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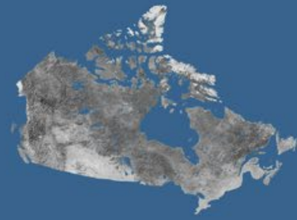

CanmetENERGY

Leadership in ecoInnovation

Smart Grid in Canada

2012-2013

Edited by: Jennifer Hiscock and David Beauvais

This report provides a summary of smart grid development progress in Canada during 2012-2013. It is written for industry, government and research stakeholders of smart grid development.

Canada

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Introduction

This report is the third in a series of reports, and is intended to be a useful reference for smart grid practitioners in Canada, and for international smart grid stakeholders interested to learn more about smart grid activities in Canada. Natural Resources Canada's CanmetENERGY research labs manage the Canada Smart Grid Action Network. Members of this network have contributed to this report which highlights the current status of smart grid progress in Canada in the 2012-2013 timeframe. It includes provincial and regional activities, identifies projects under way and discusses how smart grids will be implemented throughout distribution systems in Canada and similar electricity markets.

Readers should refer to the 2011-2012 report[1] for an introductory overview of smart grid activities in Canada, and the 2010-2011 report[2] for a broader industry overview of smart grid in Canada.

[1] CanmetENERGY, Smart Grid in Canada 2011-2012: http://www.nrcan.gc.ca/energy/publications/sciences-technology/renewable/smart-grid/6167

[2] CanmetENERGY, Smart Grid in Canada - Overview of the Industry in 2010, 2011: http://www.nrcan.gc.ca/energy/publications/sciences-technology/renewable/smart-grid/6133

Canada supporting smart grid development

CanmetENERGY established the Canadian Smart Grid Action Network (CSGAN) to connect national stakeholders and their work with the International Smart Grid Action Network (ISGAN). Key enablers for smart grid in Canada are connected through CSGAN to bring together the various knowledge domains associated with smart grid development, namely: research and development expertise; publicly and industry funded project results and insight; industry transition efforts and experiences; and policy. The group meets during the year with members from provincial and territorial energy ministries, federal departments, members of the academia, and utility and industry associations to share knowledge and discuss regional and national level smart grid issues. Highlights of smart grid initiatives during 2012-2013 from CSGAN members and the jurisdictions they represent are included in this section.

Figure 1: Canada smart grid knowledge domains connected through the Canada Smart Grid Action Network

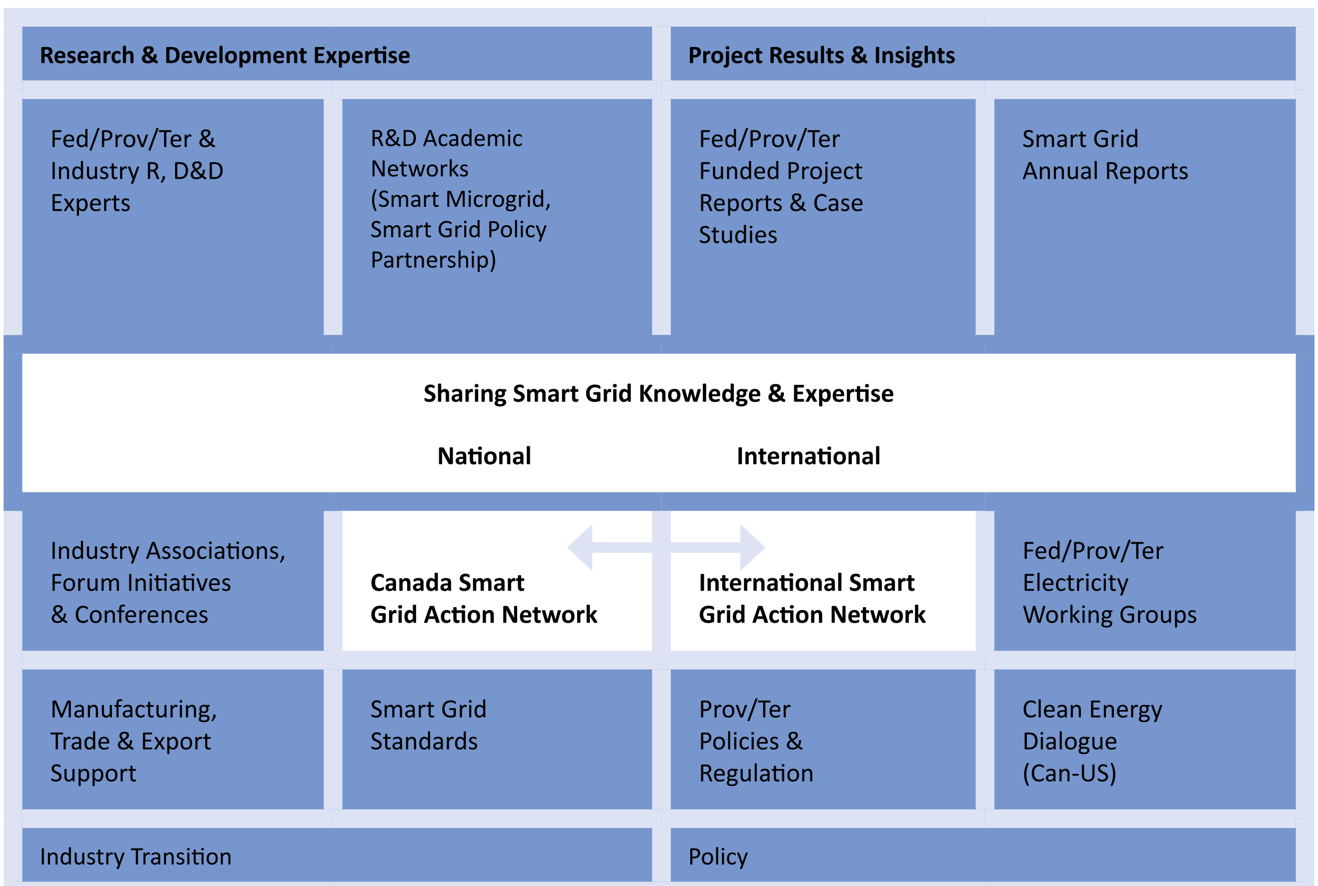


Figure 2 illustrates the deployement of six different smart grid applications in Canada. These applications are defined more comprehensively in the Appendix A of this report and include:

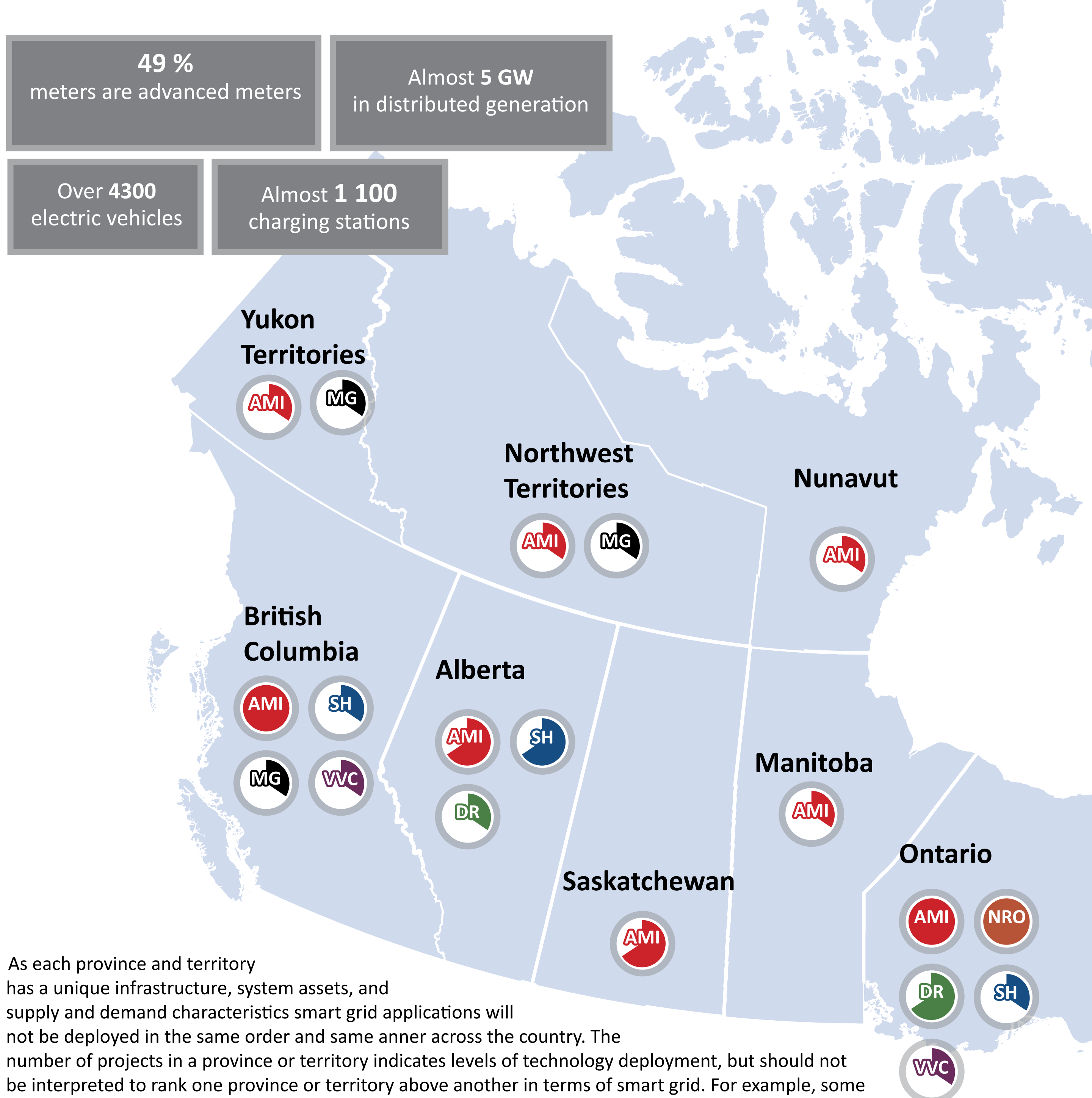
- Advanced Metering Infrastructure (AMI);
- Different Rate Structures or Plans (NRO);
- Demand Response (DR);
- Self-Healing Grids (SH);
- Microgrids (MG); and
- Voltage and Reactive Power (var) Control (VVC).

The level of deployment of these applications is indicated for each province and territory as either being under study or planned (1/3 pie chart), partially deployed or in a state of ongoing deployment (2/3 pie chart) or broadly deployed across the province or territory (whole pie). The deployment levels are indicated according to the publicly announced projects or programs and by nature are somewhat subjective[3].

[3] Later in 2013, CanmetENERGY, in partnership with provincial governments and utilities, will pilot a common set of metrics for smart grid in Canada to help establish a more quantitative dialogue across the country that can inform future policy and programs.

