrcan-rncan.gc.ca/eng/renewables/integration_der/publications.html?2010-087

Alberta, Saskatchewan: Coal-powered provinces getting greener

The Alberta electricity sector is the only one in Canada that is fully deregulated, at both wholesale and retail levels. Local generation is largely by coal, oil and gas. In recent years, wind development in the province has been significant. As of 2010, Alberta has the second-highest wind generation capacity in Canada.

In March 2010, the provincial legislature issued a specific order requiring the Alberta Utilities Commission to file a report by January 2011 on smart grid activities and regulation issues[6] in the province. So far, smart grid development in Alberta has been primarily driven by the industry.

ENMAX, the local electricity distributor in Calgary, is working towards developing its smart grid. The utility deployed a major distribution automation project to improve the reliability of the distribution system. More than 175 new automated switches made by S&C Electric have been rolled out. Automated Meter Reading (AMR) is now in place to collect meter data. Recently, ENMAX announced a major partnership with Cisco Systems Inc. in managing data from building energy management systems. In 2010, Power Measurement Limited (Schneider Electric) received a grant from the Clean Energy Fund. This C$10M project will demonstrate an innovative Energy Management Business Information Platform (EMBIP) in a Brookfield Properties high-rise in Calgary.

At FortisAlberta, the utility serving the southern part of the province, a major AMR project was concluded in 2010. Over 400,000 meters were deployed.

In Saskatchewan, the government decided recently to make smart meters[7] mandatory by 2014. The province hosted several demonstration projects of carbon capture and clean coal technologies financed under the federal CEF demonstration program.

British Columbia, Quebec, Manitoba, Newfoundland and Labrador: Hydroelectric producers

These four provinces produce over 90% of their electricity from hydro. Large dams are managed to take advantage of electricity surplus on the market and to provide balancing service to renewable energy producers. In these provinces, more hydro generation is planned or under construction for local needs and for export. Electric power for transportation, sourced from low-cost hydroelectric plants, is foreseen to increase local electricity demand in the mid-term. In these four provinces, smart grid applications are being tested for several purposes, including improvement of supply reliability and network efficiency.

In Manitoba and Quebec, past innovations in high voltage technologies contributed to the development of local expertise in power transmission. The Manitoba HVDC (High Voltage Direct Current) Research

[6] http://www.qp.alberta.ca/documents/orders/orders_in_council/2010/310/2010_093.html

[7] Smart meters may accomplish several functions, from basic automated meter reading (AMR) to more advanced metering infrastructures (dynamic pricing, remote disconnect, theft detection, etc.). The meter technology chosen and the software applications deployed by the utilities lead to different application packages.

Centre, a subsidiary of Manitoba Hydro, increased the voltage of HVDC technologies to 500 kV, while Hydro-Quebec developed an AC transmission solution operating at 735 kV, including several flexible AC technologies (FACT) devices. These two utilities and their laboratories were involved in the installation of phasor measurement for many years. Networking of the phasors to create a network of “synchrophasors” for wide-area situational awareness is being tested in Manitoba with the Midwest ISO. The University of Manitoba, ERLPhase Power Technologies Ltd. and the Institut de Recherche en Électricité d’Hydro-Québec (IREQ) are also conducting research in this area.

BC Hydro has been active in several smart grid areas for many years, with over a dozen applications underway. Their framework for smart grid advancement is shown below.

