Flexible Resources Integration in Smart Grid

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INTRODUCTION

Greater power system flexibility is required for integration of a high share of variable renewable energy. While greater power system flexibility could be found in dispatchable power plants, demand side management, storage and Interconnection to other areas, the smart grid will be at the core of future power and information exchange. The **first objective** of this project was to undertake the necessary research in support of the CNC/IEC Task Force on Smart Grid Technologies and Standards in Canada. The **second objective** of this project was to assess a novel communication solution for demand response and renewable balancing. The **third objective** of this project was to clarify the technological options and requirement to ensure seamless integration of distributed energy resources (flexible) in power system operation and markets To meet these objectives a number of outputs were produced during this project.

ACTIVITIES AND RESULTS

CNC/IEC Task Force on Smart Grid Technologies and Standards : Technology standardization is particularly important in the context of transitioning to a smarter electricity grid. Natural Resources Canada, together with the Standards Council of Canada, established a Smart Grid Standards Task Force to respond to, and provide Canadian input into, standardization efforts being spearheaded by the U.S. National Institute of Standards and Technology and at the International Level by the Electrotechnical Commission. The Task Force contributors included utilities, equipment manufacturers and regulators (Figure 1). CanmetENERGY, in collaboration with Standards Council of Canada and partners, have established a national Smart Grid Technology and Standards Task Force. The Task Force collaborated to identify key priority areas for Canadians, participate in joint projects that aim to develop North American standards and provide recommendations for the advancement of global standards efforts managed by the International Electrotechnical Commission (IEC). This effort managed by CanmetENERGY at the Varennes (Quebec) research centre and The Electrofederation of Canada lead to “The Canadian Smart Grid Standards Roadmap a strategic planning document”[2]. This document is the work product of over 50 members from the smart grid industries and stakeholders. CanmetENERGY has a core team of experts in the area of smart grid and coordinated the federal technical review of the final report. Several federal departments and agencies contributed to the work of a task force on Smart Grid Technology and Standards, including Measurement Canada, Industry Canada, Public Safety Canada, Defence Research and Development Canada, Office of the Privacy Commissioner of Canada, and the National Energy Board. NRCan supported this effort through a contribution agreement with the Electrofederation of Canada, a national not-for-profit industry association representing over 330 companies that manufacture, distribute and service electrical and electronics products.

Development of a test bench to test demand response solutions : The introduction of distributed energy resources in a Smart Grid would require thousands to millions of access points to be controlled simultaneously to provide all sorts of services to the grid, including renewable energy balancing. Scalable solutions are therefore required, as well as adaptable solutions to all sorts of end-use devices (smart appliances, air and water heating and cooling system, inverters, electric car chargers, energy management systems, etc). The purpose of this activity was to test a novel demand response concept that would facilitate “addressing” a large number of devices to support the power system [4]. This new concept uses the strength of the Internet network to develop load communities capable of self-regulating their consumption based on information provide by an operator.