Figure 2

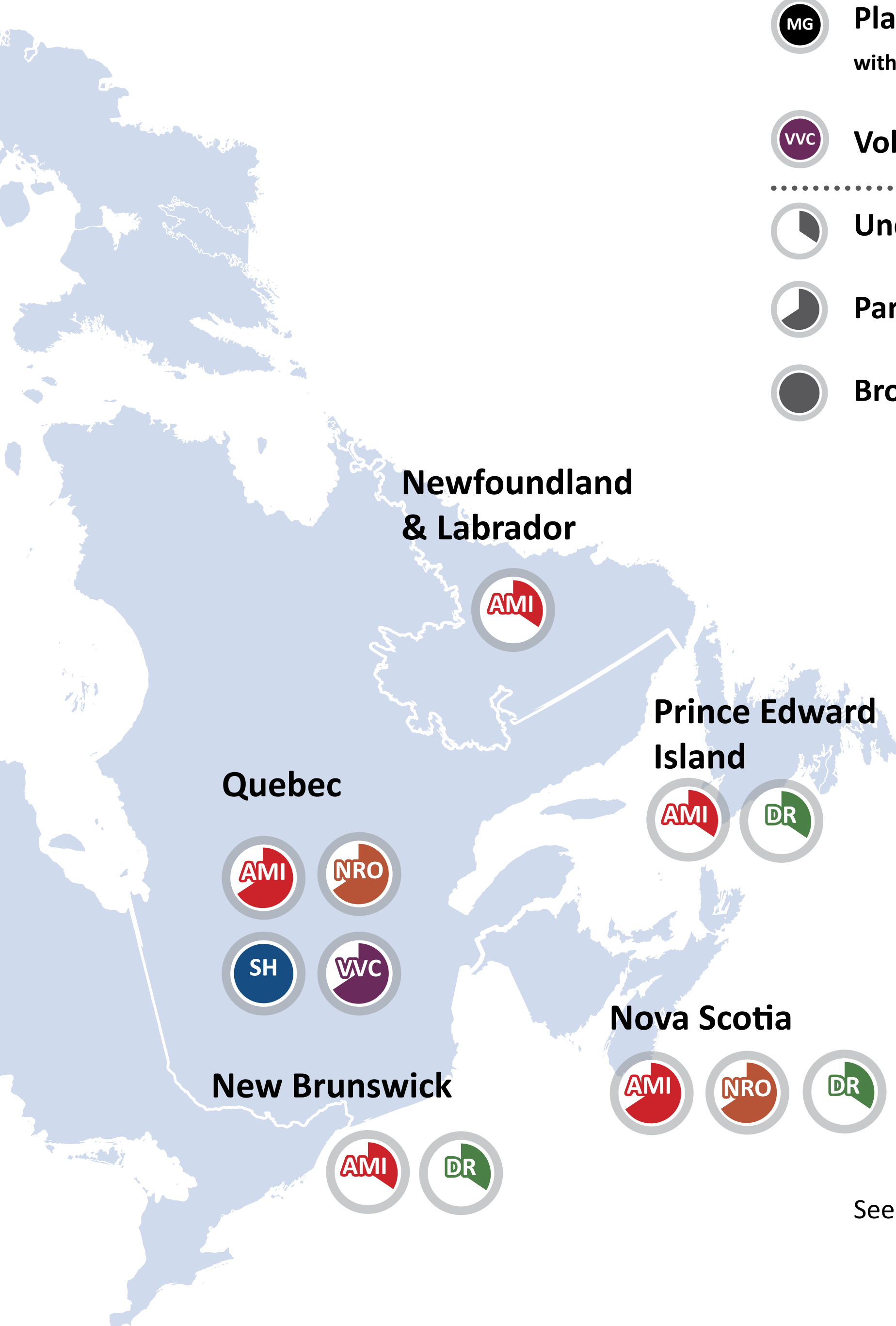
Smart Grid Deployment in Canada — 2013



As each province and territory has a unique infrastructure, system assets, and supply and demand characteristics smart grid applications will not be deployed in the same order and same anner across the country. The number of projects in a province or territory indicates levels of technology deployment, but should not be interpreted to rank one province or territory above another in terms of smart grid. For example, some provinces may never broadly deploy microgrids but rather choose to apply them only to certain parts of the system.Local and regional priorities will determine which applications are invested in more fully.

- AMI — Advanced Metering Infrastructure
- NRO — New Rate Options
- DR — Demand Response for Load Shifting or Ancillary Services
- SH — Self-Healing Grids (fault detection, isolation and restoration)
- MG — Planned Islanding or Smart Microgrids with local generation and/or storage
- VVC — Voltage and Reactive Power (var) Controle

- Under Study / Small Pilots
- Partial / Ongoing Deployment
- Broad Deployment



See Appendix A for textual descriptions

Smart Grid Standards – Carving out the playing field and leveling it

The national adoption of internationally accepted interoperability standards will give Canadian stakeholders the widest possible selection of smart grid products and services and will help to ensure that privacy and security requirements are met.Familiarity with these standards will also help to ensure that Canadian companies develop products for the broadest possible international marketplace.

In 2012 the Standards Council of Canada and the Canadian Electricity Association agreed to co-chair Canada's Smart Grid Standards Advisory Committee (SGSAC). This advisory committee will provide strategic advice, input and guidance for the implementation of the Canadian Smart Grid Standards Roadmap[4] to ensure the deliverables are relevant in a Canadian context and in the best interest of Canada.

Composed of stakeholders from government, industry and consumers, members of the Advisory Committee are looking at smart grid policy, legislation and regulatory considerations, privacy and security requirements, as well as implementation issues from a Canadian context.

Over the next three years, it will:

- Solicit feedback on the adoption of smart grid standards by utility and service providers;
- Identify standards related to smart grid being adopted in federal, provincial and territorial regulations;
- Aim to better understand the privacy and cyber-security implications associated with the deployment of the smart grid in the Canadian context; and
- Examine cross cutting issues associated with the use of smart meters as associated products and services.

For further information, please contact Visar Mahmuti of the Standards Council of Canada or Devin McCarthy of the Canadian Electricity Association[5].

[4] The Canadian Smart Grid Standards Roadmap: http://www.scc.ca/en/about-scc/publications/roadmaps/canadian-smart-grid-standards-roadmap

[5] Visar Mahmuti: vmahmuti@scc.ca Devin McCarthy: mccarthy@electricity.ca

International collaboration on smart grid

Canada continued to actively participate in the International Smart Grid Action Network (ISGAN) in 2012-2013. As one of 24 member countries, Canada played a lead role in producing the following publications and events:

- Case book: "Spotlight on Advanced Metering Infrastructure: AMI Case Book Version 1.0"[6];
- International webinar entitled "Unlocking Markets and Supporting Innovation in Smart Grids"[7].

The AMI Case Book was presented to the 4th Clean Energy Ministerial held in April 2013 in India. It includes 6 cases of country experience with advanced metering infrastructure (AMI), the first of which features Ontario's AMI deployment. The cases describe the AMI project, identify its objectives, key elements of design, results measured thus far and lessons learned. Key findings from the report were discussed under a number of headings including customer engagement, mandatory versus opt-out smart meter roll-outs, combining pricing plans with AMI, privacy and cyber security, big data, and the business case for AMI. The report reveals that many jurisdictions around the world are still considering AMI or are in the early stages of AMI deployment.

Many consider it a platform for further smart grid capabilities, while some do not consider it a necessary technology. Of the 21 countries that responded, 13 were engaged in some level of deployment of AMI, with the remaining countries conducting pilots in AMI technologies to determine their inclusion in smart grid deployment. NRCan served as the lead author and editor for the Case Book, which is available on the ISGAN website.

The Ontario Ministry of Energy organized the "Unlocking Markets and Supporting Innovation for Smart Grid" webinar, hosted by the Clean Energy Solutions Center. Ontario's presentation was complemented by the perspectives of the India Smart Grid Forum, operating in an emerging market, and by Siemens Canada as a multinational industry player in smart grid. The webinar explored policy drivers, the dynamics between players, and different approaches to enabling utilities and industry to innovate in the way that they implement smart grid and develop new smart grid technologies. The slides and a recording of the webinar can be found online on the Clean Energy Solutions Center website.

Exporting Canadian smart grid technology and expertise

Canada's Department of Foreign Affairs, Trade and Development (DFATD) has identified smart grid as a sector with key potential for Canadian export, trade and international collaboration. In the past year, several activities have organized a Smart Grid Mission to Europe, and hosting other delegations from Central and South America.

The mission to Europe in November 2012 brought a delegation of select Canadian industry and academia representatives to five leading European centers in smart grid research and development. Canadian companies were able to identify opportunities in the European marketplace along with some immediate opportunities for follow-up conversation.

[6] ISGAN, Spotlight on Advanced Metering Infrastructure: AMI Case Book Version 1.0, 2013: http://www.iea-isgan.org/?r=home&m=upload&a=download&uid=1344

[7] ISGAN, Unlocking Markets and Supporting Innovation in Smart Grids webinar, retrieved September 2013: https://cleanenergysolutions.org/content/unlocking-markets-and-supporting-innovation-smart-grids-webinar

Canadian technologies in energy storage, power quality measurements, enterprise solutions and communications seem to hold great potential for further developments in the European market. Similarly, Canadian researchers conducted insightful discussions Exporting Canadian smart grid technology and expertise with their European counterparts, opening the door to highly desirable collaborative research, technology partnership and exchange of know-how and resources in this critical field of research for Canada. As a follow-up to this mission, a delegation comprised of multi-national enterprises and small and medium enterprises in the power sector from France, Italy and the UK are visiting Canada in 2013 to forge new agreements for cooperation with potential Canadian companies in the field of smart grid.

Provincial and territorial support for smart grid

Canada is advancing in areas of smart grid development such as load management, data management and advanced metering infrastructure. Leadership in these fields is exhibited in large part by its provinces and territories. Smart grid development continued as a policy and programs initiative in a number of provinces and territories during 2012-2013. While each province and territory's approach to smart grid differs according to its assets and needs, a balance of economic development and energy and environmental policy drivers can be found in the provinces most active in smart grid development. A selection of highlights from the provinces and territories are included here.

ONTARIO: Supporting new technology development, Ontario continued funding for smart grid projects, investigated the development of a Clean Energy Institute, provided funding for a Smart Energy Centre of Excellence in northern climates, and launched the Green Button program.

- In July 2013 the Ministry of Energy announced that its Smart Grid Fund will accept a second round of project proposals for pre-commercialization demonstrations and capacity development projects[8]. In this second round, private companies, colleges, universities and non-governmental organizations can be accepted as project proponents and utilities can receive funding to support their participation in the project.
- During the last year, Ontario has been investigating the potential of a Clean Energy Institute, posed in June 2012, to serve as a catalyst for energy sector collaboration. MaRS, the Ontario Ministry of Energy and the Ministry of Economic Development, Trade and Employment who are driving that process are nearing the end of the review period.
- The Northern Ontario Heritage Fund Corporation announced funding for a Smart Energy Centre of Excellence[9] in Sault Ste. Marie. It will focus on advanced energy generation and energy management projects with community benefit, developing new smart grid technology and regional investment vehicles. The Center also plans to host an international smart energy conference for smaller cities.
- Ontario is the first jurisdiction outside of the US to launch a Green Button[10] program. It is working in collaboration with local distribution companies and partners in the US to employ standards and best practices for all customers to securely and easily access their energy data. The Green Button initiative is discussed in greater detail later in this report.

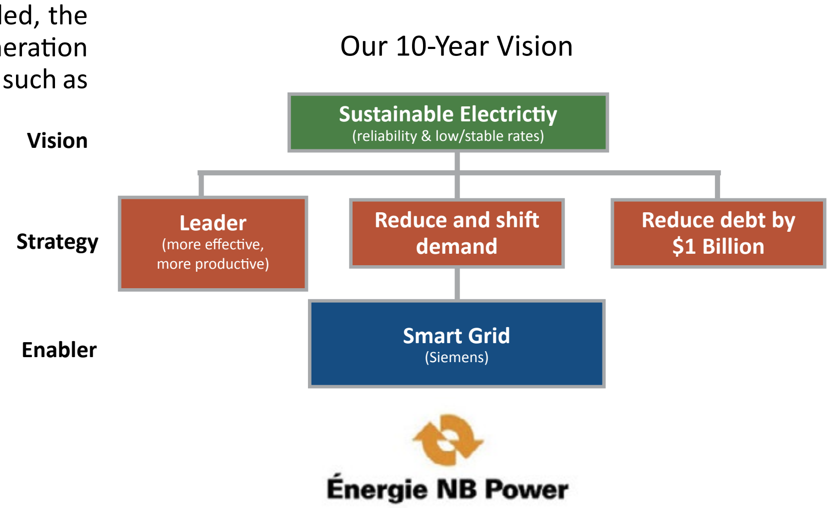
[8] Ontario Ministry of Energy, Smart Grid Fund, retrieved September 2013: http://www.energy.gov.on.ca/en/smart-grid-fund/
[9] Sault Ste Marie Innovation Centre, Smart Energy Centre of Excellence: http://www.sootoday.com/content/news/details.asp?c=58203
[10] Ontario Green Button Initiative: http://greenbuttondata.ca

In part to address the role of local distribution companies in the development of smart grid and smart grid technologies, the Ontario Energy Board (OEB) released two reports in the last year. These reports are in response to Ontario's Directive[11] to the OEB to promote smart grid development in the province. The first was a Supplemental Report on Smart Grid[12], which provided further guidance for smart grid plans to be developed by local distribution companies, and introduced a scorecard approach to measuring performance. Five months later, the Ontario Energy Board released its Staff Report to t he Board on PerformanceMeasurement and Continuous Improvement for Electricity Distributors[13]. The report presents a proposed scorecard for measuring performance that is intended to provide more performance-based regulation through eight new customer-centric measures.