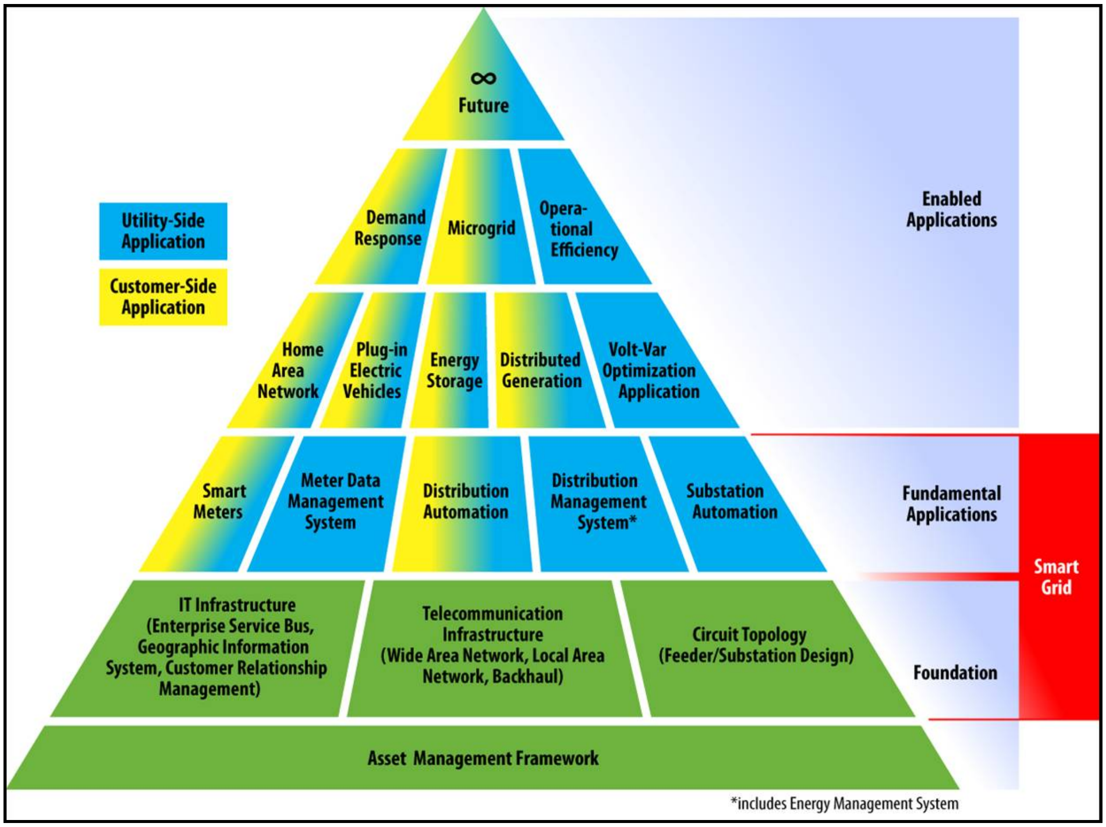

Figure 3: BC Hydro’s Smart Grid Framework *(Courtesy of BC Hydro)*

This Crown-owned utility launched the Smart Metering Program and the Smart Grid Program in line with the new British Columbia Clean Energy Act. The deployment of smart meters was announced in January 2011. The development of a Distribution Management System (DMS) with Telvent Canada Ltd., based in Calgary, will usher in modern grid applications such as volt & var and network reconfiguration. Planned islanding of rural networks is being tested to maintain the service of a community with run-of-the-river hydro. More recently, BC Hydro received a CEF grant to demonstrate planned islanding with utility-scale storage. This project, valued at C$12.5M, will demonstrate the benefits of storage systems to reduce outage times and provide reserve capacity.

In British Columbia, there is a growing information technology and communications industry to support smart grid development. Some of the local technology manufacturers are Tantalus in smart grid AMI/DR communications, Schneider (formerly Xantrex) provides inverters, Power Measurement (Schneider Electric) provides high-end meters and energy management software, Delta Controls manufactures building automation systems, Corinex Communications manufactures high-speed power line communications systems, Pulse Energy developed energy management software and Legend Power developed a voltage optimization system. Several demonstrations are taking place at the British Columbia Institute of Technology (BCIT). This Institute is conducting several R&D activities, including those on microgrids, smart grid communications, demand response, and smart appliances.

Figure 4: Burnaby Campus of BCIT where smart grid technologies are being demonstrated as part of their microgrid research initiative. ***(Photo credit BCIT)***

