The Canadian Smart Grid Standards Roadmap:

A strategic planning document

Prepared by the CNC/IEC Task Force
on Smart Grid Technology and Standards

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- Task Force Working Group 1 (WG1) members included Avy Moise (chair), Ludo Bertsch, Andre Brandao, Luc Tessier, Edward Arlitt, Eric Mewhinney, Alexandre Prieur and Bill Bryans. WG1 provided advice on standards for advanced metering systems, customer applications, electric vehicles and the interface requirements between the utility and its customers;
- Task Force Working Group 2 (WG2) members included Jean Goulet (chair), Dan Blanchette, Devin McCarthy, Avy Moise, Eric Mewhinney, Grant Gilchrist, Jamie Hall, Keith Jansa, Brent Jorowski, Tab Gangopadhyay and Lisa Dignard-Bailey. WG2 provided advice on Smart Grid transmission and distribution standards, the applications of distributed energy resources, the utility requirements regarding the electromobility infrastructure and conducted a Canadian utility survey to identify key priority areas;

- Task Force Working Group 3 (WG3) included Bill Bryans, Ed Juskevicius, Tony Capel, Mahendra (Mike) Prasad, Edward Arlitt and John O'Neill. WG3 contributors addressed Smart Grid cyber security, the North America Reliability Corporation standards and the consumer privacy legislative framework.

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Foreword

The transition to a smarter electric grid holds significant promise for the achievement of a number of important public policy objectives. Smart grid technologies will enhance the reliability, resiliency and efficiency of the electric network, as well as improve environmental performance by enabling consumers to play a more active role in their energy use decisions and helping to integrate renewable resources such as wind.

Many of the technologies that will enable this transition have yet to be demonstrated, while others are still under development. As these technologies mature and are brought into the marketplace, standardization will become increasingly necessary to ensure the development of an efficient and effective smart grid.

Indeed, standards form the basis for virtually all products and services in any economy. For the smart grid, an effective standards regime will enable smart appliances and smart meters to inform consumers of the amount of energy they consume, and at what cost. It will spur infrastructure development and investment in related technologies such as plug-in electric vehicles. Importantly, an effective standards regime enhances Canada's competitiveness by ensuring alignment with the global marketplace, without which Canadian technology vendors could find their products incompatible or obsolete.

For these reasons, Natural Resources Canada and the Standards Council of Canada's National Committee to the International Electrotechnical Commission created a Task Force on Smart Grid Technology and Standards to recommend priority standards for the smart grid. This document is a product of a two-year project undertaken by the Task Force, and serves as a roadmap to navigating the evolving standards environment. The evolution of the smart grid is such that the new standards environment must both support a smarter North American electric grid as well as provide guidelines for utilities and manufacturers on their participation in the emerging global marketplace.

This project supports a number of key government objectives, including expanding Canada–United States collaboration under the Clean Energy Dialogue. By identifying a path forward on the priority standards for Canada, this work supports that of the United States National Institute of Standards and Technology to develop a broad range of standards for the smart grid. Continental alignment in this regard is critical, given the interconnectedness of our trading relationship and electrical infrastructure.

On behalf of the Standards Council of Canada and Natural Resources Canada, we would like to extend our gratitude to all the organizations and experts who have contributed their time and knowledge to the publication of the Smart Grid Standards Roadmap, as well as to those who will help pave the way for its implementation.

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1 Introduction

Over the past two years, Natural Resources Canada (NRCan), in cooperation with the Standards Council of Canada's (SCC's)[1] Canadian National Committee to the International Electrotechnical Commission (CNC/IEC), recognized the pressing need for a national body to define and coordinate Canada's Smart Grid standardization initiatives. Under the divisions of legislative responsibility of the Canadian constitution, electricity matters falling within the boundaries of a single province are a provincial jurisdiction.

The CNC/IEC provides policy advice to SCC on matters pertaining to IEC and has oversight responsibility for Canadian activities at IEC.[2] To meet that need, the CNC/IEC created the *Task Force on Smart Grid Technology and Standards*, hereinafter referred to as the *Task Force*, which first convened in February 2010 and has continued to meet on a regular basis through to January 2012. SCC provided three guiding principles for the Task Force's work:

- ensure that Canada's needs are reflected in products developed under the IEC's Smart Grid initiatives;
- leverage—to the maximum extent possible—national and North American efforts to ensure Canadian Smart Grid priorities are identified and incorporated into the IEC's work plan; and
- coordinate standards development in such a way as to avoid national and regional differences as much as possible (unless appropriately identified and understood as necessary).

Task Force membership consists of experts representing the entire spectrum of Smart Grid stakeholder sectors, including:

- generation, transmission and distribution utilities
- utility equipment vendors
- building infrastructure experts
- enterprise- and consumer-level equipment manufacturers
- federal, provincial and municipal regulators
- standards development organizations (SDOs)

As a technically oriented advisory group, the Task Force is formally charged with:

- *providing advice* to CNC/IEC on policy regarding Canadian participation in national and international standardization on Smart Grid technology and standards, including harmonization of Canadian and international technical work;
- *supporting integration* of national and international electrotechnical standardization by working toward IEC standards on Smart Grid technology having the widest possible acceptance in Canada and its trading partners;

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[1] *Standard Council of Canada (SCC): http://www.scc.ca/en/home.*
[2] Refer to the *Canadian Procedural Document CAN-P-7 2011 Canadian Participation in ISO and IEC: http://www.scc.ca/en/publications-can-p-7-2011-canadian-participation-in-iso-and-iec*

- *assessing and providing feedback* on the effectiveness of the work program in meeting the needs of this electrotechnical sector;
- *establishing and maintaining liaisons* with other sector players, as appropriate (with a view to coordinating Smart Grid technology standardization activities within the electrotechnical sector); and
- *providing recommendations* to CNC/IEC on potential new fields of activity in Smart Grid technology and standards.

The goal of this document is to provide a *roadmap*—a strategic plan—to advance the standards environment from today's legacy electricity grid to tomorrow's full deployment, operation and evolution of the Canadian Smart Grid. The new standards environment will not only support a North American Smart Grid but will also provide guidelines for utilities and manufacturers to participate in the emerging global Smart Grid marketplace.

This report provides a brief overview for all stakeholders of Canada's Smart Grid policy, legislative and regulatory environment. Following Section 1 introduction, the roles played by the federal and provincial governments are highlighted in Section 2. Key Smart Grid initiatives and recommendations are described in Section 3 for privacy and security requirements. The Canadian roadmap recommendations in Section 4 provide a comprehensive technical review of high-priority standards projects within the transmission and distribution domains—including cross-cutting recommendations on spectrum standardization and cyber security. Section 5 presents a detailed description of the key issues for metering systems. Section 6 summarizes the key elements produced by three working groups:

- Working Group 1 (WG1), focused on standards for advanced metering systems (e.g., smart meters) and other post-distribution elements of the Smart Grid, such as customer networks, electric vehicles as Smart Grid storage devices, and the interface requirements between the utility and its customers;
- Working Group 2 (WG2), focused on transmission and distribution standards; and
- Working Group 3 (WG3), focused on Smart Grid privacy and security issues, particularly with respect to cyber security as it affects both consumers and utilities.

The work of these groups of the Task Force yielded cross-cutting, high-level recommendations equally applicable to all of the domains that make up the Canadian Smart Grid.

The most critical cross-cutting finding relates to the Task Force's recommendation for SCC to establish a *Smart Grid Standards Steering Committee*. This committee would continue supporting strategic oversight of managing the domestic and regional deployment of this roadmap, and further development of Canadian expert participation at the appropriate international policy management committees, such as IEC SMB-SG3 for Smart Grid, SMB-SG6 for Electric Vehicle Mobility, and the new *Advisory Committee on Electricity Transmission and Distribution (ACTAD*). In addition to key stakeholder representatives, it should also include representatives from the relevant Canadian national mirror committees to the International Electrotechnical Commission (IEC), the International Organization for Standardization (ISO), the International Telecommunications Union (ITU), the International Organization of Legal Metrology (OIML), etc. The *Smart Grid Standards Steering Committee* would champion and promote Canadian activities, filling identified gaps and periodic maintenance of the Smart Grid strategic roadmap.

Recommendation G1:

> The CNC/IEC should recommend the creation of a Smart Grid Steering Committee to coordinate and assist with the other recommendations contained in this Roadmap, work with other relevant standards policy bodies and technical committees, and periodically update the Roadmap.

The Task Force also found that Canada did not have a smart meter technical committee. Additionally, a few important technical committees are insufficiently resourced to undertake the effort; the continuity of the effort will need to be sustained over the foreseeable future.

Recommendation G2:

> The CNC/IEC should support the creation of a Canadian technical sub-committee for smart meters, and encourage greater participation and support funding to other important technical committees.

The Task Force members found that many of the potential standards to be used in the Smart Grid environment are not yet mature. There is no clear consensus of how suitable those standards will remain as the overall system strategy evolves. More research and pilot-scale demonstrations are important to gain experience with the applications of the standards required. Therefore, it is not recommended to enshrine any standards in regulation in the near term.

Recommendation G3:

> The CNC/IEC should recommend to governments and regulators to be very cautious about enshrining any standard in regulation in the near term, as some are not yet mature enough to have a proven track record. Also, forced early conversion to a new standard may prematurely render current infrastructure investments obsolete, unnecessarily adding cost burdens.

2 Smart Grid Policy, Legislation and Regulatory Overview

2.1 Overview of policy objectives

The Smart Grid is the application of technologies pioneered in the telecommunications sector, across the entire electricity supply chain, that enables better communications in real time–from generation to transmission and distribution, right down to the meter, and even inside customer premises by contract. One of the major factors empowering this transition is a growing recognition by government leaders of the potential of the Smart Grid to achieve a wide range of energy policy objectives. Certainly, this is the case for the Government of Canada, which sees Smart Grid technologies as key to a brighter, greener economic future.

The Government of Canada's approach toward the future for Smart Grid is focused on three core energy policy objectives: ensuring reliability (which includes security), adequacy, and environmental performance.[3] To meet the first objective, a Smart Grid will aim to improve real-time knowledge of what's happening on the system. The goal would be to avoid unplanned outages where possible, and improve response time when outages occur. Of course, a reliable system also has to be secure, which requires solid standards and operating protocols. The second energy policy objective, ensuring adequacy, means having sufficient infrastructure across all aspects of the electrical system, to meet customer loads. Smart Grid will enable increased use of renewable energy, allow improved demand management and therefore ensure that assets are used efficiently. Thirdly, by allowing customers to purchase cleaner, lower-carbon-emitting generation and manage their own energy consumption—and by helping to better integrate renewable energy sources at customer sites—a Smart Grid will contribute to our goal of improved environmental performance, by reducing greenhouse gas (GHG) emissions.

While much of the innovation to deploy the Smart Grid will be driven by industry, governments also have a clear role to play in facilitating research and development and in aiding the commercialization of promising new technologies. For example, the Government of Canada is taking steps to support promising demonstration projects under the Clean Energy Fund and ecoEnergy Innovation Initiative, to spur the kind of technological changes that will help deploy the Smart Grid as part of Canada's economic development strategy. For example, four Maritime utilities led by New Brunswick Power Corporation will integrate Smart Grid technologies, customer loads and the management of wind generation in a region with potentially significant renewable electricity capacity. Other provinces, such as Ontario—and, more recently, British Columbia, Manitoba and Quebec—have initiated projects to enable the Smart Grid evolution in Canada.

Policymakers have a role to play in removing barriers for new product and service offerings in areas such as Smart Home, demand response, distributed generation and electric vehicle management, in the domestic, regional and international arenas. Allowing not only traditional utility companies, but innovators from other sectors, to explore new business models and develop opportunities, that will help maximize value-creating activities around Smart Grid infrastructure. "Smart Regulation" can *significantly* boost the ability of national manufacturers to compete in the global market by providing input to international standards bodies to support emerging product development. A key role governments and regulators play in this strategy is helping the private sector develop and promote standards that open up the international market to Canadian companies, while not unintentionally hampering innovation.

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[3] NRCan minister speaking notes Canada-US Clean Energy Dialogue Smart Grids in the North American Context: A Policy Leadership Conference: http://www.nrcan.gc.ca/media-room/speeches/16/2011-01-25/clean-energy/1802.

2.2 The federal role

The federal government is contributing to this strategic planning process by leading standardization discussions with stakeholders. SCC manages and provides leadership for coordinating standardization input for Smart Grid activity. At the international level, Canadian experts, via SCC's *Accreditation Services*, are active participants in the International Electrotechnical Commission (IEC) Standardization Management Board Strategic Group 3 (SMB-SG3) for Smart Grid. In addition, other accredited Canadian experts are taking a leadership role in developing Smart Grid communications standards within IEC Technical Committees, such as TC57[4], or are active participants. Industry Canada participates at the International Telecommunications Union (ITU), representing government regulatory harmonization interests. Canadian experts also participate in a number of other relevant North American standards-setting bodies such as IEEE (Institute of Electrical and Electronics Engineers).[5] A major concern Task Force members have identified is the need for adequate funding of experts and their availability to participate in the development and harmonization of international standards.