A timeline of these and other smart grid events in Ontario is presented in the Ontario Smart Grid Forum's recent "Ontario Smart Grid Progress Assessment: A Vignette"[14], along with insights and recommendations for the coming years.

NOVA SCOTIA: Integrating distributed and renewable generation is a major driver for smart grid in Nova Scotia. Nova Scotia has set a target for 25% of its energy to be supplied by renewable energy by 2015, increasing to 40% by 2020. With over 320 MW of wind already installed, the province experienced 37.5% of its total energy generation from wind in September 2012. Smart grid initiatives such as opt-in Time-of-Day rates and storage technologies are being explored for their role in enabling greater customer control over their energy use and supporting high penetrations of renewable generation on their grid.

Ontario continues to show leadership internationally with public programs, pilot markets, and regulatory reform intended to result in benefits in the province's energy, environment and economy through smart grid. In the last year, the government recognized storage technologies as a technology area with significant potential for system and economic benefit. It posted a request for information on issues related to integrating storage into the system and how to capture the value of the diffuse benefits that storage offers. In December 2012, the Independent Electricity System Operator (IESO) of Ontario procured 10 MW of regulation capacity in a pilot to test the ability of alternative sources of stored energy to provide regulation and other services to the grid. Through a competitive process, three vendors were selected to provide regulation services from lithium-ion batteries (RES Canada), fly wheels (NRStor, Temporal Power) and commercial load management (ENBALA). The pilot represents an important step in leveling the playing field for grid services.



10-Year Vision for New Brunswick Power

11 Ontario Ministry of Energy, Smart Grid Directive to the OEB, 2010: http://www.ontarioenergyboard.ca/OEB/_Documents/Documents/Minister_directive_smart_grid_20101123.pdf

12 OEB, Supplemental Report on Smart Grid, 2013: http://www.ontarioenergyboard.ca/OEB/_Documents/EB-2011-0004/Supplemental_Report_on_Smart_Grid_20130211.pdf

13 OEB, Report to the Board on performance measurement, 2013: http://www.rds.ontarioenergyboard.ca/webdrawer/webdrawer.dll/webdrawer/rec/402097/view/Staff%20Report%20to%20the%20Board_20130704.PDF

14 Ontario Smart Grid Forum, Ontario Smart Grid Progress Assessment: A Vignette, 2013: http://www.ieso.ca/imoweb/pubs/smart_grid/Smart_Grid_Progress_Assessment_Vignette.pdf

British Columbia completed the roll-out of BC Hydro's smart meter program in 2012. In 2013, the provincial regulator approved FortisBC's application to roll-out smart meters in its jurisdiction, with the direction that the utility provide an opt-out provision for customers who do not accept the smart meters offered.

NEW-BRUNSWICK: New Brunswick released its "Clean Electricity Act" on May 7, 2013. It provides further guidance on electricity in New Brunswick, including the reintegration of many divisions of New Brunswick Power. This vertically integrated utility has adopted a 10-year plan to provide sustainable electricity to maintain reliability and low electricity prices. The strategy identified the reduction and shift. in consumption as one of three pillars of business development over the next 10 years. The vision will be implemented in collaboration with Siemens through its Smart Grid Compass methodology and the newly opened Smart Grid Center of Competence in Fredericton. Under this strategy, the province should be able to reduce the need for additional network capacity by implementing smart grid technologies and systems.

ALBERTA: Action in Alberta for 2012-2013 focused primarily on smart grid technologies that help integrate intermittent renewables. Action spanned all levels of the electric industry, including investor owned utilities, the Alberta Electric System Operator (AESO), Transmission Facility Owners (TFOs), the Climate Change Emissions Management Corporation (CCEMC), and Alberta Energy.

- As of September 2013, five investor-owned utilities had announced energy storage project proposals. Lancaster Wind Systems Inc. proposed a compressed nitrogen hydraulic energy storage system and received $500,000 in funding from the CCEMC[15]. AltaLink Investment Limited Partnership (AltaLink) announced a 14 MW lithiumion battery storage project[16] and entered the AESO connection queue[17]. Suncor Energy Products Inc. (Suncor) announced a battery storage demonstration pilot for its Wintering Hills wind power project and also entered the AESO connection queue. Enbridge Inc. continued to develop a power-to gas electricity storage concept[18]. The CCEMC invited AltaLink, Suncor, and Enbridge to submit full proposals forfurther funding consideration[19]. Finally, Rocky Mountain Power continued developing a proposal for the Saskatchewan Alberta Tie Line, which would deploy compressed air energy storage and serve as a virtual interti[20].

[15] Lancaster Wind Systems Inc., Hydraulic energy storage project, retrieved September 2013: http://ccemc.ca/project/lws-energy-stor age-solution-pilot-project/

[16] CCEMC, 2012 Renewable Energy shortlisted Projects, retrieved September 2013: http://ccemc.ca/wp-content/uploads/2012/12/Re newable-Energy-Website-Project-Descriptions.pdf

[17] AESO, Project list, retrieved September 2013: http://www.aeso.ca/downloads/Final-September_2013_Project_List.xls

[18] CCEMC, 2012 Renewable Energy shortlisted Projects

[19] *Ibid.*

[20] Saskatchewan-Alberta Tie Line Project: http://www.satl.ca/

- In anticipation of connection requests from the above proposals, the AESO released an Energy Storage Initiative Issue Identification paper in June 2013[21]. The AESO has since formed an Energy Storage Work Group to identify solutions for energy storage integration and market participation[22]. A forthcoming discussion paper will prioritize issues and propose possible solutions in late 2013.
- Alberta TFOs continued construction of transmission projects that deploy smart grid technologies. AltaLink is constructing the Southern Alberta Transmission Reinforcement project, which will deploy Flexible Alternating Current Transmission Systems (FACTS) and provide capacity to integrate an additional 2,700 MW of wind. AltaLink is also constructing the Western Alberta Transmission Line and ATCO is constructing the Eastern AlbertaTransmission Line, both of which are 500 kV High Voltage Direct Current (HVDC) lines. These HVDC lines will improve control of power flows and help integrate intermittent renewables.
- Alberta Energy provided grant funding for Alberta Innovates Technology Futures to study the feasibility of different energy storage technologies and integration models. Alberta Energy also continued to develop an Alter native and Renewable Energy Policy Framework (the Framework) for the Government of Alberta. The Framework will identify strategic opportunities to further enable development and use of alternative and renewable energy resources and technologies in Alberta. Alberta Energy anticipates public release of the Framework in 2014.

Combined, these actions throughout the Alberta electric industry provide promising indications for increased integration and market participation of intermittent renewables.

Additional details on provincial programs and activities are provided in the Smart Grid Technology Thrusts section of this report.

Industry collaboration in smart grid

Industry associations and networks are playing an important role in supporting the development of smart grid technologies,markets and policies in Canada.

SmartGrid Canada

At its annual conference, SmartGrid Canada released the results of its smart grid consumer study. It profiled electricity consumer awareness of smart grid and related issues across Canada and revealed that Canadians are generally open to the concept of smart grid and smart homes[23]. This study is being repeated in 2013 and will be presented at the annual conference.

SmartGrid Canada is an industry association committed to promoting the Canadian smart grid nationally and internationally. Among its numerous activities, the organization acts as a national expert for ISGAN work, represents Canada internationally through the Global Smart Grid Federation, and organizes trade missions to promote the industry in different countries.

[21] AESO, Energy Storage Initiative Issue Identification paper, 2013: http://www.aeso.ca/downloads/Formatted_ES_IS_Paper_Final_20130613.pdf

[22] AESO, Storage Workgroup Invitation, 2013: http://www.aeso.ca/downloads/Storage_Workgroup_invitation_.pdf

[23] SmartGrid Canada, Consumer Research: http://sgcanada.org/info/consumer-research/

Canadian Electricity Association

The Canadian Electricity Association (CEA) provides a voice for utilities and the electricity business in Canada. In the past year, the CEA has engaged in two important new initiatives for smart grid: the first is co-chairing the Smart Grid Standards Advisory Committee; the second is a partnership with Sustainable Development Technology Canada to support utility participation in smart grid technology demonstration projects. In its 2013 "Power for the Future: Electricity's Role in a Canadian Energy Strategy"[24], the CEA reported that 108,000 jobs were in the electricity sector in 2010, $21.5 billion was invested in infrastructure in 2012, and $350 billion is required in investment over the next 20 years[25]. Within its recommendations, the CEA recommended that Premiers and governments support innovation in the electricity sector by recognizing utilities as 'test benches' of innovation. Policy and regulatory supports and broader mandates were proposed to enable utility contributions to smart grid R&D and related economic development in Canada.

National Electricity Roundtable

The National Electricity Roundtable (NER) carries out two primary roles of interfacing with the federal government on broad issues that affect the entire electric power industry, and fostering the development of technologies that will also increase exports. Comprised of multi-national companies and utilities, the NER works closely with federal government departments in carrying out a jointly agreed strategy for export development. In 2012, the members elected to focus on smart grid technology and market development. Its Technology Committee has begun work in this area, analyzing the smart grid landscape throughout the country, and identifying opportunities for industry engagement in facilitating Canadian smart grid technology development for export. The Technical Committee and Policy Committee are considering opportunities for collaboration between the NER members in areas of cyber security, transmission-grid control, and demand management.

[24] CEA, Power for the Future: Electricity's Role in a Canadian Energy Strategy, 2013: http://www.electricity.ca/media/ReportsPublications/PowerForTheFutureElectricityRoleCanadianEnergyStrategyE.pdf

[25] Conference Board of Canada, Shedding Light on the Economic Impact of Investing in Electricity Infrastructure, 2012: http://www.conferenceboard.ca/e-library/abstract.aspx?DID=4673

Smart grid technology thrusts in Canada

Each province and territory has its mix of individual supply, demand, and environmental characteristics which determine their investment in electricity infrastructure. The result is a range of smart grid focuses seen across the country. Three major thrusts of activity in the last year from different regions of the country are described here.

Intelligent load management

New Brunswick, Nova Scotia and Prince Edward Island (PEI) are host to a number of initiatives in the field of intelligent demand management or intelligent load management. The initiatives make use of the available storage capacity in electric water heaters and electric space heating systems to shift when electricity is consumed in order to balance wind generation and provide emergency reserve services. Each of these projects require a new form of partnership with customers and an effective engagement approach. Highlights from the Maritime region include:

PowerShift Atlantic: Canada's flagship demonstration in intelligent load management is the PowerShift Atlantic[26] project. Two virtual power plants provide a continuous balancing service for wind power in the region, and provide a contingency reserve to the regional systems.

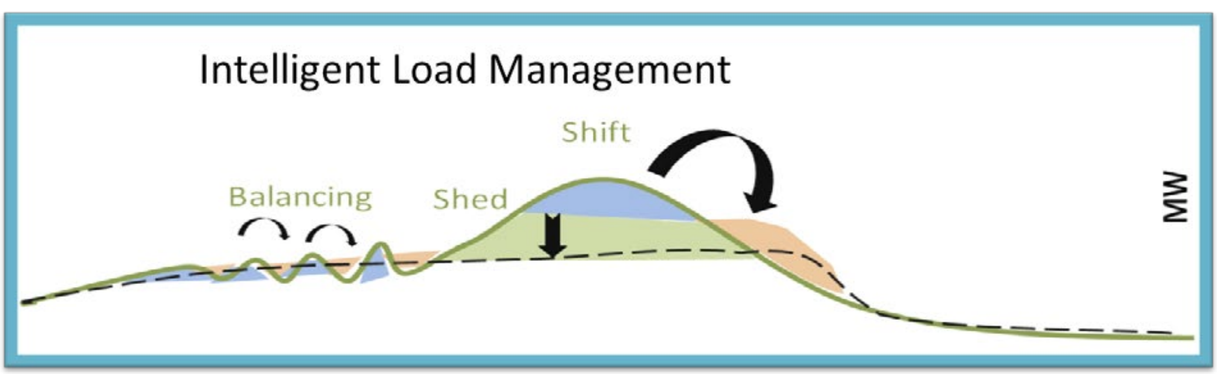
This project is implemented by New Brunswick Power, Nova Scotia Power, Maritime Electric and Saint John Energy, in collaboration with the University of New Brunswick and various Canadian and American companies. With a total budget of $32 million over 5 years, it is the largest smart grid demonstration project in Canada. During 2013, the PowerShift Atlantic team will work to connect 1931 customers resulting in a total of 21.41 MW of installed smart capacity.