Recent work at Hydro-Quebec Distribution shows the great leadership of this utility in network automation and monitoring. Several tests on medium-voltage equipment are being conducted on the IREQ test line, an important facility for assessing advanced distribution technologies. Over 2150 switches and reclosers are now automated in the province, a figure that is expected to rise to 3450 in 2012. A pilot project on voltage and reactive power management, which has been running since November 2008, demonstrated an energy saving potential of over 2 TWh province-wide. Full deployment of this solution requires regulatory approval (spring 2011). For another purpose, fault location research and demonstrations show the potential of advanced sensing on the distribution feeder to reduce outage times. A special project called the “Zone de réseau interactif”, or smart zone, budgeted at C$20M, received funding from the Federal CEF demonstration Program. This project will demonstrate the use of the Distribution Management System (DMS) to integrate the volt & VAR system, network reconfiguration, distributed generation, AMI and smart charging of plug-in electric cars in Boucherville, a suburb of Montreal. The utility also has plans for provincial AMI and smart meter deployment. In September 2010, the utility was in the process of technology selection. IREQ is supporting demand management through smart grid technologies at Hydro-Quebec Distribution. The Smart Zone and its link to the utility smart grid roadmap is presented below.

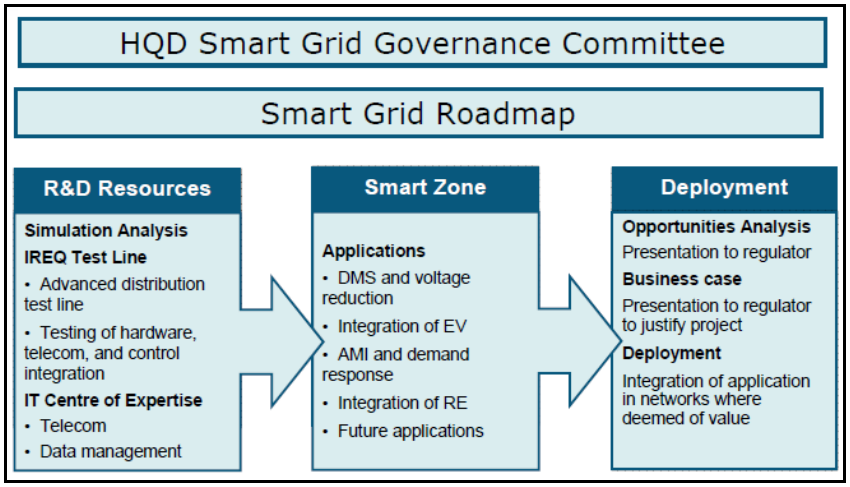

Figure 5: Hydro-Québec Smart Grid Development and Deployment Strategy *(Courtesy of Hydro-Québec)*

The smart grid industry in Quebec is also well established. Among the companies operating in the province, General Electric offers a DMS/EMS solution, CYME International (now Cooper Power Systems) offers simulation software and consulting, while Cybectec (now Cooper Power Systems) offers a remote terminal unit (RTU) for substations for data acquisition. Gentec manufactures acquisition systems for substations, as well as battery chargers and building management systems. Synapse develops intelligent thermostats and controls, Vizimax manufactures protection relays and remote automation platforms and Spectrum Expert build private telecommunication networks for utilities. ABB and Areva (now Alstom) are well established in the province, providing power equipment. Finally, CEATI is a global organization located in Montreal, Quebec that facilitates the pooling of resources to support strategic research studies through its utility interest groups[8].

With limited emissions from the electricity sector, the greatest potential for reducing GHGs in these hydroelectric powered provinces is in the transportation sector. Considerable work on electricity transportation is being done in British Columbia and Quebec. The Hydro-Quebec Zone de réseau interactif, mentioned earlier, will monitor the impact of the electric vehicle (EV) charging infrastructure on the grid as the utility conducts a number of EV demonstration projects. On the West Coast, EV research and demonstrations have been undertaken in recent years in British Columbia. Work on charging infrastructure and power quality issues are ongoing in several organizations, including CEATI, Natural Resources Canada (NRCan), BC Hydro and other North American utilities.

The green shift in Ontario: Conservation, phasing-out coal, phasing-in renewables

Activities associated with the development of the smart grid in Ontario are well known in North America. Among the most progressive measures adopted by the province are the early legislation on mandatory smart meter installation and an attractive feed-in tariff. The Independent Electric System

[8] CEATI Reports: Electric Distribution Utility Roadmap: Common Infrastructure and Electric Distribution Utility Roadmap: The Case for Change

Operator (IESO), the Ontario Power Authority (OPA) and the Ontario Energy Board (OEB), along with transmitters and distributors, are coordinating their efforts to enable renewable energy to be brought into service more quickly and efficiently.