Industry Canada manages the wireless spectrum allocation process that includes a spectrum identified for utilities, for Smart Grid communications requirements. Industry Canada[6] has identified the 1800-1830 MHz spectrum for various applications in support of the management of the electricity supply, including high-speed teleprotection, Supervisory Control and Data Acquisition (SCADA), telemetry and mobile radio, and Smart Grid development. The electricity sector continues to emphasize to Industry Canada the critical infrastructure nature of the industry and the need to protect and enhance existing spectrum resources, as well as ensure access to necessary bandwidth for Smart Grid applications.

Measurement Canada[7] is an Agency of Industry Canada, mandated to ensure the integrity and accuracy of trade measurement through the administration and enforcement of *the Electricity and Gas Inspection Act and Regulations and the Weights and Measures Act and Regulations*. The key elements considered for smart metering standardization is the requirement: that a meter must be approved; must be verified and sealed; must have a means of indication (display); and that any modifications to Advanced Metering Infrastructure (AMI) must not impact the meter's accuracy or integrity. Measurement Canada is recommending a pragmatic approach that separates the legal metrology verification from AMI applications and communications. This is allowed in the standard OIML-D31 (General requirements for software controlled measuring instruments Standard). Measurement Canada S-EG-05 Specifications for the Approval of Software Controlled Electricity and Gas Metering Devices, and S-EG-06 Specifications Relating to Event Loggers for Electricity and Gas Metering Devices are now effective and evaluated for compliance in test laboratories by Measurement Canada.

The Federal Public Security Technical Program (PSTP) is an initiative of Defence Research and Development Canada (DRDC). This program aims to enhance collaboration across government and deliver science and technology (S&T) solutions across many dimensions of public security. PSTP will mobilize resources to address challenges to public security and critical infrastructure protection, by integrating expertise across disciplines and departments. DRDC initiated a project

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[4] "Smart Home" is the term commonly used to define a residence that has appliances, lighting, heating, air conditioning, TVs, computers, entertainment audio & video systems, security, and camera systems that are capable of communicating with one another and that can be controlled remotely by a time schedule, from any room in the home, as well as remotely from any location in the world, by phone or Internet.
Refer to the IEC Smart Grid Strategic Framework available: http://www.iec.ch/zone/smartgrid/.

[5] Refer to the IEEE: http://www.ieee.org/index.html.

[6] Industry Canada Smart Grid and Digital Economy Strategy: http://www.ic.gc.ca/ic_wp-pa.htm.

[7] Measurement Canada: http://www.ic.gc.ca/eic/site/mc-mc.nsf/eng/home.

to review the cyber security issues related to the Smart Grid and SCADA communications systems.[8]

The National Energy Board (NEB) and several Canadian provinces have signed a Memorandum of Understanding with the North American Electric Reliability Corporation (NERC).[9] NERC is a regulatory authority established to evaluate reliability of the bulk transmission power system in North America. NERC develops and enforces reliability standards; assesses adequacy annually; monitors the bulk power system; and educates, trains and certifies industry personnel. A review of reliability requirements under Smart Grid is currently underway. NERC is subject to oversight by the U.S. Federal Energy Regulatory Commission (FERC). In Canada, NERC presently has memoranda of understanding in place with provincial authorities in Ontario, New Brunswick, Nova Scotia, Quebec and Saskatchewan, and with the Canadian National Energy Board. NERC standards are mandatory and enforceable in Ontario and New Brunswick as a matter of provincial law. NERC has an agreement with Manitoba Hydro making reliability standards mandatory for that entity. Manitoba recently adopted legislation that sets out a framework for standards to become mandatory for users, owners, and operators in the province. In addition, NERC has been designated as the “electric reliability organization” under Alberta’s Transportation Regulation, and certain reliability standards have been approved in that jurisdiction; others are pending. NERC and Northeast Power Coordinating Council (NPCC) have been recognized as standards-setting bodies by the Régie de l’énergie of Québec, and Quebec has the framework in place for reliability standards to become mandatory. Nova Scotia and British Columbia[10] also have frameworks in place for reliability standards to become mandatory and enforceable. The National Energy Board and the Department of Natural Resources Canada (NRCan) are following the progress of the NERC Task Forces on bulk (wholesale) electricity reliability, including ongoing effort of its own Smart Grid Task Force.

2.3 The provincial role

Under the divisions of legislative responsibility of the Canadian constitution, electricity matters falling within the boundaries of a single province are within provincial jurisdiction.[11] This is already having a profound influence on the development of the Smart Grid in Canada, and we expect it will continue to do so. Over the course of its work, this Task Force has noted that there is a wide disparity from province to province in regards to both levels of Smart Grid development activity and the manner in which those activities are being carried out. These are, of course, heavily influenced by the widely varying industry structures between the provinces.

In some cases, we have seen the enthusiasm of early adopters of Smart Grid technology running up against the challenge of deploying such technologies in advance of established interoperability standards. One such prominent example is the Ontario Smart Metering Initiative, which was conceived and implemented before the development of emerging Advanced Metering Infrastructure Standards. For example, Ontario is now coping with how to enable data access for third-party service providers when common standards are not in place across the

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[8] DRDC project results will be reported in 2012-2013 for two projects: PSTP 02-347eSec - Study in Cyber Security and Threat Evaluation in SCADA Systems; and PSTP 03-431eSec - Build a SCADA/Smart Grid Test Centre.

[9] North American Reliability Corporation (NERC): http://www.nerc.com/

[10] BC Hydro is a member of NERC and WECC. BC Ministry of Energy and Mines is a member WIRAB, that advises NERC and WECC:

- http://transmission.bchydro.com/transmission_system/reliability/
- http://www.empr.gov.bc.ca/EPD/Electricity/TD/Reliability/Pages/default.aspx

[11] Ref.: RSC, Consolidated Constitution Acts 1867 to 1982, section 92A

province.[12] Ontario's electricity industry recognizes the need to adopt widely used interoperability standards and is looking to groups such as this Task Force to make recommendations in that regard.

Consumers increasingly need access to information to allow them to use the Smart Grid more efficiently. Also, consumer products interfacing with the Smart Grid will need to follow internationally accepted equipment standards; typically, consumer equipment is drawn from the international market. That being the case, Smart Grid standards need to be harmonized and will fall into one of two general categories:

- standards that enable and/or enhance national and regional system/device interoperability from a utility point of view; or
- standards that provide compatibility between vendor equipment in the international marketplace.

The adoption and use of interoperability standards is at particular risk of being adversely affected by domestic disparities within Canada and across the border.

Some standards discussed in this report have the legislative backing of a standards body. Measurement Canada, for example, has the power to stipulate and enforce nationwide standards for various aspects of metering devices. However, the U.S. government does not have an equivalent agency. Also, decisions regarding how and when most standards discussed in this report will be used, ultimately reside with Canada's provincial and territorial authorities. There is also a recognized need for coordinating this effort within Canada and the United States. Canada's Federal, Provincial and Territorial (FPT) energy ministers initiated support for a collaborative approach to energy at their annual meeting, held in Kananaskis, Alberta[13] in July 2011. At that time, the reliability of this nation's Smart Grid and electricity network were identified as areas requiring collaboration. An FPT Energy Technology Working Group is preparing a Smart Grid Report, which will identify gaps and recommend opportunities to energy ministers at the their annual meeting in Prince Edward Island in September 2012.

Our Task Force has noted that discussions between FERC and National Institute of Standards and Technologies (NIST), in the United States, have resulted in the U.S. national regulator stepping back from legislating Smart Grid standards at the national level.[14] The U.S. regulator has, however, called for another national organization to lead in promoting and recommending Smart Grid standards for use across all U.S. states. The Task Force has followed the developments in the United States and believes that SCC and its nationally accredited standards development organizationsSDOs can continue to lead in promoting the adoption of harmonized standards in Canada. As a result, this Task Force is recommending a consolidated, national view of Smart Grid in Canada.

Regulator Recommendation R1:

> SCC's CNC/IEC should encourage Provincial, Territorial regulators and utilities, when developing business plans for Smart Grid initiatives, to ensure that systems migrate from proprietary technologies to open standards, and from their current architecture to the Canadian Smart Grid Reference Framework described in this report. This step will enable regulators and utilities to compare roadmaps and therefore identify areas of commonality, interoperability, deployment timing and possible technological risk.

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[12] Ref.: Ontario Smart Grid Forum, "*Modernizing Ontario's Electricity System: Next Steps. Second Report of the Ontario Smart Grid Forum*," May 2011, Section 2-2 ("Third Party Access"), page 22

[13] The Alberta Utilities Commission (AUC), Alberta Smart Grid Inquiry, Proceeding ID No. 598, January 31, 2011. http://www.auc.ab.ca/items-of-interest/special-inquiries/Documents/smart_grid/Alberta_Smart_Grid_Inquiry_final_report.pdf

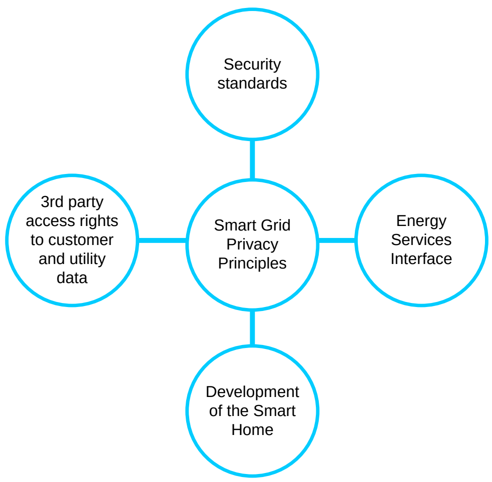
[14] U.S. Federal Energy Regulatory Commission, Docket No. RM11-2-000, "*Smart Grid Interoperability Standards*" (Issued July 19, 2011), page 1

3 Privacy and Security Requirements

Privacy has a close and complex interrelationship with a number of Smart Grid interoperability issues that are central to this report. There is a growing awareness of the need to develop first principles for consumer privacy that should be embedded in the architecture and standards of Smart Grid infrastructure. These issues have been at the forefront of the Task Force's examination of the various interoperability standards.

In Canada, the provincial privacy commissioners are tasked with responding to consumer complaints regarding possible infringements to the applicable privacy law.[15] At the heart of current Smart Grid privacy discussions is a set of core principles, which states that the consumer should have the ultimate authority over access and usage of their own energy-related data. Figure 1 identifies the four aspects linked to the *Smart Grid Privacy Principles*.

Figure 1: Interrelationships between Privacy, Security and Smart Grid



Perhaps nowhere in Canada are these *Smart Grid Privacy Principles* more explicitly linked to the Smart Grid's architecture than in Ontario. The Ontario Information and Privacy Commissioner has set out a series of "Privacy by Design" principles for the Smart Grid.[16] The Ontario Smart Grid Forum, an advocacy body for the development of smart grids, has formally recognized these principles as crucial to the development of the Smart Grid. Our Task Force notes that these principles broadly apply to developing Smart Grid across Canada. Legislators and regulators need to consider the precise instruments and mechanisms by which such principles should be applied and enforced.

These *Smart Grid Privacy Principles* include: the energy service interface, the development of the Smart Home, the third-party access to customer and utility data, and the cross-cutting security standards.

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[15] For example, British Columbia's privacy commissioner has launched an investigation into BC Hydro's Smart Meter program, after receiving complaints that the information collected by the device breaches personal privacy. The Commissioner's Office received complaints and correspondence from more than 600 British Columbians about the smart meter program, which prompted the investigation. The commissioner found that BC Hydro is complying with the *Freedom of Information and Protection and Privacy Act*, with regard to the collection, use, disclosure, protection and retention of the personal information of its customers. However, the crown Corporation was not in compliance with regard to the notification it provides to its customers about smart meters. Source: www.oipc.bc.ca

[16] Privacy by Design: http://www.ipc.on.ca/english/Resources/Discussion-Papers/Discussion-Papers-Summary/?id=967

<u>The Energy Services Interface and the Development of the Smart Home</u>: NIST has begun to conceptualize an Energy Services Interface (ESI) as a crucial meeting point in the Smart Grid between systems belonging to utilities, customers and third parties. The ESI is therefore one of the most crucial areas of the Smart Grid, where privacy issues will play out. This Task Force has considered how these functions should be enabled by available interoperability standards. The Task Force has made recommendations allowing Canadian homes to connect to the Smart Grid in a secure and private framework. The technical details of the Canadian *Smart Grid Advanced Metering Infrastructure Logical Architecture* and recommendations are described in Section 5 of this report.