A Virtual Power Plant to balance wind energy -
A Canadian Smart Grid Project

PowerShift Atlantic Regional Characteristics

Objectives

PowerShift Atlantic case study, published by CanmetENERGY



[26] CanmetENERGY, PowerShift Atlantic case study, 2013: http://www.nrcan.gc.ca/energy/offices-labs/canmet/publications/smart-grid/14697

Heat for Less Now!: The city of Summerside in Prince Edward Island offers its "Heat for Less Now!" electric heating program powered by off-peak wind generation. The project, managed by Summerside Electric, has installed over 500 water and space heaters which act as thermal storage of wind energy. For participating customers, this program provides heating for less than ¢8/kWh, enabling 30% savings over 5 years compared to heating with oil. By making use of electricity generated by wind in off-peak times—that was previouslysold to neighbouring jurisdictions at a discount—the program offers savings on both the electricity bill and the heating bill. The $1.6 million pilot project was funded in part by the Federation of Canadian Municipalities' Green Municipal Fund and received a Sustainable Community Award in 2013.

Time-of-Day Pricing and Smart Heating: Nova Scotia has an opt-in Time-of-Day rate which offers customers with smart appliances savings by consuming more electricity in off-peak imes. In its first few years of operation, more than 10,000 smart heaters capable of responding to price signals have been installed in the province.

These intelligent demand management projects demonstrate how it is possible for Canadian utilities to expand their service offerings with new equipment and new pricing options that benefit both customers and the system. New business models need to be developed in order to transition from the traditional service of simply providing electricity.

Siemens Canada opened its Smart Grid Centre of Competence in Fredericton, New Brunswick, in 2013. In partnership with New Brunswick Power, the Centre will host the design and roll-out of smart grid software to reduce and shift demand and modernize the grid. The centre has already hired more than 30 staff, 15 of which are researchers focusing on smart grid and intelligent load management. Siemens intends to complement this with university research and is currently exploring partnership opportunities.

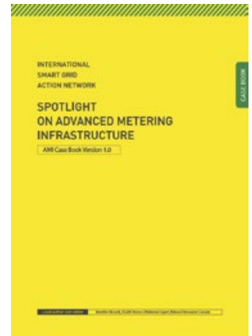
Big data

Ontario is one of the first jurisdictions in the world to have deployed smart meters for residential customers and small commercial customers throughout its system, as reported in the ISGAN Case Book “Spotlight on Advanced Metering Infrastructure: AMI Case Book Version 1.0”. This important initiative has facilitated a number of follow-on activities to increase the usefulness of the data generated through the advanced metering infrastructure (AMI) for businesses and customers.

Ontario Meter Data Management Repository (MDM/R): With almost 80 local distribution companies (LDCs) in the province, Ontario developed a centralized meter data management system it calls the Meter Data Management Repository (MDM/R). While some utilities are capable of managing their own meter data, the MDM/R system ensures that billing across the province is consistent and accurate regardless of the service territory. The operation of the MDM/R is placed under the responsibility of the Independent Electricity System Operator (IESO). In operation since 2008, 4.5 million smart meters send hourly data to this system, generating a rich data set from which to create value for customers, LDCs and the broader electricity system in the province. Currently, the system processes more than 96 million meter reads and responds to 130-250 thousand billing requests per day, but additional functionality can be enabled so that the system can do more than billing for local distributors.

To this end, the Ontario Ministry of Energy has initiated consultations with IBM (the Operational Service Provider) to solicit expert advice on the potential use and future development of the MDM/R. Various options are being considered which could support business applications such as demand management and energy conservation, platforms for customer engagement and network management in real time. In this way, the MDM/R can support consistent services across the province, and promote innovation.

Green Button: Extracting value from big data requires some standardization. Launched by the Ontario Ministry of Energy in 2012 in partnership with MaRS Data Catalyst, the “Green Button” standard is being brought to Ontario to allow customers easy access to view and use their meter data.



The case book regarding Spotlight on Advanced Metering Infrastructure from the International Smart Grid Action Network deals with AMI deployment in Ontario

Green Button

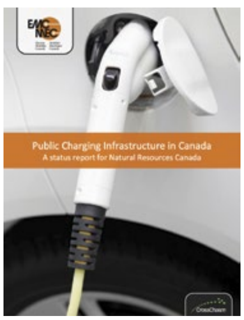
In April 2012, IBM opened the doors to its Canada Research and Development Centre in Markham, Ontario. The Centre, which connects multiple research locations, hosts world-leading research as part of a consortium with $210 million of investment and participation from 7 Canadian universities and industry. Research focuses on game-changing domains, in energy, health, water, cities and agile computing. The Centre has hired over 200 researchers and developers to date where smart grid is a focus amongst a range of agile research, cloud and big data projects.

The first derivative of the Green Button program is the "Download My Data (DMD)" standard, which enables customers to download information about their electricity use from the LDC website with a simple click. Currently, this application is available in more than 7 utilities providing electricity to 2.6 million customers in the province. A second "Connect My Data (CMD)" standard will be piloted in late 2013. This standard will allow a customer to authorize and share their own consumption information with a third party, such as an energy service company.

GE Canada opened its Grid IQTM Global Innovation Centre in October 2012. Located in Markham, Ontario, the $40 million Centre is designed to foster innovation and collaboration on projects to improve grid efficiency, reliability and security. One of the immediately visible ways GE facilitates this is with its Customer Experience Centre, featuring a 60-foot interactive display of smart power systems that can be built today and in the future.

Electric vehicles (EV) infrastructure

In Canada, more than 4,300 electric vehicles (EVs) have been sold to date according to the Plug `N Drive[27] estimate at the time of writing. According to a study by Electric Mobility Canada in 2013[28], more than 744 recharging stations for electric vehicles are available in the country, able to charge more than 945 vehicles (with multiple charging heads per location). The number of charging stations and charging locations has increased in recent months, following a number of government incentive programs. For example, British Columbia reports that over 450 public charging terminals are now installed, which would bring the number of public terminals in Canada to 1,074.



Public charging infrastructure in Canada, April 2013. Courtesy Electric Mobility Canada.

Based on the latest estimates, there would be electric vehicle supply equipment (EVSE) available for public charging available for every 3.7 electric or hybrid-electric vehicles, in addition to the charging stations that customers have for private use. These estimates are considered conservative as there is no mandatory reporting of public infrastructure.

Province	EVSE Locations	EVSE Heads
AB	13	13
BC	259	321
MB	5	5
NB	7	7
NL	7	7
NS	6	6
ON	188	236
PE	11	11
QC	243	334
SK	5	5
Total	**744**	**945**

[27] Plug 'N Drive: http://www.plugndriveontario.ca/

[28] Electric Mobility Canada, Public Charging Infrastructure in Canada, 2013: http://www.emc-mec.ca/eng/pdf/EMC_EVSElocations_NRCan_R2.pdf

VERnetwork: AddEnergie has scaled its charging station network, the VERnetwork[29], beyond Quebec boundaries this year. The company has became the largest provider of networked charging stations in Canada. AddEnergie is the only Canadian manufacturer-operator of charging stations and manages more than 500 EVSEs in Quebec, British Columbia, Ontario and New Brunswick. The VERnetwork allows station owners to set a price for charging, but typically the cost is $1 per hour. In association ation with Ivanhoe Cambridge, Gentec, Rio Tinto Alcan, Sovar and others, AddEnergie will deploy another 600 Level 2 EVSEs and 5 DC fast charge stations to demonstrate its Charging Station Central Network Management System (CSNMS™). It uses a cloud based software system that manages the charging, billing, authentication and the smart grid control applications of the installed base of EVSEs. This project is co-funded by the project partners and Natural Resources Canada's ecoENERGY Innovation Initiative fund.

AddEnergie charging stations

Whistler – San Diego Green Highway: On January 17, 2013, the Government of British Columbia announced an investment of $1.3 million for the installation of 13 DC fast charging stations. These stations are located in the corridor called the "West Coast Green Highway" which connects California, Washington State, Oregon and now British Columbia by DC fast charge stations. This project is managed by BC Hydro who will own the charging stations, and received funding from the British Columbia Government's $14.3 million Clean Energy Vehicle Program announced November 5, 2011.

Montreal – Burlington EV Charging Corridor: On June 17, 2013, the governments of Quebec and Vermont announced a partnership for the Quebec-Vermont EV Charging Corridor. Early in the fall of 2013, EV drivers will have access to 31 public charging stations along the 160 km between Montreal and Burlington, Vermont. These stations are integrated into Hydro-Quebec's Electric Circuit[30] and the Drive Electric Vermont network.

Interactive Smart Grid Zone in Boucherville: There are many tests in Quebec studying the impact of EVs onelectrical networks. Results so far indicate that the integration of charging stations for EVs should not cause problems on the Hydro-Quebec distribution network which was designed for a winter peak from electric heating. Despite this, Hydro-Quebec is taking a proactive and conservative approach to EV integration. The Smart Grid Zone in Boucherville was designed with this purpose in mind, to carefully study the interaction between the network and various EV charging components as part of the $25.5 million project with funding from NRCan. This Smart Grid Zone hosts nearly 31 model Mitsubishi i-MiEV all electric vehicles. There are 45 AC Level 1 and 2 charging stations and 1 DC fast charging station installed. Towards the end of 2013, a "Vehicle to Grid" smart charging station is planned. The stations in the Smart Grid Zone are managed by the Electric Circuit with operational support from the Canadian Automobile Association (CAA).

EVs in Hydro-Quebec's Smart Zone

[29] AddEnergie, VERnetwork: http://www.reseauver.com

[30] Hydro-Quebec Electric Circuit: http://www.lecircuitelectrique.com/index.en.html

Nova Scotia ShareReady Electric Vehicle Pilot Program: Nova Scotia is considering the impact of EVs with its Share-Ready Electric Vehicle Pilot program[31]. In a study of the environmental benefits of EVs in Nova Scotia, researchers found that with the current supply mix the EVs produced less greenhouse gases than the most fuel efficient gasoline vehicles in their class. Considering the province's renewable generation targets, the environmental benefits of adopting EVs are expected to increase throughout that period.

Tools for Customers and Utilities: EVs raise important issues for utilities to support the charging infrastructure. As the number of EVs increase, utilities need to prepare to support the charging of these vehicles. Ontario hosted an EV Roundtable with LDCs to explore steps toward EV integration into the grid. Complementing their EV rebate program offering customers between $5,000 and $8,500, Ontario began offering rebates of $1,000 or 50% of the cost of installing home charging systems in January 2013[32]. While similar incentives are offered in Quebec and British Columbia, under the Ontario program customers register their charging location (by postal code), giving utilities greater visibility of incoming loads. Non-profit Plug `N Drive[35] offers services to customers to help them through the EV charger selection and installation process, provides maps of public charging locations in partnership with CAA, and provides education tools for EVs and EV charging.