The Green Energy and Green Economy Act[9], enacted in 2009, demonstrated a clear commitment on the issue of smart grids and clean energy. There is strong leadership in the government and in all energy-related organizations in the province to decommission all coal-fired generating plants by 2014. In Ontario, the IESO hosted the Ontario Smart Grid Forum and published its report entitled Enabling Tomorrow's Electricity System that presents the industry perspective on smart grids.[10]

Figure 6: First Light Solar Farm, 9.1 MW, Stone Mills, Ontario *(Photo credit Dave Turcotte)*

There are over 80 electricity distribution utilities in Ontario and one major Crown corporation, Hydro One. Each local distribution company (LDC) is responsible for the development of their advanced metering infrastructure, network automation and asset monitoring applications. Several vendor solutions are being deployed. Hydro One chose Trilliant for its AMI deployment over its large territory. The utility uses WiMAX to link the AMI network to the utility. Hydro One is planning to develop a smart zone in Owen Sound, where several advanced distribution solutions will be tested. Two transmission substations, four distribution substations and seven feeders will be modernized. The business objectives to be verified in this pilot are the maximizing of distributed generation, distribution automation and planning tools. Smart charging of the utility's EVs and customer enablement solutions are possible, later additions to the Smart Zone. An illustration of this project is shown in Figure 6.

9 www.mei.gov.on.ca/en/energy/gea May 14, 2009
10 http://www.ieso.ca/smartgridreport/, February 2009

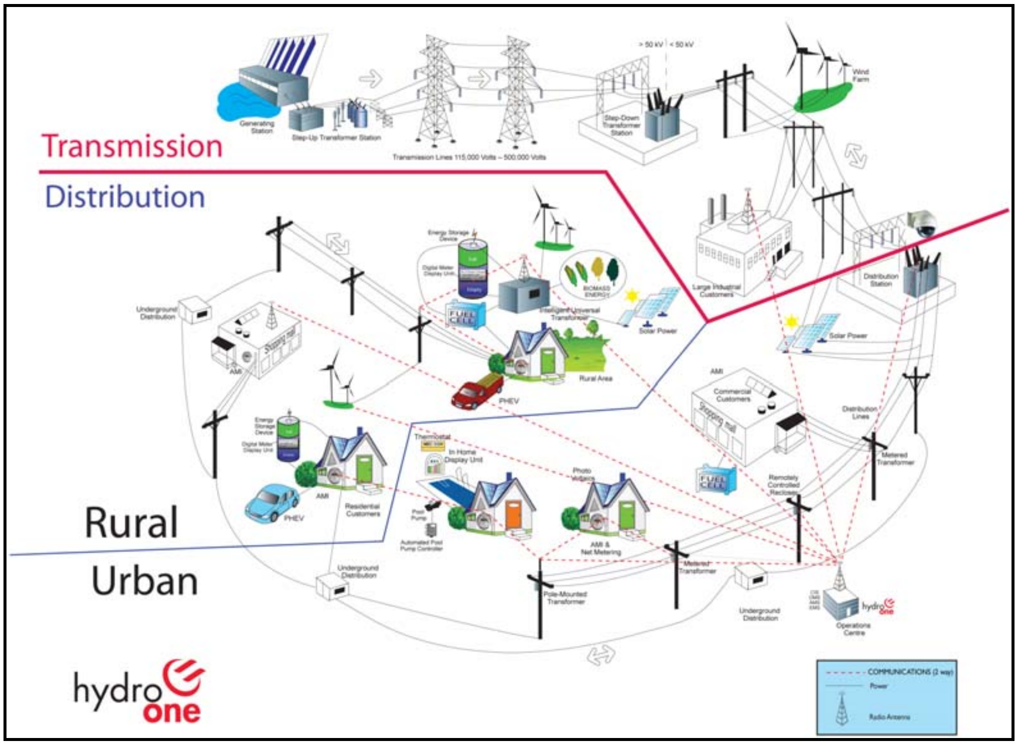

Figure 7: Hydro One's Advanced Distribution System Project ***(Courtesy of Hydro One)***

Demand response programs are being developed by utilities and by the OPA. This provincial agency is in charge of conservation and peak reduction programs. In the Greater Toronto Area, several initiatives are aimed at reducing congestion. Direct load control of thermostats, dispatching of combined-heat and power and distributed generation are some of the solutions chosen to eliminate the need for new transmission facilities in this region.