<u>Third-Party Access to Customer and Utility Data</u>: Beyond the *Smart Grid Privacy Principles* are the detailed protocols and ground rules by which third-party service providers may access customer data and receive data on the customer's behalf from their local utility. In Ontario, this issue has risen to prominence; an emerging class of private-sector players has expressed interest in accessing real-time smart metering data to provide a burgeoning array of Smart Home products and services. Section 5 of this report also includes a technical approach to resolve this access issue in a safe and secure manner. The Task Force notes that the North American Energy Standards Board (NAESB) [17] has just concluded the development of a comprehensive set of detailed recommendations regarding the division of responsibility between third parties and utility companies that warrant a close examination by regulators and the Canadian electricity industry.

<u>The Need for Security Standards:</u> The application *Privacy Principles*, and ensuring the confidentiality and integrity of Smart Grid data, are enabled by applying a wide variety of security standards. Cyber security standards may use encryption to maintain data confidentiality and the integrity of data transmitted between Smart Grid system components. Other standards address the need to have the "trusted" equipment, system design, people and procedures in place to create and maintain the required secure environments.

For smart meter security, Measurement Canada's Software Security Joint Working Group has reviewed standard OIML-D31 General requirements for software-controlled measuring instruments. (Measurement Canada was represented within the TC5/SC2 OIML Working Group.) [18] Consequently, Measurement Canada developed, in collaboration with industry stakeholders, the S-EG-05 Specifications for the Approval of Software Controlled Electricity and Gas Metering Devices, and S-EG-06 Specifications Relating to Event Loggers for Electricity and Gas Metering Devices. These specifications are being used in Canada for meter-type approval, including for: Encryption, Authenticity Check (public keys and signatures), Integrity Check and Design Requirements. These specifications allow for software upgrades under certain conditions.[19]

The NERC Technical Committees (Operating, Planning, and Critical Infrastructure) for the North American transmission systems have begun to address the implications of reliability through five task forces. In addition to being staffed by industry experts, these task forces are supported by globally renowned U.S. and Canadian governmental agencies, scientists and subject matter experts.[20] As well, the Canadian Electricity Association representing utilities has signalled its commitment toward a pragmatic approach to the implementation of Smart Grid technologies in

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[17] North American Standard Energy Board: http://naesb.org

[18] OIML : International Organization of Legal Metrology or Organisation Internationale de Métrologie Légale

[19] Measurement Canada presentation: http://www.oeb.gov.on.ca/OEB/_Documents/EB-2011-0004/MC%20presentation%20-%20Ontario%20smart%20grid.pdf)

[20] In 2011, more than 75 industry and government partners participated in the North American Electric Reliability Corporation's (NERC's) first cyber security readiness exercise. The two-day exercise is part of NERC's ongoing security readiness program to assess NERC and the industry's crisis response plans, and to validate current readiness in response to a cyber incident.

Canada. Cyber security must be taken seriously, and customer privacy is of utmost importance.[21] [22]

The Task Force found significant Canadian participation and leadership in the development and the adoption of Smart Grid privacy principles and their promotion in Canada and the United States. However, the Task Force identified an urgent need to coordinate Canadian efforts regarding Smart Grid cyber security guidelines,[23] and makes the following recommendation:

Regulator Recommendation P&S1:

> The CNC/IEC should recommend that Canadian stakeholders participate in the specification of Smart Grid cyber security requirements and standards within NIST's Smart Grid Interoperability Panel (SGIP) and Cyber Security Working Group, to promote a harmonized North American approach to the extent possible. It is also recommended that the proposed National Smart Grid Steering Committee consider where and how Canadian positions on Smart Grid cyber security standards should be developed.

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[21] THE SMART GRID: A PRAGMATIC APPROACH, A "State-of-Play" Discussion Paper by the Canadian Electricity Association, 2011.

[22] When planning comprehensive system security, the following factors need to be considered: resilience and access to both physical building and surrounding premises, electronic and cyber-attacks. In doing that it is essential to consider the overall architecture necessary to deal with 'all' security systems relating to fire & burglary protection and life safety systems for home, commercial, institutional premises, the access controls and surveillance equipment.

[23] NIST released an updated version of their document in February, 2012, which incorporates public comments into the NIST Framework and Roadmap for Smart Grid Interoperability Standards, Release 2.0 . Chapter 6 is dedicated to Cyber security. The chapter includes an outline of the going-forward three-year strategy of NIST's SGIP Cyber Security Working Group (CSWG): http://www.nist.gov/smartgrid/framework-022812.cfm.

4 Transmission and Distribution Standards

4.1 Introduction

The Canadian Smart Grid Standard and Technology Task Force recognizes the value of the core IEC TC57 architecture presented in the IEC Technical Report 62357-1. The IEC Smart Grid Standardization Roadmap is based on the work of the IEC TC57. Canada is actively participating in the development of this international reference architecture and participates in the Standard Management Board Smart Grid Committee. The schematic in Figure 2 is adapted from the IEC 62357-1 and identifies the cross-cutting applications layers, services, and standards protocols that apply in the management of a power system and how they relate to each other within a Canadian context. The Task Force completed a detailed assessment and identified a number of priority standards and gaps in this section of the report. A description of the key layers presented in figure 2 includes the following key reference layers:

- application-to-application and business-to-business communications for energy markets, customers and other energy service providers;
- control centres for energy and distribution management system (EMS and DMS) using Common Information Model (CIM);
- SCADA communications between control centres and the field equipment using interfaces and mappings;
- field equipment communications for substations and feeder automation; and
- cross-cutting infrastructure requirements, including industry communications protocols, wide area network (WAN) and telecontrol communications media and services and security standards.

The goal of interoperable systems can be very hard to achieve in a diverse environment with different requirements, many different vendors, and a wide variety of standards. Fortunately, the industry can overcome these issues by:

- using gateways and protocol converters to help the migration from legacy systems to modern Smart Grid technologies;
- using object modeling that represents the physical equipment; and
- using metadata[24] to facilitate information exchange between systems and applications.

The Task Force identified the key standards required to ensure interoperability for Canadian Smart Grids (Figure 2). The Task Force has taken a pragmatic view by recommending Canadian deviations from the IEC standards framework. This reflects the wide-scale adoption of ANSI C12 meter standards use in Canada and the necessary transition period required before migrating to the core IEC standards (IEC 61850 and CIM). The following subsections of the roadmap describe the findings of the Task Force for Canadian energy markets (4.2), control centres (4.3), Supervisory Control and Data Acquisition (SCADA) (4.4), field devices and distributed energy resources (4.5), and the cross-cutting communications network infrastructure (4.6). The Task Force recommendations considered the current status of the Smart Grid implementation in Canada and reports on the results of a utility survey conducted in 2011.

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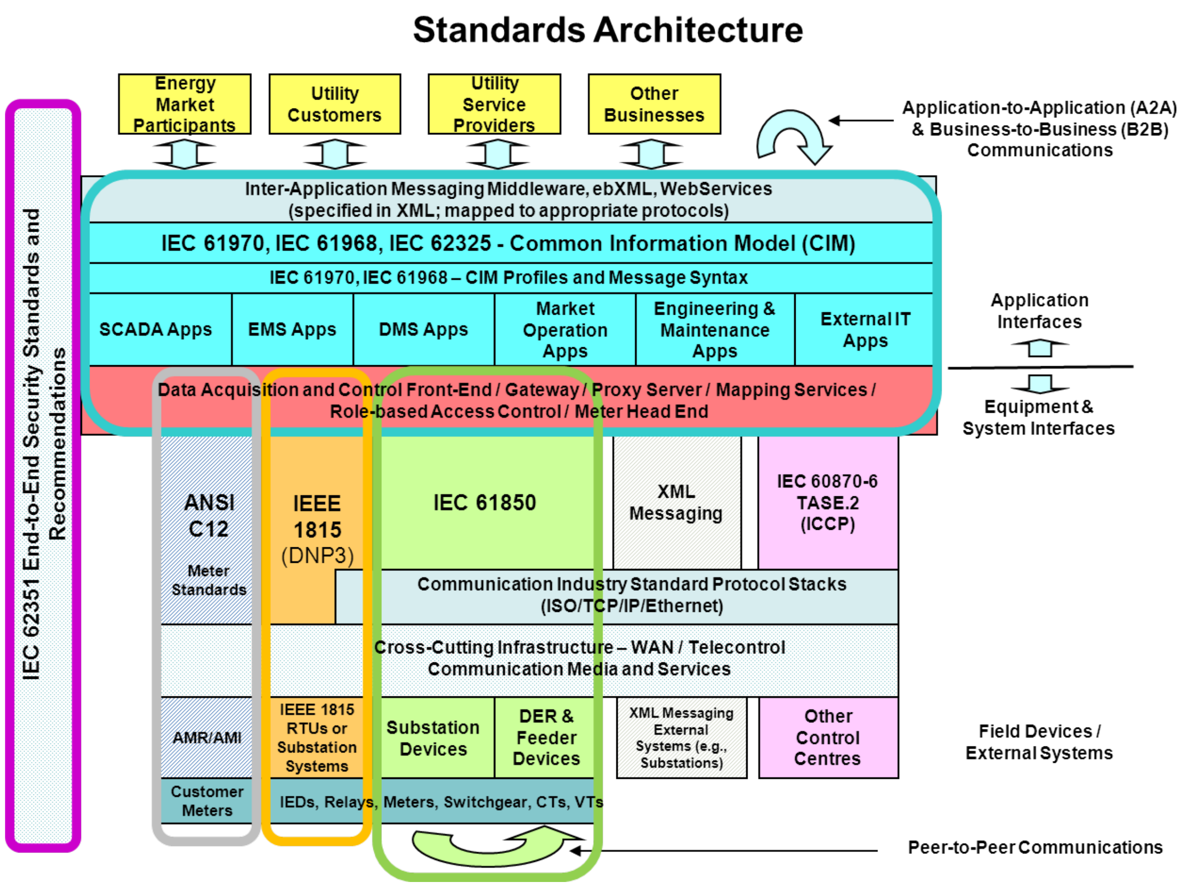
[24] Metadata: Information used by the utility systems to describe basic data sets. For example, Extensible Markup Language (XML) can be used to define metadata.

The Canadian reference architecture provides a framework for future standardization work to extend IEC core standards or develop new standards within the IEC. The architecture highlights, using colour lines, the key areas of focus for this Canadian Smart Grid Roadmap. The schematic allows Canadian stakeholders to compare current industry standards—as they apply to utility transmission and distribution infrastructure—with the evolving reference architecture being developed by the IEC working groups.

Figure 2: Canadian Smart Grid Standards Architecture adapted from IEC 62357-1



As the functionalities required by Smart Grid are deployed throughout the generation, distribution and delivery infrastructure, additional standards will be needed. Existing and emerging standards being developed in other industry sectors must be evaluated to determine their suitability, and must be incorporated into the proposed architecture, as appropriate. This approach will both minimize the overall proliferation of standards and avoid conflicting or redundant requirements. This evaluation will require good cross-sector knowledge of the standards being developed internationally. Creating a Canadian Smart Grid Steering Committee would serve as an ideal means to assemble the cross-sector experts needed.

4.2 Energy market communications

Energy market communications has historically been a relatively closed transactional environment, limited to: i) wholesale transactions controlled by an independent electricity system operator; and ii) to a very minor extent, utility-controlled interactions with customers (manual demand response). With the coming of the Smart Grid, both ends of the market, wholesale and retail, are expected to open up, to a large degree. New standards that can promote interoperability are required for both types of markets.

The Common Information Model (CIM) is an abstract model (published by the IEC TC 57) to represent all major *objects* in an electric utility enterprise typically needed to model the operational aspects of a utility. This standard should be understood as a tool enabling integration in any domain where a market system model must facilitate interoperability and plug-and-play compatibility between applications and systems independent of any particular implementation. CIM specifies the basis for the semantics for this message exchange. (Refer to Table 1.) The profile specifications, contained in parts of the IEC 62325 standards, currently only support European-style markets. A project within the IEC 62325 part 352, to support the North American-style market, is planned, with the collaboration of the Independent Regional Council (IRC). The IRC represents 10 regional transmission operators in Canada and the United States. These operators are characterized by *regional markets*, with day-ahead unit commitment by a market operator, intraday and real-time balancing through central dispatch, and settlement based on Locational Marginal Prices (LMP).[25]

Although Canada has not participated in the work done by the IEC TC57 Working Group 16 to develop these standards parts, several independent Regional Transmission Operators (RTO) are members of the North American Energy Standards Board (NAESB). NAESB has several active committees developing wholesale and retail electricity market standards. The NAESB Wholesale Electricity Quadrant (WEQ) standard was published with requirements for all information flows—from registration through to performance evaluation of demand resources and including deployment, with 33 exchanges in total. IRC members developed a flexible framework intended to cover local variations in market rules, while still standardizing the information payloads in these exchanges over time. Following the ratification of both the wholesale and retail electricity market requirements documents, the NAESB Working Group embarked on a more-detailed data requirements phase. In 2011, the wholesale and retail groups reconciled the processes and aligned their models. The project team was therefore able to deliver a common set of requirements.[26]

The Task Force identified a need to encourage participation of experts in the work of the IEC TC57 Working Group 16. The Working Group would develop profiles for the North American wholesale energy market (IEC 62325 part 352) and propose new work items for standardizing information exchanges for demand response electricity markets (NAESB WEQ and REQ standard market profile). The two energy market communications standards priorities are highlighted in yellow in the list of key standards in Table 1.