[31] Ontario Ministy of Transportation EV charging rebate, retrieved September 2013: http://www.mto.gov.on.ca/english/dandv/vehicle/electric/

[32] Plug `N Drive: http://www.plugndriveontario.ca/

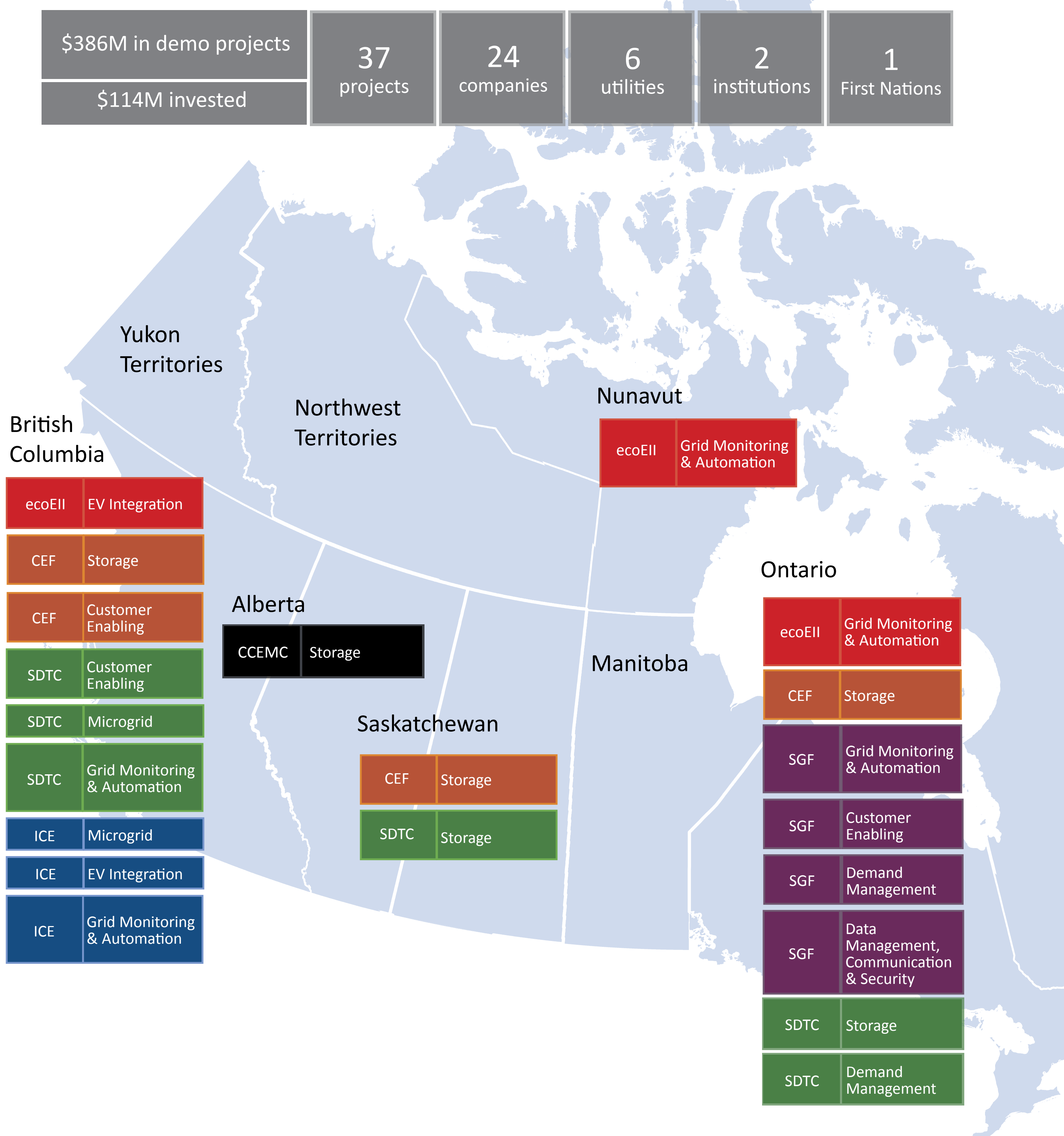
Smart grid innovation in Canada – A multi-faceted system

Smart grid R&D, demonstrations, and pilots in Canada tell a story of government funding, utility leadership, industry innovation and evolving markets. The dialogue in Canada continues around the business case for smart grid technologies, removing barriers to technology adoption and technology development, and supporting economic development with a growing industry sector. It's an important time for shared learning, collaboration and stretchgoals. Figure 3 highlights publicly funded demonstration and pilot projects across the country, representing $114 million in investment in smart grid projects recently completed or ongoing. There are 37 projects from 7 different funds included in this scan in the categories of cyber security, demand management, EV integration, grid monitoring and automation, microgrid, data management and communication and storage demonstration. Together, they amount to over $386 million in total project value, the bulk of which was invested in the past five years. A list of these projects is found in the Appendix A of this report. These projects are part of what grew to be a billion dollar sector in 2013 in Canada, largely through utility investment.

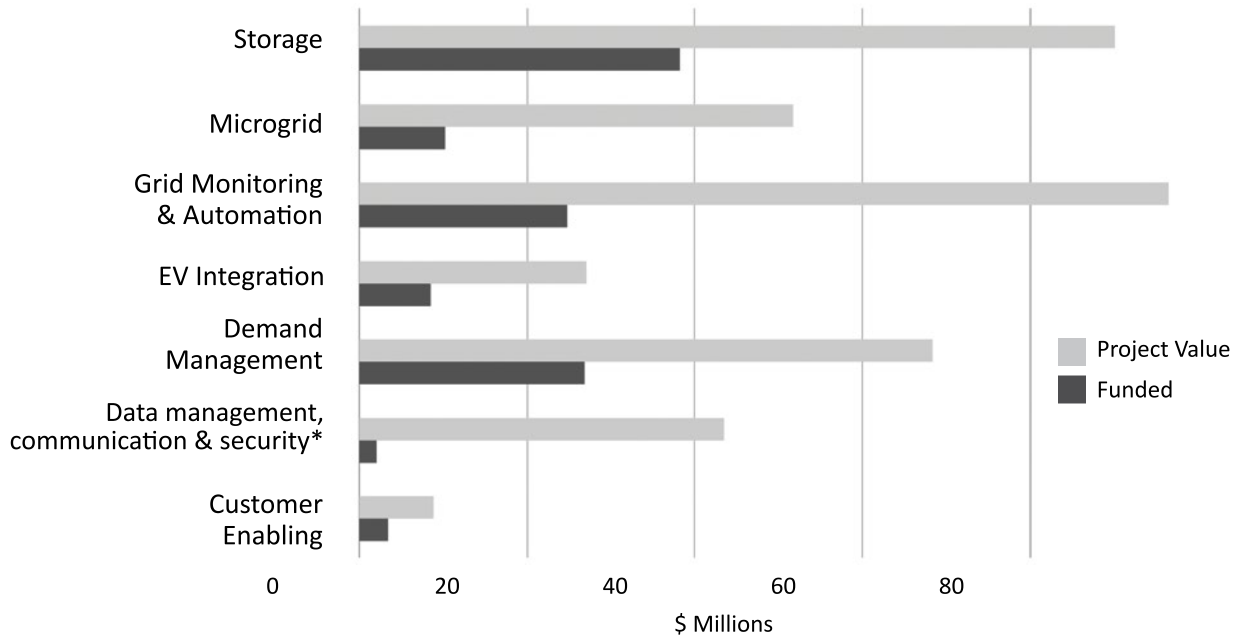
Canada's utilities are at the center of achieving clean, reliable and sustainable electricity supply supported by smart grid systems. As one of its seven recommendations in their July 2013 "Power for the Future" report, the CEA encouraged Canadian Premiers and their governments to support innovation in the electricity sector by seeing utilities as test beds of innovation, and by creating more adaptive regulatory environments that can in turn create incentives for innovation. Provincial, territorial and national efforts to support innovation in smart grid and energy systems must include engaging utilities in order to develop Canadian solutions and support economic development. Most of the demonstrations in Figure 3 have been in partnership with utilities both large and small.

Figure 3

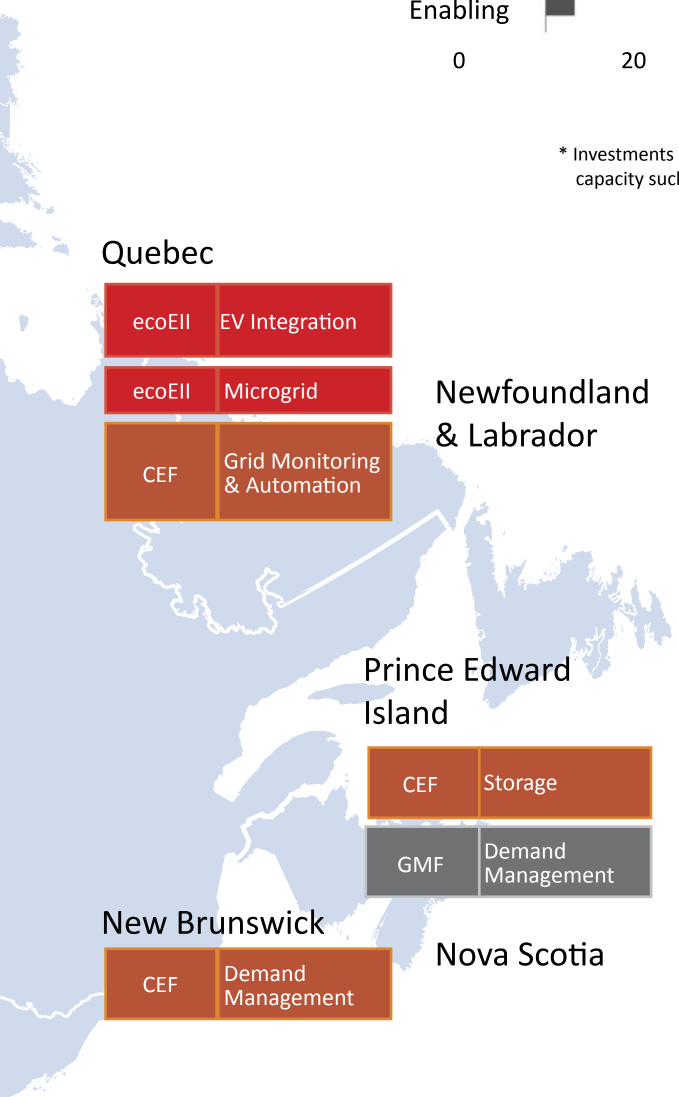
Publicly Funded Smart Grid Demonstrations & Pilots in Canada



Smart grid project value by technology area 2005 - 2013



* Investments in this category include cross-cutting data analytics technology and capacity such as the IBM Canada R&D Centre



- ecoEII — NRCan – ecoEnergy Innovation Initiative
- CEF — NRCan – Clean Energy Fund
- SDTC — Sustainable Development Technology Canada – SD Tech Fund
- GMF — Federation of Canadian Municipalities – Green Municipal Fund
- ICE — BC – Innovative Clean Energy Fund
- CCEMC — Alberta – CCEMC
- SGF — Ontario – Smart Grid Fund

See Appendix A for textual descriptions

These demonstration and pilot projects are part of a growing Canadian innovation ecosystem for smart grid technologies. Throughout the innovation chain, multiple players are brought together through the stages of early and applied R&D, demonstration, pilots and commercialization. Federally, the Natural Sciences and Engineering Research Council (NSERC), Social Sciences and Humanities Research Council (SSHRC), Natural Resources Canada's CanmetENERGY, the National Research Council (NRC), and Sustainable Development Technologies Canada (SDTC) actively support internal and external research, development, and commercialization of technologies. In order to train the next generation of innovators and foster greater collaboration and economic development from Canadian technology development, a number of networks are connecting researchers and entrepreneurs in Canada.

One example is SDTC's SD Tech Fund Virtual Incubator, which is working in part with the CEA to encourage innovation partnerships between industry and Canada's utilities on smart grid, distributed energy, and energy storage solutions[33]. Other regional and national initiatives are being explored in the coming year to raise the international profile of Canada's growing smart grid innovation capacity.

While Canada faces a looming skills shortage in the power sector as the previous generation retires, important investments are being made in training the next generation of power systems engineers and entrepreneurs through Canada's smart grid R&D networks and provincial initiatives supporting smart grid entrepreneurs. The NSERC Smart Microgrid Research Network, SSHRC Smart Grid Policy Research Partnership, and CEATI Smart Grid Task Force facilitated partnerships between academic researchers, policy makers, industry members and utilities respectively over the last year to increase Canada's capacity for smart grid policy, technology development and smart grid deployment.