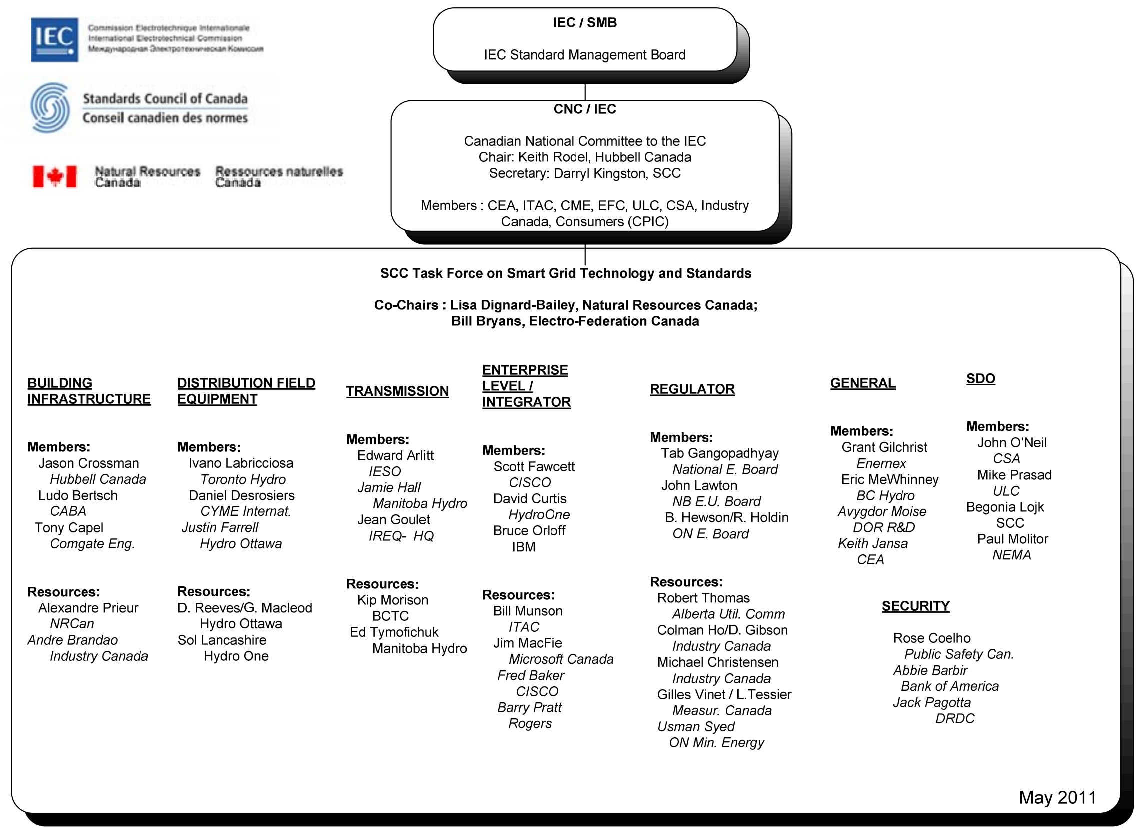

Figure 1: Task Force of Smart Grid Technology and Standards

During this activity, CanmetENERGY completed the installation of a test bench (Figure 2) linking one electric water heater to a community of thousand of simulated nodes. Both hardware and software development were completed to interface with the electric water heater, to establish the communication with thousands of simulated agents (Figure 3), to build a visualization platform in laboratory and to simulate the impact on the power system. Now that the preliminary work is completed, the programming of the novel demand response solution has begun and a proof of concept in laboratory is planned in 2012 (refer to discussion and next step section).

Figure 2: Demand Response test bench with an electric water heater

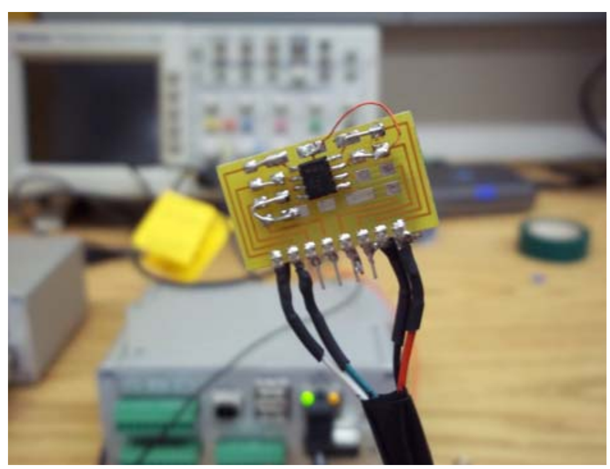

Figure 3: Temperature sensor and microcontroller used for interfacing with the community of loads over the Internet

Publication on smart grid and flexible resources : The third objective of this project was to clarify the technological options and requirements for Smart Grid integration of distributed energy resources (flexible resources). To meet this objective, several outputs were produced during this project. This includes the report : "*Smart Grid to balance Renewable Energy - Contributing Distributed Energy Resources*"[5] explaining the challenges of integrating distributed energy resources in power systems, presenting the research state-of-the-art in the area and reviewing current market practices. In addition, a report produced by CRC and CanmetENERGY on "Communications Technologies for Flexible Resources within the Customer Premises"[6] and the related "Assessment of Communications Technologies for Smart Grids"[7] conference papers are all contributing at informing the industry of technological options and barriers.

Discussion and next steps

This 18 months project funded by the Clean Energy Fund Program at NRCan supported several R&D initiatives in the area of smart grid and the introduction of distributed energy resources. In summary, a task force aiming at fostering collaborating on standards development was supported, along with the publication of a report on the challenge of balancing renewable and communicating with end-use devices. The project financed the development of a demand response test bench to support future proof of concept and standardization work in that field. The preliminary work to prove a novel demand response solution was completed, which include the hardware and software development to manage a real load, simulate the communication with simulated agents, store data and visualize the results.