CEATI's utility interest group has received a CEF grant to demonstrate the reuse of plug-in hybrid electric vehicle (PHEV) storage for utility applications. This C$8.2M project will use lithium ion storage for load levelling at three utilities in Ontario and Manitoba. The Manitoba HVDC Research Centre, Toronto Hydro and Hydro One are involved in this initiative. Academic support is provided by Ryerson University, host of the new Centre for Urban Energy. Several projects are underway to address the problem of demand growth in urban centres like Toronto. Demand side management, energy storage and local generation are among the approaches being studied. Other universities in Ontario are conducting work on smart grids, including the University of Waterloo and the University of Toronto.

Several companies have increased their investments in manufacturing in response to the Ontario government incentives for solar and wind energy, as well as to support the deployment of smart meters and demand response solutions. Metering companies Itron, Elster and GE Multilin are based in Ontario. Lixar (now Gridpoint), Regen Energy, Direct Energy and EnerNOC are among the companies providing demand response aggregation or solution in the province. Enbala Power Systems offers regulation solution for power systems and has a pilot project for retail customer participation in providing ancillary services to the IESO[11].

The telecommunications industry has been operating for many years in Ontario. For smart grid communications, Redline offers WiMAX solutions and RuggedCom communications products such as switches, routers and base stations for harsh environments. Kinect offers smart grid sensors and communications for grid asset management, and e-Radio offers smart grid communications embedded in FM communications.

Finally, the Ontario Centre of Excellence for Energy[12], a funding organization located in Toronto, invests in research on energy systems and new technologies such as smart grids and electricity transportation. This centre links academic institutions with Ontario industry to promote innovation and technology transfer.

Nova Scotia, New Brunswick and Prince Edward Island: Wind energy in the Atlantic Energy Gateway

These three Maritime Provinces have the highest electricity prices in Canada, largely based on the cost of the fuel used to generate power. New Brunswick has a mix of resources that include nuclear, hydro, coal and oil. The Nova Scotia supply is mainly from coal, but it also uses hydro and oil. These two provinces are interconnected, but they operate their own power systems.

Prince Edward Island generates over 15% of its electric power from wind. A CEF demonstration project, driven by the Wind Energy Institute of Canada, will study problems related to production, operation, storage, and the installation of small and large wind energy technologies. The project budget is C$25M.

A recent wind assessment study[13] in New Brunswick showed capacity factors exceeding 40% in several areas, accounting for more than 5,500 MW of commercially feasible wind generation. In Nova Scotia, besides wind, there is considerable potential for tidal generation. However, increasing the share of variable renewable in the Maritimes would require improvement of the power system's flexibility. Improvement of transmission facilities, the merging of power areas or the development of local generation for balancing resources are among the scenarios under study.

In this context, smart grid development in the area will likely address the challenge of integrating renewable energy into the power grid while minimizing cost. A Maritime consortium consisting of New Brunswick Power, Nova Scotia Power, Maritime Electric and Saint John Energy received a grant from the CEF for a 4-year, C$38M demonstration project. The PowerShift Atlantic project aims to balance wind energy with dispatchable loads and thermal storage. The project will involve the installation of

[11] Source: http://www.enbala.com/smart_grid_pilot_program.html
[12] http://www.oce-ontario.org/Pages/Home.aspx
[13] "Large Scale Wind Power in New Brunswick," prepared by Ea Energy Analyses for the New Brunswick System Operator and the New Brunswick Department of Energy, August 2008.

monitoring and control systems in 2,000 buildings in PEI, NB and NS. Commercial HVAC systems will be modulated and the duty cycle of residential electric thermal accumulators and water heaters will be adjusted to fit the availability of wind power in the region. The University of New Brunswick is working closely with the consortium. Dalhousie University in Halifax is also doing research in this area.