NSERC Smart Microgrid Network

In June 2013, Canada held its first Renewables in Remote Microgrids conference to bring over 150 experts, community members, manufacturers and researchers together from across North America. Sessions were held on how lessons learned from recent successes in places such as Alaska and NWT, along with forward thinking policies, can benefit remote communities and grow domestic clean energy investment, expertise and manufacturing capacity. This conference covered the technical, financial and social aspects of developing more sustainable energy solutions for First Nations and Aboriginal communities, military bases, and mines while showcasing projects with wind and solar integration and smart microgrids. For more information, and presentations, go to the conference website. http://www.bullfrogpower.com/remotemicrogrids/presentations.cfm.

Established in 2010, the NSERC Smart Microgrid Network (www.smart-microgrid.ca) is a major 5-year collaborative project between academia, industry, and government. To date, over 66 students have been recruited to work on projects in the areas of operation, control, and protection; planning and regulatory issues; and communication and information technologies.

In the past year, research teams have worked with industry partners to develop tools and techniques to advance smart grid implementation in Canada. For example, innovative control and energy management strategies have been developed and are beingimplemented to maintain critical downstream distribution loads with battery and PV systems. Frameworks for identifying and monetizing the costs and benefits of microgrids have been developed. Sensor nodes for communicating real-time environmental data wirelessly have been built and tested.

[33] SDTC, SD Tech Fund Virtual Incubator, retrieved September 2013: http://www.sdtc.ca/index.php?page=virtual-incubator&hl=en_CAA

Members of the network have also been active participants in many smart grid and microgrid forums over the past year, including the Alberta Power and Energy Innovation Forum (Edmonton), Renewables in Remote Microgrids Conference (Toronto), and IEEE Power and Energy Systems General Meeting (Vancouver). In a workshop conceived and hosted by partner BC Hydro, Network students learned to appreciate real-world considerations for designing microgrids for operation during emergency grid outages.

SSHRC Smart Grid Policy Dimensions Research Partnership

Created in 2012, “Unlocking the potential of smart grids: A partnership to explore policy dimensions” entered into its second year of programming. This research network, supported by the Social Sciences and Humanities Research Council of Canada (SSHRC), brings together researchers from five Canadian universities to investigate the policy and other social dimensions of smart grid development and deployment. Joining the researchers are representatives from eight utility, governmental, business and civil society organizations and partners at three universities in the United States. The network has engaged six graduate students in the projects thus far.

In May 2013 at its annual workshop, the Partnership reviewed progress following its first year and agreed plans for its second and third (and final) years. Presentations examined citizen perceptions of smart meters, transportation’s links to the smart grid, regional developments (Ontario, Quebec and parts of the United States) and smart energy networks. The coming year will see detailed studies on a media analysis of smart grid representation in major Canadian newspapers and cross-comparative regional case studies of smart grids (British Columbia, Ontario and Quebec). Additional details, including presentations from the workshop, may be found at the Partnership’s website[34]. Further information may also be obtained from either the Partnership’s lead investigators[35], Prof. James Meadowcroft, Carleton University, and Prof. Ian Rowlands, University of Waterloo.

Centre for Energy Advancement through Technological Innovation (CEATI)

CEATI maintained a strong focus on smart grid initiatives throughout 2012-2013 with a series of webinars, projects and studies participated in by its Canadian and American members and under the guidance of its Smart Grid Task Force. This year’s annual general meeting will focus on smart grid strategic plans, distributed intelligence and interoperability, and addressing integration challenges with advanced field devices. Topics explored in webinars included self-healing grids (automated switching, fault identification and restoration), data analytics, Green Button and the IEEE standardization of Smart Energy Profile 2.0. Among its numerous studies and publications was the National Plugin Electric Vehicle (PEV) Charging Infrastructure Deployment Guidelines[36].

Other reports produced for CEATI members covered energy management systems and demand response, storage, dynamic loading, synchrophasors and fault location, automation and the integration of distributed generation. Publicly available reports can be found on CEATI’s website[37]. Those interested in any of CEATI’s Smart Grid Program reports and other events can contact Program Manager Sonya Konzak[38].

[34] CRSH, Smart Grid Policy Research: http://tinyurl.com/SG-Partnership

[35] James Meadowcroft: james_meadowcroft@carleton.ca, Ian Rowlands: irowlands@uwaterloo.ca

[36] CEATI, Canadian EV Infrastructure Deployment Guidelines, 2013: http://www.ceati.com/freepublications/0536_Web.pdf

[37] CEATI, Online Publications: http://www.ceati.com/publications/free-publications

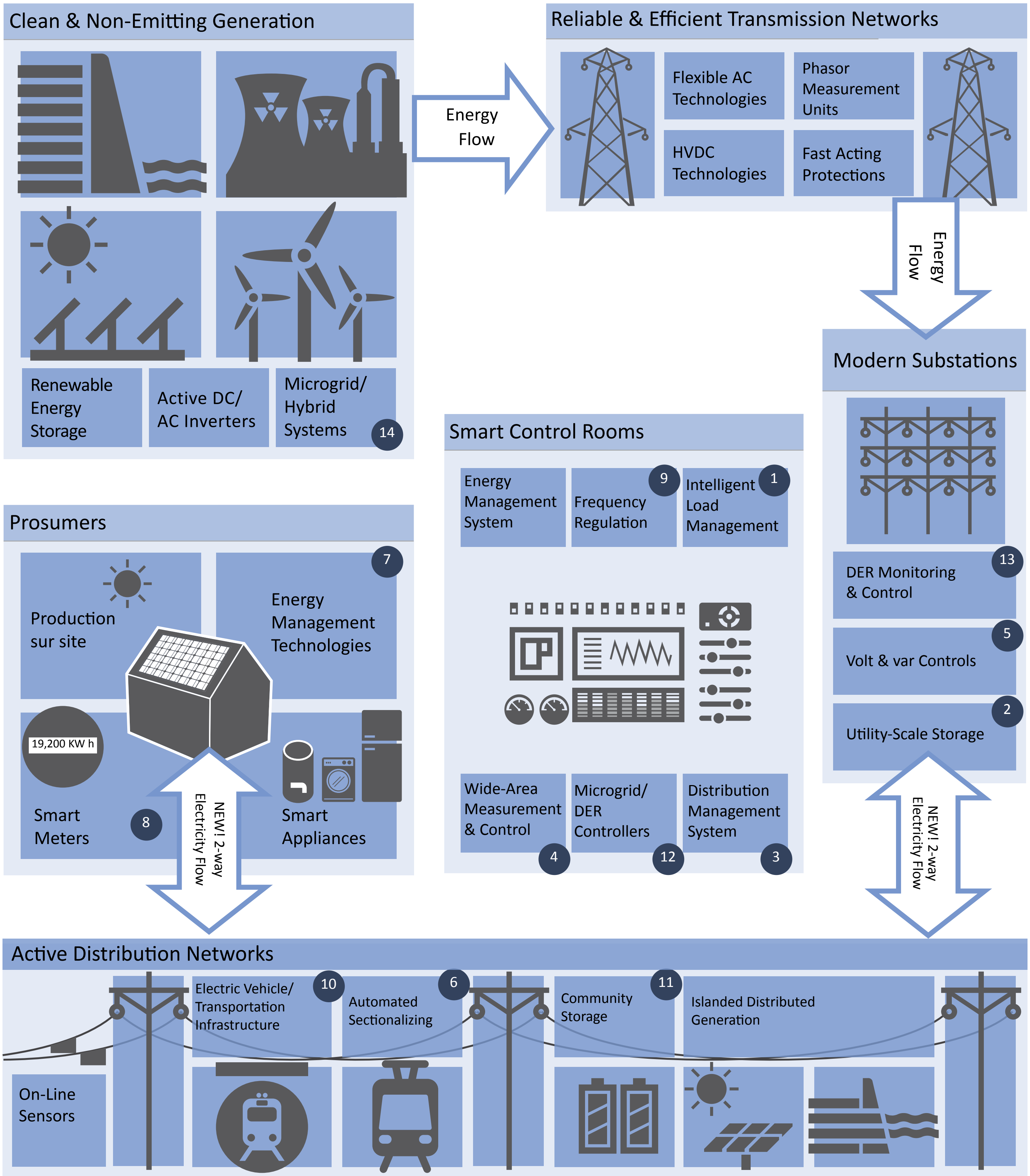
[38] Sonya Konzac: sonya.konzak@ceati.com RSH, Smart Grid Policy Research: http://tinyurl.com/SG-Partnership

The business of building smart grids

Any conversation about smart grid technology development and deployment quickly turns to an important conversation about the business case for the rate-paying customer (who is also a voter) and the desired growth of local economies. The result is a vast array of identified opportunities influenced by traditional approaches to managing electricity systems, game-changing developments in information and communication technologies and systems engineering, limited investment capacity, market dynamics and politics. The conversation is local, regional, national and international in scope between all stakeholders in smart grid, but born in particular by electricity regulators. Together with policy makers, utilities, civil society organizations and industry, regulators are working to calculate the economic, environmental and societal value of smart grid investments.

Figure 4 attempts to illustrate the major areas of smart grid implementation in an electricity system, from generation to the empowered consumer, or prosumer. While pictured simply, the following illustration shows how applications on the grid are connected and how investment in one area can benefit other areas of smart grid systems. It also illustrates a trend toward more distributed energy resources. Smart grid technologies can be applied throughout the system to allow remote and automated management of supply and demand on the system in real-time through advanced communication and controls. The side bars highlight projects which are helping to determine the business case for smart grid technologies in each of these areas. The projects include large-scale deployments, demonstrations and pilots, many of which are being conducted in small and mid-size communities across Canada which can offer favourable conditions for testing and learning before scaled deployment.

Figure 4: Smart grid applications throughout the electricity system



See textual description p.30

Figure 4 Legend: Smart grid applications throughout the electricity system

1. **ILM & PowerShift Atlantic: Virtual Power Plant**
   The virtual power plant uses, load and wind forecasting and aggregation capabilities to perform near real-time load shifting of commercial and residential loads and provide new ancillary services to the grid. PowerShift Atlantic will demonstrate one of the world's first virtual power plants designed to allow for more effective integration and balancing of wind power onto the power grid.

2. **Utility-Scale Storage: BC Hydro Energy Storage and Demand Response Project**
   BC Hydro installed a 1 MW NaS battery at their substation in Field. Field is connected to the main grid by a distribution feeder through Yoho National Park that is prone to outages due to weather conditions and falling trees. Now the community can disconnect from the main grid and run as a microgrid for 6-8 hours. Customers participate in a voluntary demand response program while the battery is operating in order to prolong the time that they can run off of battery power during an outage. The battery also supplies the town's peak demand from 4-8pm and is then recharged overnight.

3. **Distribution Management System: Hydro One**
   Hydro One is piloting an Advanced Distribution Management System (DMS) to operate with its Smart Zone in Owen Sound, in a partnership with IBM Canada, GE Digital Energy, Trilliant and Schneider/Telvent. Managing distributed generation, outage management, Fault Location, Isolation and Service Restoration, Operational Analytics and many other systems will be tested and managed by the Smart Zone Advanced DMS.

4. **Wide Area Measurement and Control: ACOR (Synchrophasor-based reactive power compensation) at IREQ (Hydro-Quebec)**
   L'Institut de recherche en électricité du Québec (IREQ) is developing a grid response improvement program which uses wide area awareness and closed loop controls to increase facility capacity, reliability and security. It will improve existing tools and develop new optimization tools, such as a compensator control system to increase grid capacity.

5. **Volt & var Optimization: CATVAR at Hydro-Quebec**
   Hydro-Quebec installed a combined method of conservation voltage regulation and reactive power control, known as CATVAR. The intelligent monitoring and control system maintain end-of-line voltage closer to the lower thresholds, which lead to reduction in energy draw from loads. Reactive power is managed with capacitors to reduce energy losses and better manager the voltage along the feeder.

6. **Automated Sectionalizing: PowerStream Self-Healing System**
   PowerStream is one of the few distributors in North America to have installed a full self-healing grid with centralized decision-making and automated switches and reclosers on its network. The system reduces outages for customers by re-routing power around faulted sections of a feeder. The project includes 20 feeders and 2 substations all remotely monitored and controlled automatically.