This project was critical to the orientation of the smart grid research at CanmetENERGY-Varennes. It supported investigation on the current state-of-the-art, on barriers and knowledge gaps in the industry and well as promising technologies and business models. For example, this project highlighted the importance of open standards, open networks (like the Internet) and open power markets (open to DER participation) to foster the development of demand response, storage and distributed generation. This project emphazed the role of aggregation in the future electrical industry, to support local communities during outages (microgrids) or the bulk power system (virtual power plants) on day-to-day operation.

This project led to the preparation of a new Eco-Energy Innovation Initiative project proposal: Real node environment for balancing renewable generation with flexible resources (RENI-509). This project will further develop demand response solutions to provide different services to system operators or utilities. A major focus will be on finalizing the proof-of-concept in laboratory, expand the solution to more devices types (inverters, EV charger, thermostats) (Figure 4) and to test the solutions with utilities. With the demand response test bench, the Standardization work will also continue with test on algorithms, protocols and the development of "use-cases".

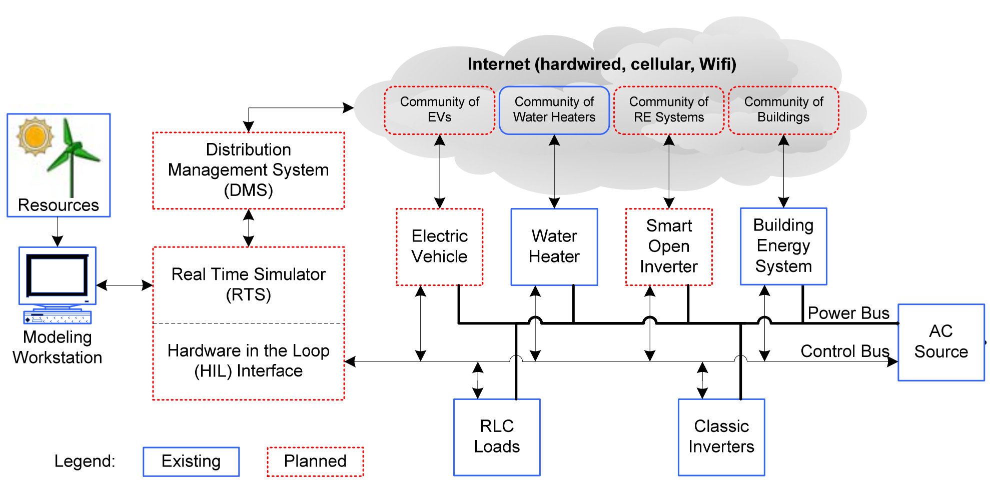

Figure 4: Overview of real node environment for balancing renewable generation with flexible resources

BUDGET

F31.007A AND B (077CE-A,B) 2010-2012

CEF	Other Federal	External in-kind	External Cash	Leverage
420 k	74 k	141 k	-	50%

PROJECT TEAM

- **CanmetENERGY**: Alexandre Prieur, David Beauvais, Arsène Sabas, Jean-Luc Victor, Salman Nazir, Vincent Boisselle, Fernando Colangelo, Claude Guay, Michael Léonard
- **Communication Research Center**: Andre Brandao, Julie Haiying Zhu, Jasmin Roy, François Lefebvre
- **University of Sherbrooke**: Philippe Mabilleau, Simon Ayoub
- **McGill University**: François Bouffard
- **Task Force Members:** Refer to Figure 1 for a list

REFERENCES AND PUBLICATIONS

[1] International Energy Agency, "Harnessing Variable Renewables – A Guide to the Balancing Challenge", 200 pp., ISBN 978-92-64-11138-7;

[2] Alexandre Prieur and Ludo Bertsch, Examples of Smart Home Technology Projects across Canada, Presentation to CNC/IEC Task Force on Smart Grid, July 2010.

[3] Standard Council of Canada, The Canadian Smart Grid Standards Roadmap – a strategic planning document, prepared by the CNC/IEC Canadian Smart Grid Technology and Standard Task Force, Accepted for publication, 2012.

[4] Simon Ayoub, Philippe Mabilleau, Alexandre Prieur, David Beauvais, Alain Moreau, "Distributed Load Management Algorithm for a Virtual Community of Electric Loads", submitted to the journal IEEE transaction on Smart Grid, 2012

[5] David Beauvais, Alexandre Prieur and François Bouffard, "Smart Grid to balance renewable energy – Contributing Distributed Energy Resources", CanmetENERGY, 2012-177 (RP-TEC) 411-FLEXIN.

[6] "Communications Technologies for Flexible Resources within the Customer Premises", CRC report, 2012 (publicly available at www.crc.ca)

[7] Communication Research Center, Assessment of Communications Technologies for Smart Grids, to be published 2012.