Other smart grid initiatives in the Maritimes include work in Saint John, NB. The city-owned utility uses the Tantalus TuNET AMI system for meter data collection and remote control of water heaters. Finally, to achieve greater load shifting by its customers under time-of-use rates, Nova Scotia Power provides technical support to customers in the installation of electric thermal storage.

Federal government activities

Industry Canada's is responsible for telecommunication policy including wireless spectrum allocation, and has initiated some smart grid activities at its Communications Research Centre in Ottawa. In addition, Measurement Canada, an agency of Industry Canada, is responsible for the accuracy of smart meters in Canada. An important decision related to telecommunications is currently affecting smart grid development in Canada. On December 12, 2008, Industry Canada released its decision on the 1780-1850 MHz spectrum allocation. Research and the efforts made through the Utilities Telecom Council of Canada (UTCC) led to the allocation of the 1800-1830 MHz radio systems band for the maintenance and management of electric power grids.

Natural Resources Canada is managing R&D in the energy sector, through its CanmetENERGY research centres in Varennes. It conducts research and development on smart grids for the integration of renewable energy in collaboration with partners from industry, universities. NRCan coordinates its efforts with other government departments and international organizations that have smart grid initiatives.

Figure 8: CanmetENERGY research laboratory in Varennes, Canada[14]

Load modelling and network simulation with distributed resources are among the activities conducted, along with grid technology assessment, demonstration projects and standardization. CanmetENERGY collaborates with the remote British Columbia communities of Nemiah and Hartley Bay on the design and demonstration of remote microgrids, using solar, run-of-the-river hydro and wind generation. Smart grid technologies are being tested to cope with surplus and shortages of renewable energy and to optimize the dispatch of diesel generators. The figure below illustrates a demonstration project by Pulse Energy in Hartley Bay BC.

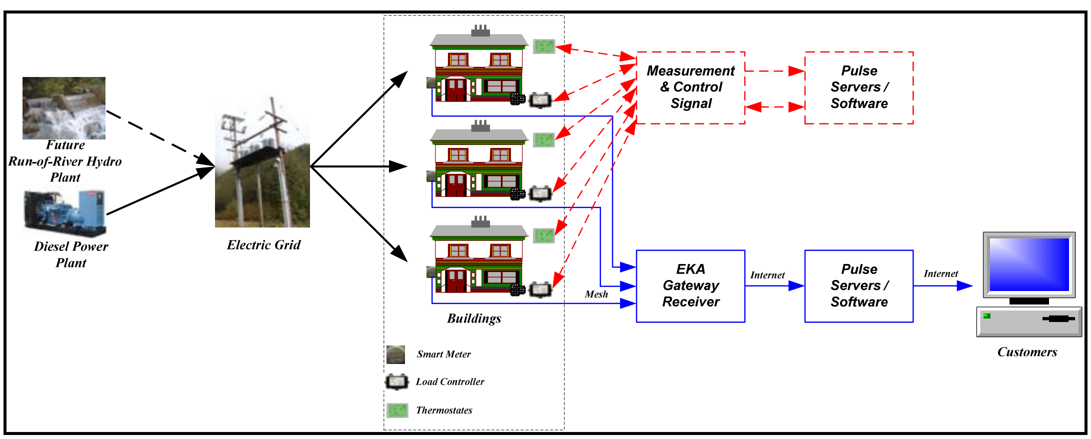

Figure 9: Hartley Bay smart grid demonstration project by Pulse Energy

Moreover, CanmetENERGY in Varennes is conducting research and development on intelligent buildings. This research focuses on energy management, energy prediction, and development and implementation

[14] http://canmetenergy-canmetenergie.nrcan-rncan.gc.ca/eng/renewables/integration_der.html

of automated demand response in commercial buildings. The figure below shows the three main automated demand response demonstration sites.