7. **Energy Management Technologies: Energate Customer Engagement for the Smart Grid**
   Home energy management systems and tools for customer awareness of their electricity consumption are key components to enabling greater demand response on smart grid systems. Energate Inc. is leading the Customer Engagement for the Smart Grid project which includes 6 Ontario Local Distribution Companies and their customers to test different combinations of portals, mobile applications, smart thermostats and other technologies and programs on Energate's home energy management platform.

8. Smart Meters: Ontario smart meters and advanced metering infrastructure
Ontario was one of the first jurisdictions in the world to fully deploy smart meters and advanced metering infrastructure (AMI) throughout its electricity system. With 4.8 million meters deployed and connected to a centralized meter data management repository, Ontario's Local Distribution Companies are now working with entrepreneurs to develop valuable services for customers and improve their efficiency in delivering the electricity service.

9. Frequency Regulation: IESO Ancillary Services from Alternatives Sources Pilotes
Frequency regulation is typically provided by conventional generation, such as hydro or natural gas to balance the small and sudden changes between supply and demand on the grid on a second-by-second basis. This is usually provided through an Automatic Generator Control (AGC) systems. The Independent Electricity System Operator (IESO) in Ontario is testing the ability of flywheels, batteries and aggregated loads to provide regulation service to the grid with a 10 MW pilot beginning in 2013.

10. EV Integration: AddENERGIE VERnetwork
Electric vehicles (EVs) and other forms of electric transportation can extend the flexibility of smart grids to meet customer needs for clean transportation and grid needs for dispatchable loads. AddENERGIE is building charging networks in Quebec, British Columbia and New Brunswick that in cooperation with local utilities to plan and manage the grid with EVs and charging stations as smart grid assets.

11. Community storage: eCAMION Utility Energy Storage Pilot
eCAMION in partnership with Toronto Hydro has installed a smart lithium-ion battery storage system that can regulate power flow to reduce overloads on the system, reduce demand peaks on the system and improve power quality for a community centre in North York. The 250 kW system is connected to rooftop solar power, the building as well as the grid and is in direct communication with the Toronto Hydro SCADA system to store and release energy on demand.

12. Microgrid and Distributed Energy Resource Controllers: Opus One Integrated Urban Community Energy Project
Opus One is developing and demonstrating a smart grid software/hardware platform to manage electricity generation, storage and resource demand at the distribution level on the Toronto Hydro distribution grid. It will address specific distribution grid challenges, such as how to operate seamlessly within the larger electrical grid system and how to successfully incorporate and manage high local quantities of distributed generation and electric vehicle charging.

13. DER Monitoring and Control: Prolucid Grid Technologies for Distributed Generation
Prolucid is collaborating with Toronto Hydro to demonstrate new grid technologies that will enable the effective introduction and management of Distributed Energy Resources – such as solar, wind, and combined heat and power generation – onto the electricity grid. The system will aim to provide generators and grid operators with the ability to control and curtail generation, monitor the state of the power grid in real-time, and ultimately increase the renewable generation that can be connected to the grid.

14. Microgrids/Hybrid systems: Pulse Energy Microgrid in Hartley Bay
The village of Hartley Bay in British Columbia worked with Pulse Energy to develop a smart microgrid system to decrease the amount of diesel fuel consumed to supply the off-grid community's energy. Using smart meters, they were able to diagnose where the system losses were and develop a strategic maintenance cycle and energy management system. The project used real-time smart meter data, demand response and the operation of the diesel generator to drop the energy consumption by 15-20%, save approximately $77,000 per year in diesel costs and solve voltage problems and increase the generator life.

Outlook for smart grid in Canada

On the 10th anniversary of the 2003 blackout, the North American electricity sector has come a long way in increasing the intelligence of its grid and enabling its operators to prevent similar wide-spread events. Smart grid is building off of Canada's information communication technology (ICT) and clean tech strengths, and presents highly valuable opportunities for economic growth domestically and internationally. With opportunity comes challenges, the complexity of systems change in electricity markets and on interconnected grids demands a level of innovation that crosses sectors and disciplines.

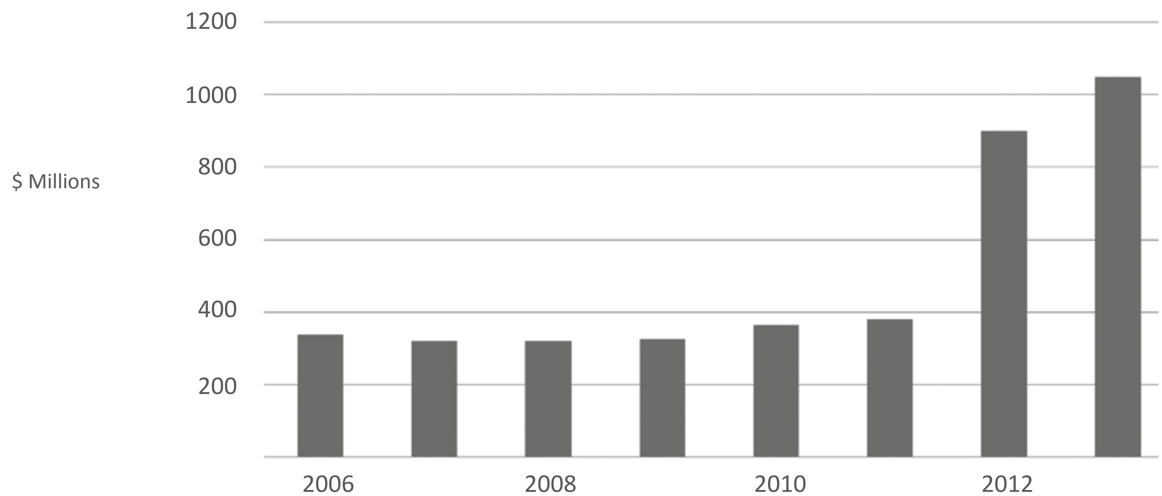
While smart grid is still a relatively new sector for Canada, it is growing. CanmetENERGY estimates the annual investment in smart grid will exceed a billion dollars in Canada in 2013, with major utility investments in AMI and other grid monitoring and automation technologies. Figure 5 was created from a scan of public smart grid R,D&D spending, major smart grid projects deployed by utilities, and estimates of utility invesment in smart grid. Smart grid investments are a growing part of the average $13 billion, estimated by the Conference Board of Canada, which will be invested annually in electricity infrastructure from 2011 to 2030[39].

The 2013 Canadian Clean Technology Industry Report[40] estimated that Canada's smart grid industry claimed $340 million in revenues in 2011, reflecting a growth in the number of companies and the global market. $54 million of those revenues were reported to be invested in R&D. While only 67% of companies who participated in this study were actively exporting, 80% of these expect to within the next two years. Canada's capacity for innovation and export is important because the potential gains are global in scale. As the third largest exporter of electricity in the world, Canada's domestic market offers favourable conditions for figuring out solutions that can serve a diverse range of electricity markets. There is a lot of potential for innovation in Canada's 582 TWh of annual electricity demand, spread over diverse geographies, demographics, markets and climates.

[39] Shedding Light on the Economic Impact of Investing in Electricity Infrastructure: http://www.electricity.ca/media/pdfs/Advocacy%20 Reports/EconomicImpact_SheddingLight_E.pdf

[40] Analytica Advisors, The 2013 Canadian Clean Technology Industry Report – Complete Edition, (Ottawa) 2012

Figure 5: Canadian smart grid investment has grown into a billion dollar market



Note: Investments in generation, transmission and distribution capacity expansion or refurbishment are not included

Canadian leadership in smart grid is evidenced by active participation from its provinces, utilities, system operators, and researchers in the International Smart Grid Action Network, international standards development, and the Green Button standard, world-class demonstration projects and multi-national investment in R&D in Canada. Looking ahead to the coming year, many new projects are expected to strengthen academic, industry, and utility collaboration with the announcement of Ontario's Smart Grid Fund round two recipients, SDTC's SD Tech Fund, and Virtual Incubator, and other federal and provincial initiatives in development. The Canada Smart Grid Action Network will continue to share the lessons learned from these experiences, facilitate cross-jurisdictional conversation, and promote greater collaboration in this growing sector.

Appendices

Appendix — A

Textual description of Figure 1:

Figure 1 illustrates the knowledge domains connected through the Canada Smart Grid Action Network. It organizes different sources of knowledge under four categories: Research & Development Expertise, Project Results & Insights, Industry Transition, and Policy. These domains are connected at the centre by the national Canada Smart Grid Action Network, and the International Smart Grid Action Network.

Shown as sources of Research & Development Expertise are:
- Federal, provincial and territorial and industry research, development and demonstration expertise; and
- Research and development academic networks such as the Smart Microgrid research network and the Smart Grid Policy Partnership.

Shown as sources of Project Results and Insights are:
- Federal, provincial and territorially funded project reports and case studies; and
- The smart grid annual report in Canada (this report).

Shown as sources of Industry Transition knowledge and experience are:
- Industry associations, forum initiatives and conferences;
- Manufacturing, trade and export support; and
- Smart grid standards.

Shown as sources of Policy knowledge are:
- Federal, provincial and territorial electricity working groups;
- Provincial and territorial policies and regulation; and
- The Canada-US Clean Energy Dialogue.

Textual description of Figure 2:

Figure 2 illustrates the deployment of six different smart grid applications in Canada. These applications include:

- **Advanced metering infrastructure (AMI):** Smart meters or advanced metering is commonly referred to as advanced metering infrastructure (AMI) which refers to the meters and the associated communications infrastructure. In Canada it supports automatic remote meter reading and interval metering, enabling new methods of electricity data collection and network planning. The smart meter could also be used as a gateway for information exchange with the customer. Depending on the local conditions, AMI could be used to support outage management, new rate options, demand response, electricity system loss detection and link to in-home displays and energy management systems.

- **New rate options:** New rate options are made possible with the deployment of interval meters (smart meters recording hourly or sub-hourly consumption). New rates can serve different customer energy needs and help to increase the value proposition of electricity services to customers. For example, time of use and off-peak rates offer customers incentives to reduce and or shift their peak demand to take advantage of off-peak heating and cooling rates. Net metering rates can be used to measure the contribution of embedded generation to system value. Prepaid rates can offer budget constrained customers a means of avoiding debt and keeping the lights on.

- **Demand response:** The primary purpose of demand response programs is to decrease system peaks. Electricity systems have a capacity limit beyond which new electrical infrastructure must be built to satisfy any increase in demand. Demand Response applications provide cost effective solutions to avoid or at least defer the capital expenditures and operational costs of increasing the size of the system. In general, demand response can be implemented in one of two ways: through a direct load control (instructional signal) sent by the utility or system operator or third party aggregator to a customer; or through an indirect control (price signal) sent to a customer. New forms of load management and technologies, such as virtual power plants, are being developed to provide ancillary services to the grid, such as spinning reserve, load following (e.g. wind variation smoothing) and frequency regulation.

- **Self-healing grids:** Sometimes referred to as fault location, isolation and service restoration (FLISR), or fault detection, isolation and restoration (FDIR), technologies applied to increase the capacity of the distribution grid to re-route power around faulted sections or restore power from a fault all fall under this category. A fully self-healing grid requires little-to-no intervention from a grid operator. However, the deployment of remote controlled switches and reclosers on utility feeders is considered a starting point. Greater intelligence can be provided through real-time feeder sensing and information and control systems such as outage management systems (OMS) and distribution management systems (DMS).

- **Microgrids:** Planned islanding takes advantage of distributed generation or storage as a way to create a "microgrid" within a larger network that can be isolated and maintained during outages on the surrounding grid. The distributed resources could also be used to reduce the peak demand in the area. At this point in Canada the deployment is rare, but guides are being developed to facilitate the transition to this functionality in locations across the country.

- **Voltage and reactive power (var) control:** Voltage and reactive power (var) control uses substation automation and capacitors to flatten the voltage profile of a feeder, leading to energy conservation and loss reduction. VVC applications can also allow distribution networks to support greater amounts of variable power from renewable electricity generation such as wind and solar photovoltaic. VVC applications can be standalone installations at substations, or integrated into distribution management systems (DMS).