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[25] Independent System Operator/Regional Transmission Operator Council (ISO/RTO), IRC 2009 State of the Markets Report: www.isorto.org.

[26] Scott Coe, CanmetENERGY report March 2011 : NAESB standard "covers the 290 data elements which are needed to build the 33 WEQ information flows and support the 31 REQ use cases, with indicators to applicability to wholesale and retail for each element." Refer to NAESB weblink : http://www.naesb.org/dsm-ee.asp.

Table 1: Energy Market Communications Standards

Standard	Title			
IEC 62325	**Framework for energy market communications**			
	Part	**Subtitle**	**Status**	**TC/SC/WG**
	102	Energy market example	Published	TC57 WG16
	301	Common information model (CIM) for markets	To be published	TC57 WG16
	351	Profile for European-style markets	To be published	TC57 WG16
	*352	Profile for North America wholesale energy markets (IRC ISO-RTO Council)	Planned	TC57 WG16 / NAESB
	450	Methodology	To be published	TC57 WG16
	451, 452	Document profiles	To be published	TC57 WG16
	501	General guidelines for use of ebXML	Published	TC57 WG16
	55X	Translations	New work	TC57 WG16
NAESB	*	Profile for North American wholesale and retail demand response markets (NAESB)	Gap	NAESB
*** priorities and gaps highlighted**				

4.3 Control centres—energy and distribution management systems

Canadian utilities are implementing the Common Information Model (CIM), CIM IEC 61970 and 61968 within their control centres.[27] [28] These standards cover both electric utility transmission and distribution business operations. The CIM is expressed in Unified Modeling Language (UML), which enables system integration and information exchange. CIM also defines a set of standard system interfaces for exchanging information between Information and Communications Technology (ICT) systems. The CIM can be extended to enable both the standard extensions for new functional areas and for private extensions for specific utility requirements, such as relevant geospatial data models**.** The CIM IEC 61970 standard defines the energy management system (EMS) Application Programming Interfaces. The CIM IEC 61968 standard defines the System Interfaces for Distribution Management.

The core models defined in the IEC 61970-301 Standard for Transmission Management System, and the models defined in the IEC 61968-11 Standard for Distribution Management System, complement the models defined in IEC 62325-301 for the energy markets. These models were presented in section 4.2 of this report.

CIM profiles are a standard part of the IEC 61968 and IEC 61970-4xx series of Component Interface Standards. These standards specify the functional requirements for interfaces that a component (or application) shall implement to exchange information with other components (or applications) and/or to access publicly available data in a standard way. The component interfaces describe the specific message contents and services that can be used by applications

[27] Hydro-Québec CIM implementation plan, presentation to the CEA, February 22, 2012; and Manitoba Hydro presentation to the CNC/IEC Smart Grid Task Force, 2011.

[28] Canadian Control centres will continue to use IEC 60870-6.2 TASE.2 (ICCP); finding a replacement is not a priority. There are few incentives to replace IEC 60870-6 with CIM technologies, but this could change in the future.

for this purpose. In tables 2 and 3, several CIM Profiles projects[29] have been highlighted as priority projects:

- The IEC 61970 part 452, CIM Static Transmission Network Model Profile, aims to rigorously define the subset of classes, class attributes, and roles from the CIM for executing state estimation and power flow applications. The North American Electric Reliability Council (NERC) Data Exchange Working Group (DEWG) Common Power System Modeling group (CPSM) produced the original data requirements, used as the basis for producing the CIM Profile. These requirements are based on prior industry practices for exchanging power system model data for use primarily in planning studies. However, the list of required data has been extended in part 452 to facilitate a model exchange that includes parameters common to breaker-oriented applications.[30] In addition, the IEC 61970 part 45X aims to provide additional profiles, including part 451 - CIM profile for SCADA Data Exchange and part 455 - CIM Model Population Profile.[31]
- The IEC 61968 Part 11 contains the CIM extensions for distribution. The standard is not complete, and several Canadian utilities have developed extensions of their own. There is an opportunity to include Canadian extensions in future editions of the standard.
- The IEC 61968 Part 14-2 is another highlighted project for mapping Multispeak 4.0 to the IEC 61968 parts 3 to 10. This project is a result of work done by the NIST Priority Action Plan (PAP) 8 to develop strategies for integrating and expanding IEC 61970-301, IEC 61968, Multispeak and IEC 61850 for Smart Grid applications.[32]
- The IEC 61968 Part 100 aims to define a set of implementation profiles for IEC 61968 using technologies commonly applied to enterprise integration. This document describes how message payloads defined by parts 3 to 9 of IEC 61968 are conveyed using web services and the Java Messaging System. Guidance is also provided for using Enterprise Service Bus (ESB) technologies. The goal is to provide details that would enable interoperable implementations of IEC 61968.[33]

Table 2: Control Centre Standards for Energy Management Systems

Standard	Title			
IEC 61970	**Energy management system (EMS) application program interface**			
	Part	**Subtitle**	**Status**	**TC/SC/WG**
	1	Guidelines and general requirements	Published	TC57 WG13
	301	Common information model (CIM) base	Ed.3 published	TC57 WG13
	*452	CIM model exchange specification	To be published	TC57 WG13
	453	CIM based graphic exchange	Published	TC57 WG13
	*45X	Additional profiles	New work	TC57 WG13
	501	CIM RDF Schema	Published	TC57 WG13
	502-8	Web Services mapping	New work	TC57 WG13
	50X	Additional message format	New work	TC57 WG13
*** priorities highlighted**				

[29] From IEC 61970-452, 57/1107/NP.
[30] From IEC 61970-452, 57/1107/NP.
[31] IEC TC 57 working group 13 report, Shanghai, 2011.
[32] Multispeak background found at : http://collaborate.nist.gov/twiki-sggrid/bin/view/SmartGrid/PAP08DistrObjMultispeak.
[33] IEC 61968-100 new proposal: reference IEC 57/1151/NP.

Table 3: Control Centre Standards for Distribution Management Systems

Standard	Title			
IEC 61968	**Application integration at electric utilities–System interfaces for distribution management**			
	Part	**Subtitle**	**Status**	**TC/SC/WG**
	1	Interface architecture and general requirements	Ed.2 to be published	TC57 WG14
	1-1	Enterprise Service Bus implementation profile	New work	TC57 WG14
	1-2	Web Services	New work	TC57 WG14
	3	Network operations	Published	TC57 WG14
	4	Record and asset managements	Published	TC57 WG14
	9	Meter reading and control	Published	TC57 WG14
	*11	Common information model extensions for distribution	Published	TC57 WG14
	13	CIM RDF Model exchange for distribution	Published	TC57 WG14
	*14-1	Mapping between Multispeak 4.0 and IEC 61968, parts 3 to 10	Planned	TC57 WG14
	*14-2	CIM profile for Multispeak 4.0 Profile for IEC 61968 3 to 10	Planned	TC57 WG14
	*100	ESB implementation profile	Planned	TC57 WG14
*** priorities highlighted**				

4.4 SCADA communications between control centres and the field equipment

Supervisory Control and Data Acquisition (SCADA) systems are used to obtain data from the field or to exchange data between control centres. For control centres, the Task Force believes CIM should fulfill this role. Currently, SCADA servers acquire field data using IEEE 1815 (known as DNP3) and serve it to proprietary applications.

In the future, a SCADA system will use IEC 61850 standards to access data from substation and field devices. The SCADA system will act as a server using CIM IEC 61970 standards to exchange data with Control Centre EMS applications (e.g., Smart Grid State Estimator). The Task Force identified the need to resolve the differences in models between IEC 61850 and the CIM IEC 61970. The TC57 Working Group 19 effort will eliminate duplication through reuse of CIM classes by using IEC 61850 standards.

Legacy standards, such as IEEE 1815, implicitly assumed an “anonymous point-oriented model” to identify the values received and devices controlled. A data value source, such as an analog measurement, status, or accumulator (i.e., counter) value, is, therefore, a Remote Terminal Unit (RTU) point number or name. This is in contrast to the “device-oriented models” being developed in the TC57 Working Group 10 with the 61850 standards. For this Working Group, real-world substation and field devices are represented by object models. The value of the object is identified by a structured name identifying the device that supplies it and the object it contains.

Although adapters will always be required to translate proprietary data formats in legacy systems, a goal is to harmonize standards within TC57 so that a single representation of SCADA data is used in all standards. Single representation eliminates the need for translation in adapters. This would lead to a seamless architecture and is part of the vision of the future reference architecture. Table 4 lists the key standards for SCADA.

The Task Force has identified two high-priority projects that will help build this seamless architecture:

- *Communications between control centres and substations* crucial to allowing the free flow of data between field equipment and control centre applications. The possibility of using IEC 61850 for communications between substations and control systems is identified in the IEC TC57 reference architecture document (IEC 62375) without any specification of how it will be used. The issue was evaluated in 2002 by an IEC task force. The conclusion was that IEC 61850 is suitable, but may eventually require the following extensions:[34]
  - a new mapping of the communications services on a protocol suitable for wide area communications. Bandwidth, latency and packet loss issues need to be considered;
  - extensions of the data model to provide a control centre view of the substation. A further important benefit to users is the possibility of entering configuration information only once; and
  - currently, substation configuration information is available in the SCL (substation configuration language). Control centre configuration information is available in the CIM. The models have been harmonized, so that an automatic transfer of the information from one model to the other should be possible. New work shall describe how that configuration information can be transferred between CIM and SCL.

- *Communication of synchrophasor information needed for advanced Smart Grid applications.* Synchrophasor data, as measured and calculated by Phasor Measurement Units (PMUs), are required for advanced Smart Grid applications. The synchrophasor and related message formats to transmit synchrophasor data over long distances are defined in IEEE C37.118. There is a need to ensure that PMU communications mechanisms comply with the IEC 61850. The IEC 61850 Part 90-5 Technical Report describes how this should be done.[35]

Table 4: Standards for Supervisory Control and Data Acquisition

Standard	Title			
IEC 61850	**Communications networks and systems for power utility automation**			
	Part	**Subtitle**	**Status**	**TC/SC/WG**
	1, 2, 3, 4, 5, 6, 8-1, 9-2, 10, 7-1, 7-2, 7-3, 7-4	Main parts – developed for substations	Ed. 2 under publication	TC57 WG10
	80-1 TS	Exchange of 61850 information using IEC 60870-5-101/105	Published	TC57 WG10
	*90-2 TR	Communications between control centres and substations	To be published	TC57 WG19
	*90-5 TR	Communication of synchrophasor information (IEEE C37.118-2005)	To be published	TC57 WG10 / IEEE C37.118
IEC 61970 CIM	451	CIM-SCADA Data Exchange	New work	TC57 WG13
IEEE 1815		Standard for data acquisition and control between SCADA and field equipment	Published	IEEE 1815
*** priorities highlighted**				

[34] From IEC 61850-90-2 draft R0-24.
[35] From IEC 61850-90-5, reference IEC 57/1144/DTR.

4.5 Field equipment communications for substations and distribution automation

Intelligent Electronic Devices (IEDs) will have applications critical to power system reliability within smart grids. For power system protection, field devices will communicate with other field devices, using peer-to-peer communications. This opens the door to decentralized networks, compared with existing centralized networks, in which a master relays and make decisions. These components enact *self-healing* procedures that cannot currently be monitored or controlled in real time by today's SCADA systems. IT and telecommunications best practices and technological advances will enable performance and security tools to monitor and manage the growing field area networks, substation local area networks and communications between them.