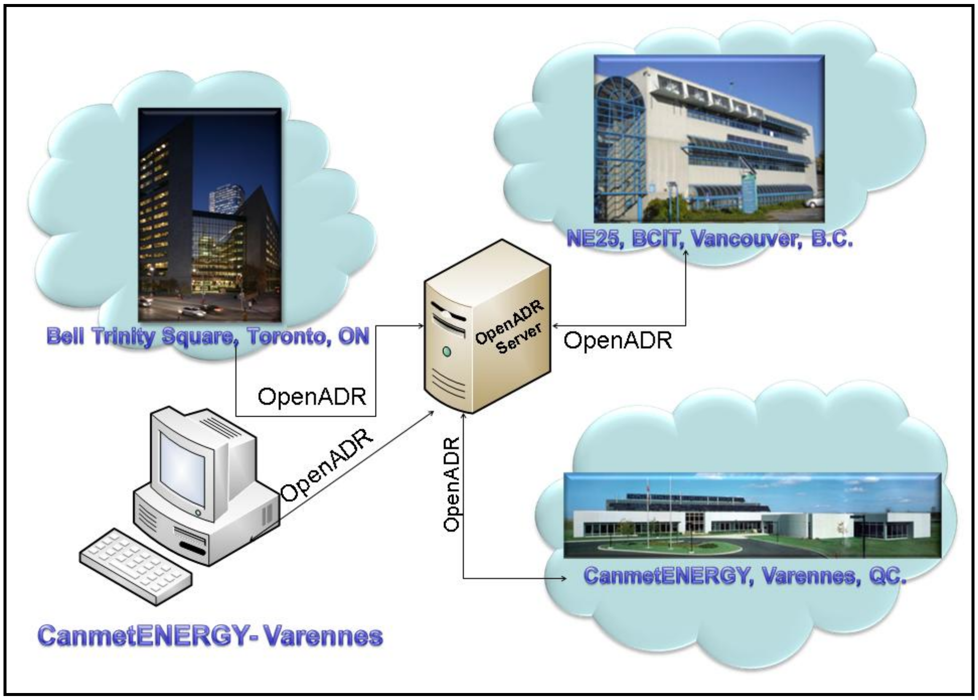

Figure 10: Diagram showing the open automated demand response (openADR) protocol being tests by CanmetENERGY and project partners.

CanmetENERGY, in collaboration with the Standards Council of Canada and partners, has established a national Smart Grid Technology and Standards Task Force. The task force members collaborate to identify key priority areas for Canadians, participate in joint projects to develop North American standards, and provide recommendations for the advancement of global standards efforts, managed by the International Electrotechnical Commission (IEC).

In 2004, a new program area in storage technologies was added to the Canadian research initiatives. This includes the development of lithium ion accumulators at the National Research Council (NRC), the testing of a vanadium redox battery system at the CanmetENERGY's laboratories in Ottawa, and the evaluation of small-format storage for behind the building meter applications.

NRCan collaborates with international organizations such as the International Energy Agency (IEA) and the Asia-Pacific Partnership (APP) on policies and R&D issues related to grid modernization. NRCan collaborated recently in the IEA GIVAR (Grid Integration of Variable Renewable) project that developed a Flexibility Assessment Tool (FAST), which signals specific measures for different types of power systems to maximize flexibility, and thus their capacity to integrate large proportions of variable renewable.

CONCLUSION

In conclusion, smart grid development is well underway in Canada. Each province has its own priority while building their clean energy strategy and defining the role of a smart grid. Several utilities are proactive in increasing their grid reliability, while others are leading the way in reducing demand or increasing the use of renewable energy. Provinces with substantial wind, hydro or fossil fuel resources have so far tailored their electrical industry to their natural resources. Utilities serving rural and urban customers face different issues. All these facts may explain, so far, the different priorities and varying levels of smart grid development across Canada.

The federal government supports smart grid development in several ways. The recently established Clean Energy Fund provided support for R&D and the demonstration of clean technologies. To address common energy challenges, the Clean Energy Dialogue was recently initiated between Canada and the United States. In addition, a targeted effort for industry is supported by the Department of Foreign Affairs and International Trade (DFAIT), such as planning industry trade missions.

The electricity sector has contributed to economic growth and employment in Canada for many years. This role is expected to become more important in our future. The development of a modernized power system involves many stakeholders directly, such as utilities and power producers, but also other sectors like transportation, as well as consumers and the construction and telecommunications industries. Canadian universities, research centres and non-profit organizations are also key players in building a smarter grid. Given the importance of electricity to the well-being of Canadians, it is important to build awareness and foster collaboration that will allow smart grids to support and enable the clean and profitable energy future that we envision for North America.