The level of deployment of these applications is indicated for each province and territory as either being under study or planned (1/3 pie chart), partially deployed or in a state of ongoing deployment (2/3 pie chart) or broadly deployed across the province or territory (whole pie). The deployment levels are indicated according to the publicly announced projects or programs and by nature are somewhat subjective.

Figure 2 displays a map of Canada with the provincial and territorial boundaries shown. For each province and territory the deployed smart grid applications as of 2013 are:

Yukon:
- Advanced Metering Infrastructure is under study or in a pilot phase; and
- Microgrids are under study or in a pilot phase.

Northwest Territories:
- Advanced Metering Infrastructure is under study or in a pilot phase; and
- Microgrids are under study or in a pilot phase.

Nunavut:
- Advanced Metering Infrastructure is under study or in a pilot phase

British Columbia:
- Advanced Metering Infrastructure is broadly deployed;
- Self-Healing Grids are under study or in a pilot phase;
- Microgrids are under study or in a pilot phase; and
- Voltage and Reactive Power (var) Control is under study or in a pilot phase.

Alberta:
- Advanced Metering Infrastructure is partially deployed;
- Demand Response is under study or in a pilot phase; and
- Self-Healing Grids are partially deployed.

Saskatchewan:
- Advanced Metering Infrastructure deployment is ongoing

Manitoba:
- Advanced Metering Infrastructure is under study or in a pilot phase

Ontario:
- Advanced Metering Infrastructure is broadly deployed;
- Different Rate Structures or Plans are broadly deployed;
- Demand Response deployment is ongoing;
- Self-Healing Grids are under study or in a pilot phase; and
- Voltage and Reactive Power (var) Control is under study or in a pilot phase.

Quebec:
- Advanced Metering Infrastructure deployment is ongoing;
- Different Rate Structures or Plans are partially deployed;
- Self-Healing Grids are broadly deployed; and
- Voltage and Reactive Power (var) Control is partially deployed.

Newfoundland & Labrador:
- Advanced Metering Infrastructure is under study or in a pilot phase

Prince Edward Island:
- Advanced Metering Infrastructure is under study or in a pilot phase; and
- Demand Response is under study or in a pilot phase.

New Brunswick:
- Advanced Metering Infrastructure is under study or in a pilot phase; and
- Demand Response is under study or in a pilot phase.

Nova Scotia:
- Advanced Metering Infrastructure is partially deployed;
- Different Rate Structures or Plans are partially deployed; and
- Demand Response is under study or in a pilot phase.

Some quick statistics for smart grid applications in Canada are:
- 49% of meters in Canada are advanced meters;
- There is almost 5 GW of distribution-connected generation;
- There are over 4300 electric vehicles; and
- And almost 1100 charging stations for those electric vehicles.

Textual description of Figure 3:

Figure 3 highlights publicly funded demonstration and pilot projects across the country, representing $114 million in investment in smart grid projects recently completed or ongoing. There are 37 projects from 7 different funds included in this scan in the categories of demand management, electric vehicle integration, grid monitoring and automation, microgrid, data management, communication and cyber security, customer enabling and storage demonstration and capacity development projects. The proponents of these projects included 24 companies, 6 utilities, 2 institutions and 1 First Nations community. Together they amount to over $386 million in total project value, the bulk of which was invested in the past five years.

Funds listed are:

- NRCan Clean Energy Fund (CEF);
- NRCan ecoENERGY Innovation Initiative (ecoEII);
- Sustainable Development Technology Canada Clean Tech Fund (SDTC);
- Ontario Smart Grid Fund (SGF);
- BC Innovative Clean Energy Fund (ICE);
- Alberta Climate Change and Emissions Management Corporation (CCEMC); and
- Federation of Canadian Municipalities Green Municipal Fund (GMF).

From 2005 – 2013 the project funding and values for each project category were:

- Storage: over $38 million in funding and over $90 million in project value;
- Microgrid: over $10 million in funding and over $51 million in project value;
- Grid Monitoring & Automation: over $24 million in funding and over $96 million in project value;
- Electric Vehicle Integration: over $8 million in funding and over $27 million in project value;
- Demand Management: over $20 million in funding and over $49 million in project value;
- Data management, communication and cyber security: over $2 million in funding and over $43 million in project value, however much of this value is represented by the IBM Canada R&D Centre which studies cross-cutting data analytics technology outside of smart grid; and
- Customer Enabling: over $9 million in funding and over $27 million in project value.

Project categories were displayed on a Canadian map, indicating which smart grid technology categories were funding in a province or territory, and by which fund. They are listed here:

Nunavut:

- NRCan ecoENERGY Innovation Initiative funded grid monitoring and automation

British Columbia:

- NRCan Clean Energy Fund funded storage and customer enabling projects;
- Sustainable Development Technology Canada Clean Tech Fund funded customer enabling, microgrid and grid monitoring and automation projects; and
- BC Innovative Clean Energy Fund funded microgrid, electric vehicle integration and grid monitoring and automation projects.

Alberta:

- Alberta Climate Change and Emissions Management Corporation funded a storage project

Saskatchewan:

- NRCan Clean Energy Fund funded a storage project; and
- Sustainable Development Technology Canada Clean Tech Fund funded a storage project.

Ontario:

- NRCan ecoENERGY Innovation Initiative funded grid monitoring and automation projects;
- NRCan Clean Energy Fund funded a storage project;
- Sustainable Development Technology Canada Clean Tech Fund funded storage and demand management projects; and
- Ontario Smart Grid Fund funded grid monitoring and automation, customer enabling, demand management and data management, communication and cyber security projects.

Quebec:

- NRCan ecoENERGY Innovation Initiative funded electric vehicle integration and microgrid projects; and
- NRCan Clean Energy Fund funded a grid monitoring and automation project.

Prince Edward Island:

- NRCan Clean Energy Fund funded a storage project; and
- Federation of Canadian Municipalities Green Municipal Fund funded a demand management project.

New Brunswick:

- NRCan Clean Energy Fund funded a demand management project

Publicly funded demonstration projects in Canada

These projects are listed in Figure 3: Publicly funded smart grid demonstration projects in Canada.

Funds	First Year	Province	Category	Project Lead
SGF	2012	Ontario	Customer Enabling	Energate
SGF	2012	Ontario	Customer Enabling	ecoBee
SGF	2012	Ontario	Data management and communication	N-Dimension Solutions Inc.
SGF	2012	Ontario	Data management and communication	IBM
CEF	2010	Maritimes	Demand Management	PowerShift Atlantic
CEF	2010	British Columbia	Customer Enabling	Schneider Power Measurement
SGF	2012	Ontario	Demand Management	Enbala
SDTC	2005	Ontario	Demand Management	Tantalus Systems Corp
SDTC	2005	British Columbia	Customer Enabling	Schneider Power Measurement
GMF	2011	Maritimes	Demand Management	Summerside
ecoEII	2013	Québec	EV integration	AddÉnergie Technologies Inc.
ecoEII	2013	British Columbia	EV integration	BC Hydro
ICE	2012	British Columbia	EV integration	Delta-Q
ecoEII	2013	Ontario	Grid monitoring and automation	Opus One Solutions Energy Corp.
ecoEII	2013	Ontario	Grid monitoring and automation	Prolucid Technologies Inc.
ecoEII	2013	Nunavut	Grid monitoring and automation	Qulliq Energy Corporation
CEF	2010	Québec	Grid monitoring and automation	Hydro-Québec
SGF	2012	Ontario	Grid monitoring and automation	Prolucid Technologies Inc.
SGF	2012	Ontario	Grid monitoring and automation	Essex Energy
SGF	2012	Ontario	Grid monitoring and automation	d-Techs
SGF	2012	Ontario	Grid monitoring and automation	General Electric

Fund	First Year	Province	Category	Project Lead
SDTC	2012	British Columbia	Grid monitoring and automation	Schneider Power Measurement
ecoEII	2013	Quebec	Microgrid	Nimschu Iskudow Inc.
ecoEII	2013	Quebec	Microgrid	TUGLIQ Energy Co.
CEF	2010	Maritimes	Storage	Wind Energy Institute of Canada
CEF	2010	Saskatchewan	Microgrid	Cowessess FN
SDTC	2009	British Columbia	Microgrid	Pulse Energy Inc
SDTC	2006	British Columbia	Microgrid	General Electric (Microgrid)
ICE	2011	British Columbia	Microgrid	Corinex Communications Corp
ICE	2008	British Columbia	Microgrid	BCIT
CCEMC	2011	Alberta	Storage	Lancaster Wind Systems Inc.
CEF	2010	Ontario	Storage	Electrovaya
CEF	2010	British Columbia	Storage	BC Hydro
SDTC	2010	Ontario	Storage	eCAMION
SDTC	2011	Ontario	Storage	Hydrostor
SDTC	2010	Saskatchewan	Storage	Shipstone Corp
SDTC	2010	Ontario	Storage	Temporal Power

Textual description of Figure 4:

Figure 4 attempts to illustrate the major areas of smart grid implementation in an electricity system, from generation to the empowered consumer, or prosumer. While pictured simply, this illustration shows how applications on the grid are connected and how investment in one area can benefit other areas of smart grid systems. It also illustrates a trend toward more distributed energy resources.

The electricity system pictures 6 infrastructure categories that link generation of electricity to the customers or prosumers: clean and non-emitting generation, reliable and efficient transmission networks, modern substations, active distribution networks, and prosumers are all linked together by energy flow. The sixth category, smart control rooms links each of the infrastructure areas together via information communication and controls. Bi-directional energy flow is depicted as a new capability for electricity grids, flowing between prosumers, active distribution networks and modern substations.

The smart grid technologies under each infrastructure category are:

Clean and non-emitting generation:
- Renewable energy storage;
- Active DC/AC inverters; and
- Microgrid hybrid systems.

Reliable and efficient transmission networks:
- Flexible AC technologies;
- HVDC technologies;
- Phasor Measurement Units; and
- Fast acting protections.

Modern substations:
- Distributed energy resource monitoring and control;
- Volt and var controls; and
- Utility-scale storage

Active distribution networks:
- On-line sensors;
- Electric vehicle and transportation infrastructure;
- Automated sectionalizing;
- Community storage; and
- Islanded distribution-connected generation.

Smart control rooms:
- Energy management systems;
- Frequency regulation;
- Intelligent load management;
- Wide-are measurement and control;
- Microgrid and distributed energy resource controllers; and
- Distribution management system.

Textual description of Figure 5:

Figure 5 was created from a scan of public smart grid R,D&D spending, major smart grid projects deployed by utilities, and estimates of utility investment in smart grid. The graph shows a steady investment of approximately $350 million to $390 million in smart grid projects until 2012 when the investment increases significantly to approximately $900 million, and exceeding $1 billion in 2013. Smart grid investments are a growing part of the average $13 billion, estimated by the Conference Board of Canada, which will be invested annually in electricity infrastructure from 2011 to 2030.

Appendix B

Acronyms

AESO	Alberta Electric System Operator
AMI	Advanced Metering Infrastructure
CEA	Canadian Electricity Association
CEATI	Centre for Energy Advancement through Technological Innovation
CCN	Clean Energy Fund (NRCan)
CSGAN	Canada Smart Grid Action Network
DER	Distributed Energy Resources
DFATD	Department of Foreign Affairs, Trade and Development
DR	Demand Response
ecoEII	ecoENERGY Innovation Initiative (NRCan)
EV	Electric Vehicle
EVSE	Electric Vehicle Supply Equipment
FIT	Feed-In Tariff
ICT	Information Communication Technologies
IESO	Independent Electricity System Operator (in Ontario)
ISGAN	International Smart Grid Action Network
IT	Information Technology
MG	Microgrids and/or planned islanding
NER	National Electricity Roundtable
NRCan	Natural Resources Canada
NSERC	Natural Sciences and Engineering Research Council
NSMG-Net	NSERC Smart-Microgrid Research Network
OEB	Ontario Energy Board
NRO	New Rate plans to facilitate customer demand response
R,D&D or R&D	Research, development and demonstration or research and development
SDTC	Sustainable Development Technology Canada
SGSAC	Smart Grid Standards Advisory Committee
SH	Self-healing grids; able to reroute power automatically
SSHRC	Social Sciences and Humanities Research Council
VPP	Virtual Power Plant
VVC	Voltage and VAR (reactive power) Control

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