Areas where these differences need to be reconciled occur when information is shared between a system using one set of models (e.g., an EMS/SCADA system based on the CIM) with a system using the other models (e.g., an automated substation using the 61850 standards). Another example would be a fault location system or maintenance management system based on CIM network and asset models using data from a 61850-based automated substation to provide fault and asset data. Table 5 lists the main parts of the IEC 61850 required for substation automation and the Task Force has identified two standards projects that are highlighted as priorities:

- The IEC Technical Report entitled "Use of IEC 61850 for the communication between substations" should be promoted in Canada, as it will guide the implementation of advanced line protection schemes. When IEC 61850 was prepared, it was intended for the use of information exchange between devices of a substation automation system. However, the concepts can be used in other application domains of the power utility system. Therefore, IEC 61850 is on the way to becoming the foundation for a globally standardized utility communications network. With existing and new applications for power system operation and protection, the requirement to exchange standardized information directly between substations increases. The IEC 61850 shall be the basis for this information exchange. IEC 61850 provides the basic features to be used for that information exchange. However, some extensions to IEC 61850 may be required.[36]
- The IEEE1815 (Distributed Network Protocol (DNP3)) is the standard most frequently used by Canadian utilities, while IEC 61850 is making progress.[37] The IEEE 1815 committee is collaborating with IEC TC57 Working Group 10, to publish a specification describing how to implement gateways between IEC 61850 and IEEE 1815. Two primary-use cases are addressed: mapping between an IEEE 1815-based master and an IEC 61850-based remote site; and mapping between an IEC 61850 based master and an IEEE 1815-based remote site. Mapping aspects included in the standard are: conceptual architecture; general mapping requirements; the mapping of Common Data Classes, Constructed Attribute Classes and Abstract Communication Service Interface (ACSI); and the architecture of a gateway for translation and requirements for embedding mapping configuration information into IEC 61850 System Configuration Language (SCL) and an DNP3 Device Profile. This specification addresses a selection of features, data classes and services of the two standards.[38]

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[36] Refer to IEC 61850-90-1; reference IEC 57/992/DTR.

[37] The IEEE 1815.1 (part 1) specifies the standard approach for mapping between IEEE 1815 and IEC 61850 (Communications Networks and Systems for Power Utility Automation).

[38] Refer to http://standards.ieee.org/develop/project/1815.1.html.

Table 5: Standards for Substation Automation

Standard	Title			
IEC 61850	**Communication networks and systems for power utility automation**			
	Part	**Subtitle**	**Status**	**TC/SC/WG**
	1, 2, 3, 4, 5, 6, 8-1, 9-2, 10, 7-1, 7-2, 7-3, 7-4	Main parts–developed for substations	Ed. 2 under publication	TC57 WG10
	9-2			
	80-1 TS	Exchange of 61850 information using IEC 60870-5-101/105	Published	TC57 WG10
	*IEEE 1815.1	Gateways between IEC 61850 and IEEE 1815 (DNP3)	New work	TC57 WG10 / IEEE 1815
	*90-1 TR	Communication between substations, including GOOSE messages	Published	TC57 WG10
	90-4 TR	Network engineering guidelines for substations	To be published	TC57 WG10
*** priorities highlighted**				

As a pillar of the Smart Grid, the scope of usage of IEC 61850 is expanding, especially in the fields of:[39]

- the integration of Distributed Energy Resources (IEC 61850-7-420);
- feeder automation and advanced distribution management systems; and
- the integration of active electricity consumers, such as electric vehicle charging stations, homes, buildings or industrial plants.

Table 6 highlights the priority projects of IEC 61850, including two new required work items:

- The IEC 61850 Part 7-4XX series for advanced distribution automation. As a first step, the IEC TC57 WG17 is planning to publish the IEC 61850-90-6 Technical Report. This report identifies the advanced distribution applications that require coverage by IEC 61850. The following Smart Grid applications have been identified by WG17:[40]
  - o demand response
  - o volt-var management
  - o fault detection, localization, isolation and restoration (FDIR)
  - o feeder reconfiguration
  - o controlling dispatchable distributed generation units
- web services. The resulting IEC 61850-8-2 Smart Grid standard will offer[41]:
  - o open-source communication stacks
  - o low footprint implementation, to fit small device constraints
  - o de facto LAN/WAN capabilities
  - o easy convergence and interoperability with CIM
  - o embedded cyber security capabilities, and firewall/security policies compatibility
  - o connectivity to millions of communicating devices already supporting these mechanisms

[39] This is described in the IEC 61850-8-2, new proposal IEC 57/1181/NP.
[40] This is described in the IEC 57/1074/DC.
[41] This is described in the IEC 61850-8-2, new proposal IEC 57/1181/NP.

Table 6: Standards for Distribution Automation and Distributed Energy Resources

Standard	Title			
IEC 61850	**Communication networks and systems for power systems**			
	Part	**Subtitle**	**Status**	**TC/SC/WG**
	1, 2, 3, 4, 5, 6, 8-1, 9-2, 10, 7-1, 7-2, 7-3, 7-4	Main parts	Ed. 2 under publication	TC57 WG10
	*7-420	Distributed energy resources logical nodes	Published	TC57 WG17
	*7-4XX	Feeder automation	New work	TC57 WG17
		Communication for Distributed Resource Island Systems	**Gap	TC57 WG17 / IEEE 1547.4
	*8-2	Communication profile using web services	New work	TC57 WG17
	90-7 TR	Object models for DER inverters	New work	TC57 WG17
	90-8 TR	Electric vehicles	New work	TC57 WG17
	90-9 TR	Storage and batteries	New work	TC57 WG17
		Demand response for customer loads, based on IEEE 1547.3	**Gap	TC57 WG21 / IEEE1547.3
*** priorities and gaps highlighted**				

4.6 Cross-cutting infrastructure–communications media and services

A central tenet of Smart Grid development should be the extension of open standard field area networks with high bandwidth and low-latency service throughout the geography of Canada for largely last-mile connectivity purposes. (Refer to Table 7.) To this end, spectrum has been identified in Canada for electric utility applications by Industry Canada, in the 1.8 GHz band (1800-1830 MHz), as shown in Figure 3. This recognized the urgent need for Smart Grid communication solutions. It has been proposed that utilities could deploy Worldwide Interoperability for Microwave Access (WiMAX based upon IEEE 802.16 standard), Long Term Evolution (LTE) or other standardized technologies in this frequency range, to address some of the last-mile connectivity concerns.

Canada is a leader in the identification of Smart Grid spectrum; other countries may choose different bands for electricity management. This is not a significant problem, as long as similar amounts of spectrum and operating rules permitting similar technologies are adopted. For example, 1800 to 1830 is near the Global System for Mobile Communication (GSM) 1800 gap band (1785 to 1805 MHz), between the GSM[42]-1800 uplink and downlink. The 1785 to 1805 MHz band is used for time division industrial broadband networks in China. In the United States and other countries where electricity management spectrum is not yet allocated, the gaps between Advanced Wireless Services (AWS) and Personal Communication Services (PCS), or the GSM bands, are good opportunities.[43] Some U.S. utilities that cannot wait are purchasing spectrum from auction winners (e.g., 2.3 GHz or 700MHz). The United States is considering

[42] For mobile phone applications–GMS standard: Global System for Mobile Communications.
[43] U.S. spectrum broadband: http://www.broadband.gov/plan/5-spectrum/#s5-2; In Canada, the cellular mobile radio services (CMRS) were launched in the early 1980s, with licences for 40 MHz of spectrum in the cellular band. In response to tremendous growth in demand for mobile telephony services, additional spectrum was designated in 1989 (in the cellular band); in 1995 (in the PCS band); and in 2001 (additional PCS spectrum). The Advanced Wireless Service (AWS) auction in 2008 made available an additional 105 MHz to the commercial mobile industry in three different bands: AWS, PCS and 1670-1675 MHz. http://www.ic.gc.ca/eic/site/sd-sd.nsf/eng/home.

repurposing frequencies in the 700MHz range. Many utilities already have spectrum in the 700 to 900MHz range, which they use for analog and digital microwave radio. There is potential in this area for common Smart Grid spectrum to be identified. A disadvantage of not having direct harmonization with the United States is a potential for international frequency coordination challenges, as the bulk of the Canadian population is located near the U.S. border.

Table 7: List of Wireless Telecommunication Options for Metering, Middle Mile and Backhaul[44]

Component	Requirements	Possible Telecommunication Options
Smart Metering	• Short range connectivity • Low bandwidth, low duty cycle • Robust: Withstands interruptions • Must be low cost	➢Wireline ➢Wireless ➢Licence-exempt ➢Licensed
Middle Mile	• Connection to many collector stations/substations and small generation sources • Moderate cost is acceptable • Good reliability • Medium bandwidth	➢Wireline ➢Wireless ➢Licensed
Backhaul	• Connect to fewer points • High bandwidth • High reliability • Low latency	➢Wireline (Fibre/copper) ➢Wireless ➢Licensed

Figure 3: Industry Canada Wireless Spectrum 1800-1830 MHz Band for Point-to-Multi-point Backhaul for Fixed Electricity Management

WiMAX communication technology for wirelessly delivering service to large geographic areas—the choice of early utility networks—is a mature technology. The standard is well-established, and the WIMAX Forum promotes its interoperability.[45] With the emergence of LTE for mobile cellular services,[46] research and development investment in WiMAX technology has diminished. The future of WiMAX is in doubt among cellular telephony providers. Utilities may represent an alternate market for WiMAX technology because it can be deployed without dependency on an external telecom provider, which is appealing to some utilities. There is a precedent: the utility industry has managed to keep the 900 MHz analog radio equipment manufacturers in business as their primary market since 1990. However, it is not clear whether utilities and other niche markets will be sufficient to make WiMAX a healthy, growing technology. Canadian utilities have signalled to their suppliers that development roadmaps are required. One desirable roadmap

[44] Source: Miranda Kong, Spectrum Regulation, Presentation at ISACC 44th Plenary, Ottawa, Ontario, November 4, 2010.

[45] Worldwide Interoperability for Microwave Access (WiMAX) is a communication technology for wirelessly delivering service to large geographic areas. Its conformance is verified through certification by the WIMAX Forum: http://www.wimaxforum.org/certification/certification-overview.

[46] Long Term Evolution (LTE) is a standard for wireless communication of high-speed data for mobile phones and data terminals, also marketed as 4G LTE.

option is to enhance LTE to support utility operating conditions, allowing migration.[47] Some of the utility market-focused suppliers are already offering LTE products. In Canada, having spectrum policy for electricity management mitigates product development risk and allows the utility suppliers to develop communications solutions to meet the unique and stringent needs of electric utilities.

4.7 Cross-cutting security

Today, cyber security frameworks are an essential part of every utility's communications. There are numerous methods to secure communications. Therefore, each utility must assess how and to what extent their communication network should be secured. To help utilities in this task, a series of technical specifications was issued by IEC TC57 WG15 to describe security enhancement for key power systems communications standards. These enhancements are necessary, because, at the time the original standards were produced, security issues were not part of the scope. Three important projects are highlighted in Table 8 as priorities:

- IEC 62351 Part 5—Security for IEC 60870-5 and derivatives: IEC 60870-5, Part 101 and, particularly, Part 104, require security enhancements to ensure their implementation and use in non-secure environments. This technical specification also addresses security for IEEE 1815.
- IEC 62351 Part 6—Security for IEC 61850 profiles: The different communications profiles of IEC 61850 require security enhancements to ensure their implementation and use in non-secure environments.
- Security for CIM: There is currently no work under way to describe security enhancements for the CIM. Ideally, work being done on CIM communications profiles should include security aspects from the start, and should not require a separate security specification. However, WG13 and WG14 experts developing CIM profiles may not have the security expertise of their WG15 colleagues. Therefore, the situation has to be assessed as work progresses on CIM profiles, to evaluate the need for such a security specification.

Table 8: Standards for Security

Standard	Title			
	Data and Communications Security			
	Part	**Subtitle**	**Status**	**TC/SC/WG**
	3	Security for profiles including TCP/IP	Published	TC57 WG15
	4	Security for profiles, including MMS	Published	TC57 WG15
	*5	Security for IEC 60870-5 and derivatives	Published	TC57 WG15
IEC 62351	*6	Security for IEC 61850 profiles	Published	TC57 WG15
	7	Objects for Network Management	Published	TC57 WG15
	8	Role-Based Access Control	Published	TC57 WG15
	9	Key management	In progress	TC57 WG15
	10	Security architecture	In progress	TC57 WG15
	*	Security for CIM	Gap	TC57 WG15
*** priorities and gaps highlighted**				

[47] Electricity transmission and distribution utility decentralized operation—focused on security, but not accounting and hardened for industrial environments.

In addition, significant linkages need to be established with the Joint Technical Committee (JTC1/SC27), which develops security standards suitable for industrial application. The JTC1/SC27 has developed a series of base-security standards, originally addressing the ICT sector. Unlike the ICT sector, where the protection of information is typically most important, the industrial sector places the most emphasis on the protection of people, the environment and physical assets. Therefore, security standards must be tailored to meet Smart Grid and other critical infrastructure requirements. This is an evolving field, and additional work will be required to identify and promote the standards needed.[48]

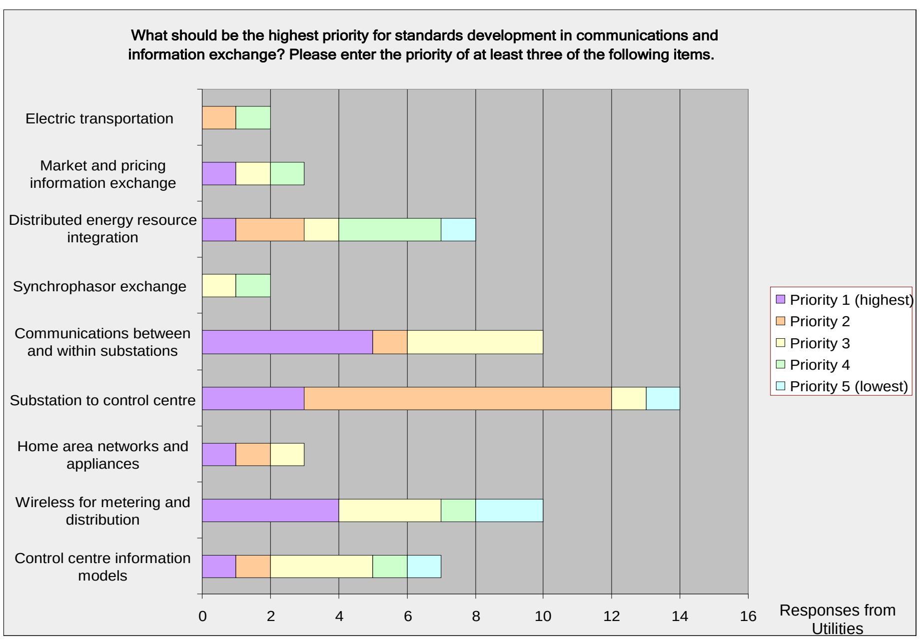
4.8 Survey results of Canadian implementation

The results of a cross-Canada utility survey conducted by Task Force Working Group 2 (WG2) is shown in Figure 4. The top three priorities for the industries are the following:

- communication between and within substations. The relevant standards for this priority area include IEC 61850 for substation, IEEE 1815 (DNP3) for SCADA and IEEE C37.118 for synchrophasors;
- wireless communications for metering and distribution. This priority reflects the need to develop cross-cutting, wide-area network infrastructure solutions needed to convey the information from the field equipment to the Distribution Management Systems; and
- communication between substations and control centres. This priority area requires a technical report describing how to transform IEC 61850 data into IEC 61970 CIM data.

The Canadian Task Force has included these top three priorities as part of its key transmission and distribution Smart Grid recommendations, as depicted in Figure 4.

Figure 4: Results of Survey to Identify the Top Three Priorities for Standards Development



[48] For example, work in IEC/TC65 WG10 *Security for industrial process measurement and control—Network and system security*, aims to develop a series of standards that targets the industrial sector.

4.9 Recommendations for closing the T&D standards gaps

The Task Force consolidated the following six key Transmission and Distribution (T&D) system recommendations:

Recommendation T&D1:

It is important for Canadian experts to participate in, or initiate work on, harmonization of NAESB energy market standards with the IEC TC57 WG16. This would support new work on harmonization of standards for the wholesale and retail electricity markets and demand response.

> The CNC/IEC should encourage Canadian experts' participation in IEC TC57/WG16 for developing the IEC 62325-356 profile for North American wholesale energy markets. As well, the CNC/IEC should become an active contributor to NAESB Demand Response standards.

Recommendation T&D2:

There is far too much variability in the current CIM projects, and multi-vendor CIM deployments are nearly non-existent. To achieve the advantage of interoperability, CIM standards must evolve to more closely resemble the application programming interface standards they were originally intended to be.

> The CNC/IEC should encourage the creation of standardized profiles for CIM implementations and the creation of mappings between Multispeak 4.0 and IEC 61968 CIM as a means to improve control centre systems interoperability.

Recommendation T&D3:

The future Smart Grid requires standards that will support improved situation awareness over a large geographic area, to help avoid large-scale blackouts.

> To support Smart Grid interoperability requirements, the CNC/IEC should encourage the adoption and application of IEC 61850 for the purpose of communication between substations, between substations and control centre and for the transfer of synchrophasor data.

Recommendation T&D4:

Although the IEC 61850 if one of the core standards identified, it still needs to reach greater maturity for field equipment, substations and Distributed Energy Resources.

> The CNC/IEC should encourage the development of guidelines and standards for utilities to migrate from existing, commonly used technologies to the architecture described in IEC 61850. At the same time, the CNC/IEC should recognize the large, existing investment by utilities in the older technologies. This will require gateway solutions and protocol converters during the initial transition period. In addition, the CNC/IEC should encourage the extension of this standard to distribution automation equipment and distributed energy resources.

Recommendation T&D5:

The dominance of proprietary solutions is blocking the creation of communication network solutions for distribution feeder automation.

> The CNC/IEC should encourage the standardization and adoption of high-bandwidth, low-latency, low-cost field communication networks; this area is often dominated by proprietary solutions and Canada's vast geography. In addition, the CNC/IEC should

encourage a dialog between the Canadian and U.S. policymakers regarding the use of a common spectrum.

Recommendation T&D6:

The CNC/IEC should encourage the development and use of the IEC 62351 standard that applies security controls to power-system-specific communications technologies. One specific area that needs to be addressed and monitored is the security for CIM.

5 Metering Systems Standards

5.1 Introduction

Canada's Smart Grid interoperability framework will need to account for the realities of existing infrastructure and systems that are already deployed across Canada (and the United States), having many years of useful service life left in them. This holds true for:

- meters
- metering and related communications systems between utility and customer
- metering head-end systems
- utility enterprise-side metering and data management systems (back office)

Collectively, the meters, the systems behind the meters, and those in front of the meters, manifest themselves across Canada's diverse mixture of generation, transmission, distribution and measurement assets. Today, for example, millions of customer locations across the province of Ontario implement various proprietary forms of Advanced Metering Infrastructure and attendant "smart meters" and related control devices. These items pre-date (at times by more than 10 years) emerging or contemporary interoperability standards, such as the ANSI [49] standard C12 and the IEEE [50] standard 1377 and the IEEE standard 170x series of standards. Utility stakeholders have developed and are actively developing additional conformance testing specifications, deployment management guidelines and accreditation requirements for the AMI. These include establishment of the North American End Device Registry Authority (NAEDRA)[51], AEIC[52] Guidelines 2.0 (AMI interoperability guidelines for meter communications and supporting enterprise networks), and the application of Measurement Canada's[53] specifications for the approval of both software-controlled electricity meters and event loggers.

5.2 Canadian Smart Grid advanced metering infrastructure standards

A list of key standards referenced in electricity metering requirements, or in Canadian legislation, is provided in Table 9. These standards are expected to be deployed in a manner consistent with the recommended *Smart Grid Advanced Metering Infrastructure Logical Architecture*. The logical flow and control of the information is shown in Figure 5. This logical schematic provides an expanded view of the AMI/AMR Customer Domain Field Area Network (FAN) and Premises Area Network (PAN). From a communications standpoint, the Customer AMI Domain (depicted in the top-left quadrant of Figure 5) is divided internally into three security perimeters:

- the utility-owned (or delegated) and controlled trusted Facility Area Network zone (**FAN trusted zone**) component of the AMI;
- the customer control and trusted Premises Area Network zone (**trusted PAN zone**); and

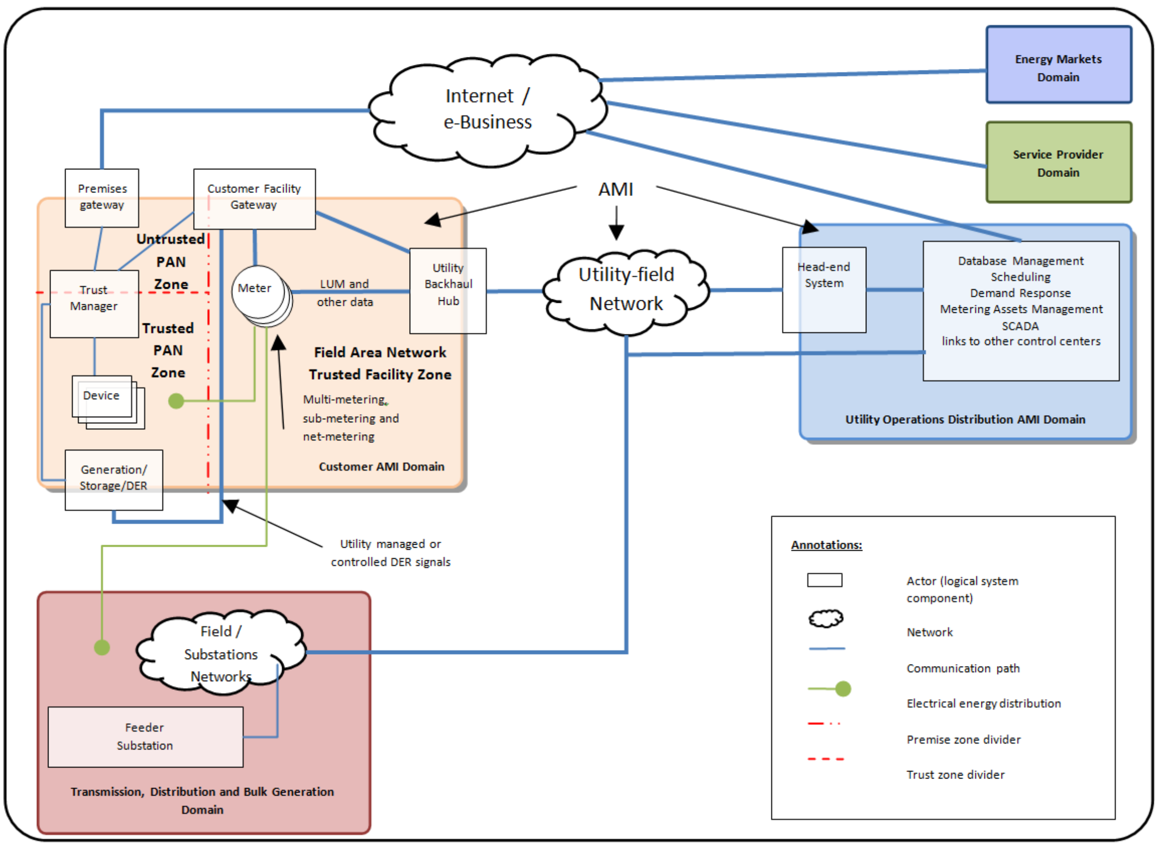
[49] ANSI: http://www.ansi.org/default.aspx.
[50] IEEE: http://standards.ieee.org/.
[51] NAEDRA: http://www.naedra.org.
[52] AEIC: http://www.aeic.org/meter_service.
[53] Measurement Canada's: http://www.ic.gc.ca/eic/site/mc-mc.nsf/eng/lm04528.html.

- the customer control and untrusted Premises Area Network zone (**untrusted PAN zone**)[54].

The *untrusted* segment of the Premises Area Network can communicate with energy markets, service providers and the utility operations domains via available channels—ideally through the premises gateway, using any network. Information and control messages may be exchanged between the utility Head End Systems and the utility-owned meters, customer-owned devices (such as home appliances, energy management systems, thermostats, electric pluggable vehicle, and electric storage) through the customer facility gateway and the customer facility *trust manager* (that acts both as a trust centre and a gateway or a bridge to the Premises Area Network).

When the customer domain devices act as Distributed Energy Resources (DER)—which allows the flow of energy to and from the electrical grid, depending on its size—the energy flow may need to be controlled by the utility (or its agents), as specified by existing or new regulations.

Figure 5: Smart Grid Advanced Metering Infrastructure Logical Architecture*



*Exhibited elements include only meters and the assets that are in front and behind the meter.

The equipment that may be co-located at the customer premise is separated and isolated using utility gateways. The gateways provide access to and separation from the utility backhaul networks (these include metering/AMI and T&D managed networks) from the PAN (including appliances, EMSs and consumer technologies). The gateways do so by using trust centres,

[54] An example of the *untrusted* PAN Zone is the wired Internet or wireless radio internet into the customer premise.

while maintaining the co-generation storage technologies (such as Plug-in Electric Vehicles), which should be connected through utility back-haul network. The AMI customer premises loose coupling to the utility network empowers the consumer, while mitigating the risk and concerns regarding information privacy, impact on reliability, accessibility, load control, load response and load management.

Typical logical architecture diagrams lay out only the communications pathways at the equipment interfaces. Figure 5 provides additional information. The blue lines represent communications paths; the thick blue lines correspond to reliable managed networks; and the thin blue lines represent customer domain unmanaged and less-reliable networks. The green lines provide an elementary indication of where in the customer domain the electrical power flows, where it is controlled and where it is measured (metered). The reason for indicating electrical energy flows is to show where the energy usage measurements take place (e.g., metering, net metering and sub-metering); the location of control points (e.g., service connect/disconnect switch, load control); and where information is needed to manage the facility and the grid loads (e.g., Distributed Energy Resources, Demand Response, Co-Generation).

The logical flow of information shown in Figure 5 addresses Home Area Networks (HAN) for home appliances and electrical vehicle charging that are within the scope of many HAN standards. One such standard is the Smart Energy Profile (SEP) 2.0 of the Zigbee Alliance.[55] The Task Force agreed more effort is required at the international level to harmonize those standards for the demand response functions required within the Smart Grid system components. For example, experts working on SEP 2.0 will be collaborating with the IEC TC57 WG21 to develop protocol and gateway interface to consumer applications. The goal is to address possible orphaned Smart Grid investments.

In addition, the Society of Automotive Engineers (SAE) has developed important Smart Grid standards, such as the SAE J2847 Recommended Practice. This practice establishes requirements and specifications for communications between plug-in electric vehicles and the electric power grid.

Similarly, the Task Force considered the importance of the migration from Internet Protocol version 4 (IPv4) to Internet Protocol version 6 (IPv6). This migration has a significant impact on the realization of the Smart Grid. BC Hydro is the first Canadian utility planning to deploy the new IPv6 private communication infrastructure for smart meters, and other grid-enabled devices, over a wireless mesh network.

Several advanced metering standards projects are identified in Table 9 as priority projects for the development of the Canada Smart Advanced Metering. Three of these standards are marked to indicate the conceptual gap between the AMI security and privacy-burden assumption protocols, and the AMI implementation of real-time processing requirements—as it applies to utilities' expectations for the use of NIST-approved cryptographic methods. In the context of the overall goals of the NIST *Cryptographic Toolkit*,[56] a gap exists where the immediate and practical demand for security and privacy are being excluded from the market because they are not yet approved by NIST. Stronger security techniques with more-efficient, key management approaches will be required. This is an area needing further study, and where

[55] Smart Energy Profile (SEP) version 2.0 is still under development, as the current standard is the SEP 1.1; refer to the Zigbee Alliance standards webpage http://www.zigbee.org/Standards/Overview.aspx

[56] "*NIST aims to approve a small set of strong cryptographic mechanisms to serve as standard building blocks for the development of secure applications and protocols. There is a recurring tension between demand for new features and the practical requirement to limit the size of the toolkit. This practical requirement stems primarily from industry needs for interoperability, reusability, and assurance (i.e., confidence in the security) of these algorithms, and motivates our preference for broadly applicable algorithms*" [ref. Tim Polk on NIST Determination regarding EAX', March 22, 2012].

the standards from the ICT sector within the ISO/IEC/JTC1/SC27 Working Group may be appropriate.

5.3 Smart metering infrastructure recommendations

As part of its strategic planning mandate, the Task Force identified six key recommendations regarding smart meter standards. The Task Force also recognized the development and use of open standards and the related call for interoperability as very important aspects for an effective multi-vendor environment of the Smart Grid.

<u>Recommendation M1</u>:

The recommended Canadian AMI architecture, shown in Figure 5, exposes the interfaces and the demarcation (separation) zones in a manner that will help regulators, utilities and implementers enact key requirements. These requirements include security, privacy of information, grid safety, interoperability and reliability. This Canadian AMI architecture is an overarching recommendation: it represents, at the highest level, the overall thrust of the Smart Grid standardization effort. This architecture also highlights the technology and service elements that need addressing, to reach the standards environment for supporting a fully functional Smart Grid.

> Therefore, the CNC/IEC should recommend to utilities and regulators the need for a clear and unambiguous separation (demarcation) between utility-owned and customer-owned equipment and services.

<u>Recommendation M2</u>:

Most smart meters today meet the necessary legislation and policies required to ensure Measurement Canada-approved smart meters communicate Legal Units of Measure (LUM) to the billing systems. However, currently there are smart meters that do not communicate LUMs, and that may require external calculations to yield LUMs, critical computation basis for accurate billing.

> The CNC/IEC should recommend to utilities and regulators that smart meters regulation and policies be established, as needed, to ensure that Measurement Canada-approved smart meters:

- communicate LUMs to the billing systems, just as they do for their local meter display;
- where the time of use is relevant to calculating customer billing: that Source Legal Unit of Measure (SLUM) is also tested for the accuracy of the start, end and duration of the time periods used to measure the SLUM communicated by the meter to the billing systems, for computing a Process Legal Unit of Measure (PLUM); and
- communicated interval or period-based LUMs for demand measurement are tested for their accuracy of demand measurement and for accuracy of the start, end and duration of the demand interval time for the intervals or periods of the LUMs (where required for reporting by the meter to the billing systems).

Recommendation M3:

Currently, utilities and the authority having jurisdiction[57], set their own standards of practices. There is no harmonized federal or provincial policy, regulation or legislation that requires common and interoperable practice for uniform accountability, operation, reporting, and accuracy of billing and management of billing information that is computed by the utility enterprise back-end systems. These processes should be end-to-end traceable, directly and indirectly to information that is communicated by Measurement Canada-approved meters (LUMs) to the billing systems.[58]

> The CNC/IEC should recommend that Smart Grid regulation and policies be established to harmonize provincial, territorial and interprovincial, and interterritorial practices.
>
> In addition, the CNC/IEC should recommend that Smart Grid regulation and policies be established to prompt provincial and interprovincial practices that, ultimately, shall result in uniformity of practice and standards-based interoperability of processing by the back-office billing data processing technologies—in a manner that also increases transparency of operations for the benefit of consumers and the utility for Canada.

Recommendation M4:

To provide support for DER integration (distributed generation–micro-grid and storage, including electric vehicle-to-grid), sub-metering and multi-metering may be necessary for payments and credits; otherwise, different billing rates may apply. It is known that many of the Smart Grid standards support such capabilities; however, these have yet to be enacted or implemented in the meters and in the head-end systems. A common strategy to address acceptable solutions has not been established.

> The CNC/IEC should recommend to utilities, regulators, Measurement Canada and meter manufacturers, that they develop strategies and requirements related to sub-metering and multi-metering applications for distributed generation at the customer's domain, where LUMS, SLUMS and PLUMS are required.

Recommendation M5:

Electric vehicle standards are still at the final stages of being published as tri-national standards. Initially, these standards focus on charging stations, physical connections to the vehicle, and safety. In some other areas, such as communications—competing standards or protocols developed by Special Interest Groups (SIG) are being debated. The possible implications of those discussions are presently far from clear. However, over the longer term, emerging standards may unlock the potential for fleets of electric vehicles or buses to be used, in effect as storage devices, providing ancillary services to the Smart Grid.

The concept of PEV charging and different payment scenarios, while roaming within or between different service provider locations, also applies to PANs. Application exists where the home or facility owner opts to have the utility charge the "guest" vehicle owner directly for electrical load consumed at the PAN. The infrastructure assumed for this is the existing and emerging Smart Grid AMI (metering infrastructure and protocols) that communicate through the facility gateway with the utilities. These infrastructure and protocols already have the design framework to carry on the task in published standards.

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[57] In the United States, the AHJ is known as the Public Utility Commission.

[58] Refer to Audit Trail Implementation Guide for ANSI C12.19 / IEEE 1377, Utility Industry Standards Tables. A Guide for implementing Measurement Canada "Interim Specifications (/ Procedures) Relating to Event Loggers for Electricity Metering Devices and Systems" , IS-E-01-E / IP-E-01-E and PS-EGMVXX-E, for re-programming ANSI C12.19 / IEEE 1377 standard based metering devices, which operate an event logger or event counters.

The CNC/IEC should recommend to utilities to deploy AMI and metering communications networks for the Smart Grid in a manner that does not operate in isolation and does permit energy usage retrieval billing and roaming Plug-in Electric Vehicle capabilities that span multi-utility networks across the entire Smart Grid. Such billing and credit capability will be the basis for utility-to-utility roaming operations, communications, micro-grid and resource usage settlement agreements.

Recommendation M6:

There is a need for Canadian experts to coordinate their efforts and promote the Smart Grid Advanced Metering Infrastructure (AMI) architecture. Canadian experts are members of the IEEE SCC31 and ANSI ASC12 SC17 and participate in the effort of the North American End Device Registry Authority (NAEDRA). In addition, Canada should enhance its participation in the international standards on interconnection of information technology (IT) equipment being led by the ISO/IEC JTC 1/SC 25. This committee has a new focus on home and building energy management, and a connection to the Smart Grid. The committee produces international standards for home electronic system, including the control of equipment for heating, lighting, audio/video, telecommunications, security, residential gateways (customer premises cabling and relevant ICT communication interfaces) and the internal Home Electronic System network and external wide-area networks, such as the Internet. The committee also looks at similar building management functions in commercial buildings. Currently, there is no Canadian national committee to the IEC on smart meter. To promote harmonization, participation at alternative standards organizations relevant to North America(for example, ANSI, IEEE and NAEDRA), has been insufficient.

The CNC/IEC should recommend the creation and funding of a Canadian harmonized national Technical Committee (CSC/TC13) on Electricity Metering Standards be formed within the Canadian National Standards System. This committee should also bring Canadian interests to metering-related standards and activities of IEEE, ANSI and NAEDRA.

Table 9: List of Standards Used in North American Electricity Metering (highlight the gaps)**

Standard	Title	Status	TC/SC/WG
S-EG-05	Measurement Canada Specifications for the Approval of Software Controlled Electricity and Gas Metering Devices	Published 2012 **Priority**	Measurement Canada WG
S-EG-06	Measurement Canada Specifications Relating to Event Loggers for Electricity and Gas Metering Devices	Published 2012 **Priority**	Measurement Canada WG
ANSI C12.18	Protocol Specification for ANSI Type 2 Optical Port [same as IEEE 1701]	V2.0 Pub. 2006 **Priority**	ASC12 SC17 WG4*
ANSI C12.19	Utility Industry End Device Data Tables [same as IEEE 1377]	V2.0 Pub. 2008 **Priority**	ASC12 SC17 WG2*
ANSI C12.21	Protocol Specification for Telephone Modem Communication [same as IEEE 1702]	V2.0 Pub. 2006	ASC12 SC17 WG4*

Standard	Title	Status	TC/SC/WG
ANSI C12.22	Protocol Specification For Interfacing to Data Communication Networks [same as IEEE 1703]	V1.0 Pub. 2008 **Priority**	ASC12 SC17 WG2*
IEEE 1377	Standard for Utility Industry Metering Communication Protocol Application Layer (End Device Data Tables) [same as ANSI C12.19]	V2.1 Approved Ballot 2010 **Priority**	IEEE SCC31 P1377 WG*
IEEE 1701	Standard for Optical Port Communication Protocol to Complement the Utility Industry End Device Data Tables [same as ANSI C12.18]	V2.0 Pub. 2010 **Priority**	IEEE SCC31 P1701/P1702 WG*
IEEE 1702	Standard for Telephone Modem Communication Protocol to Complement the Utility Industry End Device Data Tables	V2.0 Pub. 2010	IEEE SCC31 P1701/P1702 WG*
IEEE 1703	Standard for Local Area Network/Wide Area Network (LAN/WAN) Node Communication Protocol to Complement the Utility Industry End Device Data Tables [same as ANSI C12.22]	V1.0 published 2012 **Priority**	IEEE SCC31 P1703 WG*
XML-2008	*Extensible Mark-up Language (XML) Recommendation (Fifth Edition) [used by ANSI C12.19 / IEEE 1377 for enterprise data exchange language, configuration management and Table model Definition Language]*	V1.0 Pub. 2008	W3C
XHTML	XHTML 1.0 The Extensible HyperText Markup Language (Second Edition) *) [used by ANSI C12.19 / IEEE 1377 for configuration management documentation of Table model Definition Language]*	E2.0 Pub. 2002	W3C
ISO/IEC 62056-62	Electricity metering—Data exchange for meter reading, tariff and load control—Interface classes. OBIS/COSEM [incorporates the ANSI C12.19 / IEEE 1377 Data (Tables) Model]	Pub. 2006	IEC/TC13
ISO/IEC 15955 **X.237 bis**	Information Technology—Open Systems Interconnection—Connectionless Protocol for the Application Service Object Association Control Service [defines the message format used by ANSI C12.22 / IEEE 1703]	Pub. 1999 **Priority**	ITU X
ISO/IEC 10035-1, X.237 / Amendment 1	Information Technology—Open Systems Interconnection—Connectionless Protocol for the Association Control Service Element: Protocol Specification	Pub. 1995	ITU X
ISO/IEC 8824-1 / ITU-T X.680	Information technology – Abstract Syntax Notation One (ASN.1): Specification of basic notation [defines the abstract syntax notations used by ANSI C12.22 / IEEE 1703]	Pub. 1995	ITU-X

Standard	Title	Status	TC/SC/WG
ISO/IEC 8825 / ITU-T X.690	Information technology—ASN.1 encoding rules: Specification of Basic Encoding Rules (BER), Canonical Encoding Rules (CER) and Distinguished Encoding Rules (DER) [defines the payload encoding rules used by ANSI C12.22 / IEEE 1703]	Pub. 2003 **Priority**	ITU-X
RFC 6142	ANSI C12.22, IEEE 1703, and MC12.22 Transport Over IP	Pub. 2011 **Priority**	IETF
AEIC Interoperability Guidelines	Smart Grid/AEIC AMI Interoperability Standard Guidelines for ANSI C12.19 / IEEE 1377 / MC12.19 End Device Communications and Supporting Enterprise Devices, Network and related accessories.	V2.0 Pub. 2010 **Priority**	AEIC / AMTI , and NIST/SGIP PAP5/ Measurement Canada WG
FIPS PUB 180-2	Secure Hash Signature Standard (SHS) FIPS PUB 180-2). [used by ANSI C12.19 / IEEE 1377 logger hash function]	Pub. 2002	NIST
**FIPS Pub 197	Advanced Encryption Standard (AES), Federal Information Processing 28 Standards Publication 197 [used by ANSI C12.22 / IEEE 1703 logger hash function]	Pub. 2001 Gap	NIST
**SP800-38A	Recommendation for Block Cipher Modes of Operation; Methods and 32 Techniques [used by ANSI C12.22 / IEEE 1703 logger hash function]	Pub. 2001 Gap	NIST
**NIST SP 800-38B	Recommendation for Block Cipher Modes of Operation: The CMAC Mode for 38 Authentication [used by ANSI C12.22 / IEEE 1703 logger hash function]	Pub. 2005 Gap	NIST

* Developed jointly with the Measurement Canada Task Force on Data Communications Protocol for EMD.

6 Conclusion

We hope that this Smart Grid Standards Roadmap report has provided you with insight into the broad range of related standards activities. Our ongoing goal is to encourage provincial regulators and utilities—when developing business plans for Smart Grid initiatives—to support the migration from proprietary technologies to open standards, and from their current architecture to the recommended Canadian Smart Grid Reference Framework described in this report.

The Smart Grid will enable customers to manage their electricity consumption; a wide range of smart devices for these applications will be available. An important aspect of advanced smart metering is a guiding principle that the consumer should have ultimate authority over access and usage of their energy-related data. In some cases, customers will enter into a contract with third-party energy services providers, to help them participate in the electricity market. From legal and technical points of view, a clear demarcation needs to be identified, to understand the responsibility and bi-directional flow of information between the customer premises (zones) and the utility and/or third-party energy service providers.

As mentioned in this report, the Task Force recommends the promotion of Smart Grid Privacy Principles, as they are broadly applicable across Canada. This report has described the logical flow of information and security boundaries for the *Smart Grid Advanced Metering Infrastructure Logical Architecture*. The Task Force has identified the priority areas for smart meter standards and the need to bridge the gap on security standards. The complex nature of this effort will require a plan to recruit experts knowledgeable in this emerging field. The Task Force has recommended the establishment of a Canadian National Sub-committee on Electricity Metering Standards.

The most critical cross-cutting finding of the Task Force is its recommendation for SCC to establish a Smart Grid Steering Committee. The committee would continue managing the domestic and regional deployment of this roadmap, and further development of Canadian expert participation at the appropriate international policy management committees. Furthermore, the steering committee would champion and promote key standards activities—filling identified gaps, reporting on progress, or suggesting steps to address delays or conflicts.

To strengthen harmonization with the IEC, a Canadian work program, with a list of priority projects, was identified for IEC TC57 working groups (WGs). These projects included: WG10, tasked to prioritize electricity substation automation; WG13 and WG14, tasked with priority projects for control centres for energy management and distribution management systems; WG15, for cross-cutting security standards; and WG17, for addressing the integration of distributed energy resources, through several projects. Canada is fairly well represented in the key IEC TC57 WGs; however, there is a need for Canadian experts to be accredited to participate in WG16 on energy markets and WG21 on standards protocols and gateways for consumer applications. These two WGs are important because of the need to promote open standards for the wholesale and retail electricity markets. In addition, the steering committee could address the need to promote cross-cutting requirements on wireless spectrum harmonization standards and low-cost access to necessary bandwidth for Smart Grid applications.

The Task Force has followed the developments in the U.S. NIST Smart Grid Initiative, and believes SCC—and the Canadian national Standards Development Organizations—can continue to lead in promoting the adoption of harmonized standards in Canada.

Annex A: Summary List of Recommendations

Recommendation G1:

The CNC/IEC should recommend the creation of a Smart Grid Steering Committee to coordinate and assist with the other recommendations contained in this roadmap; work with other relevant standards policy bodies and technical committees; and periodically update the roadmap.

Recommendation G2:

The CNC/IEC should support the creation of a Canadian technical subcommittee for smart meters, and encourage greater participation and funding for other important technical committees.

Recommendation G3:

The CNC/IEC should recommend to governments and regulators to be very cautious about enshrining any standard into regulation in the near term. Some of these standards are not yet mature enough to have a proven track record. Also, forced early conversion to a new standard may prematurely make obsolete current infrastructure investments, unnecessarily adding cost burdens.

Recommendation R1:

The CNC/IEC should encourage provincial regulators and utilities, when developing business plans for Smart Grid initiatives, to ensure systems migrate from proprietary technologies to open standards, and from their current architecture to the Canadian Smart Grid Reference Architecture described in this report. This step will enable regulators and utilities to compare roadmaps and therefore identify areas of commonality, interoperability, deployment timing and possible technological risk.

Recommendation P&S1:

The CNC/IEC should recommend Canadians stakeholders participate in the specification of Smart Grid cyber security requirements and standards within NIST's SGIP and CSWG, to promote a harmonized North American approach to the greatest extent possible.

It is also recommended that the proposed Smart Grid Steering Committee consider where and how Canadian positions on Smart Grid cyber security standards should be developed.

Recommendation T&D1:

The CNC/IEC should encourage Canadian expert participation in IEC TC57/WG16 for development of the IEC 62325-356 profile for North American wholesale energy markets, and should become an active contributor to NAESB Demand Response standards.

Recommendation T&D2:

The CNC/IEC should encourage the creation of standardized profiles for CIM implementations and the creation of mappings between Multispeak 4.0 and IEC 61968 CIM, as a means to improve control centre systems interoperability.

Recommendation T&D3:

To support Smart Grid interoperability requirements, the CNC/IEC should encourage the adoption and application of IEC 61850 for the purpose of communications between substations, between substations and control centre, and for transferring synchrophasor data.

Recommendation T&D4:

The CNC/IEC should encourage the development of guidelines and standards for utilities to migrate from existing, commonly used technologies, to the architecture described in IEC 61850. At the same time, the CNC/IEC should recognize that the large, existing investment by utilities in the older technologies will require gateway solutions and protocol converters during the initial transition period.

- In addition, the CNC/IEC should encourage extending this standard to distribution automation equipment and distributed energy resources.

Recommendation T&D5:

The CNC/IEC should encourage the standardization and adoption of high-bandwidth, low-latency, low-cost field communications networks; this area is often dominated by proprietary solutions and is vital to Canada's broad geography.

- In addition, the CNC/IEC should encourage a dialog between the Canadian and U.S. policymakers regarding the use of a common spectrum.

Recommendation T&D6:

The CNC/IEC should encourage the development and use of the IEC 62351 standard that applies security controls to power-system-specific communications technologies. One specific area that needs to be addressed and monitored is the security for CIM.

Recommendation M1:

The CNC/IEC should recommend to utilities and regulators the need for a clear and unambiguous separation (demarcation) between "utility-owned" equipment and services, and "customer-owned" equipment and services.

Recommendation M2:

The CNC/IEC should recommend to utilities and regulators that smart meter regulation and policies be established, as needed, to ensure that Measurement Canada-approved smart meters:

- communicate LUM to the billing systems, just as they do for their local meter display;
- where the time of use is relevant to calculating customer billing: that SLUM is also tested for the accuracy of the start, end and duration of the time periods used to measure the SLUM communicated by the meter to the billing systems, to compute a PLUM; and
- communicated interval or period-based LUM for demand measurement is tested for the accuracy of the demand measurement and for accuracy of the start, end and duration of the demand interval time, for the intervals or periods of the LUMs—where required for reporting by the meter to the billing systems.

Recommendation M3:

The CNC/IEC should recommend that Smart Grid regulation and policies be established to harmonize provincial and interprovincial practices.

In addition, the CNC/IEC should recommend that Smart Grid regulation and policies be established to prompt provincial and interprovincial practices that initially will increase and ultimately shall result in uniformity of practice and standards-based interoperability of processing by the back-office billing data processing technologies, in a manner that also increases transparency of operations for the benefit of the consumer and the utility for Canada.

Recommendation M4:

The CNC/IEC should recommend to utilities, regulators, Measurement Canada and meter manufacturers, that they develop strategies and requirements related to sub-metering and multi-metering applications for distributed generation at the customer's domain, where LUMs, SLUMs and PLUMs are required.

Recommendation M5:

The CNC/IEC should recommend to utilities that they deploy advanced metering infrastructure and metering communications networks for the Smart Grid in a manner that does not operate in isolation and does permit energy usage retrieval billing and roaming Plug-in Electric Vehicle capabilities that span multi-utility networks across the entire Smart Grid. Such billing and credit capability will be the basis for utility-to-utility roaming operations, communications, micro-grid and resource usage settlement agreements.

Recommendation M6:

The CNC/IEC should recommend a Canadian harmonized national Technical Committee (CSC/TC13) on electricity metering standards be formed within—and funding come from—Canada's national standardization network. This committee should also bring Canadian interests to metering-related standards and activities of IEEE, ANSI and NAEDRA.

Annex B

Table 10: List of Abbreviations

AEIC – Association of Edison Illuminating Companies AMI – Advanced Metering Infrastructure AMR – Automated Meter Reading ANSI – American National Standards Institute APPs – Applications AWS – Advanced Wireless Services CSA – Canadian Standards Association CEA – Canadian Electricity Association CIM – Common Information Model CNC/IEC – Canadian National Committee of the International Electrotechnical Commission CSWG – Cyber Security Working Group CT – Current Transformer DA – Distribution Automation DER – Distributed Energy Resources (Wind, Solar PV, Storage, etc.) DMS – Distribution Management System DNP – Distributed Network Protocol DR – Demand Response EMS – Energy Management System FAN – Facility Area Network and/or Field Area Network (managed by the utility) FERC – Federal Energy Regulatory Commission FPT – Federal, Provincial, Territorial GOOSE – Generic Object-Oriented Substation Event GSM – Global System for Mobile Communications HUB – A bridge or data concentrator that links the utility's metering head-end system to meters and facility gateways IC – Industry Canada ICCP – Inter-Control Center Communications Protocol IEC – International Electrotechnical Commission IED – Intelligent Electronic Devices IEEE – Institute of Electrical and Electronic Engineers IRC – Independent Regional Council IP – Internet Protocol ISO – International Organization for Standardization ISO – Independent Systems Operator ICT – Information and Communications Technology ITU – International Telecommunications Union JTC1 – Joint Technical Committee 1 LAN – Local Area Network LTE – Long Term Evolution	LUM – Legal Unit of Measure (defined by *Electricity and gas Inspection Act* and managed by Measurement Canada) MC – Measurement Canada NEB – National Energy Board, Canada NAEDRA – North American End Device Registry Authority NAESB – North American Energy Standards Board NRCan – Natural Resources Canada NEMA – National Electrical Manufacturers Association NERC – North American Electric Reliability Corporation NIST – National Institute of Standards and Technology NP – New Proposal NPCC – Northeast Power Coordinating Council OIML – International Organization of Legal Metrology PAN – Personal Area Network / Premises Network (managed by the customer) PCS – Personal Communication Services PEV – Plug-in Electric Vehicles PMU – Phasor Measurement Unit PSTP – Public Security Technical Program P&S – Privacy and Security RDF – Resource Description Framework REQ – Retail Electricity Quadrant RTO – Regional Transmission Operator RTU – Remote Terminal Unit SAE – Society of Automobile Engineers SC – Sub-Committee SCADA – Supervisory Control and Data Acquisition SCC – Standards Council of Canada SCL – Substation Configuration Language SDO – Standards Development Organization SEP – Smart Energy Profile SGIP – NIST Smart Grid Interoperability Panel SGTS – Smart Grid Technology and Standards Task Force TASE – Theoretical Aspects of Software Engineering TC – Technical Committee TCP – Transmission Control Protocol T&D – Transmission and Distribution TR – Technical Report U.S. – United States UL – Underwriters Laboratories ULC – ULC Standards VT – Voltage Transformer WAN – Wide Area Network WEQ – Wholesale Energy Quadrant WIMAX – Worldwide Interoperability for Microwave Access WG – Working Group XML – Extensible Markup Language