A Canadian Smart Grid Standards Roadmap - *a strategic planning document*

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

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1. Introduction

Over the past two years, NRCan in cooperation with the Standards Council of Canada's (SCC)[1] Canadian National Committee to the International Electrotechnical Commission (CNC/IEC), recognized the pressing need for a national body to begin the task of defining and coordinating Canada's Smart Grid standardization initiatives. The CNC/IEC "provides policy advice to Governing Council 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* (CNC/TF-SGTS, hereinafter referred to as the *TF-SGTS* or simply *Task Force*), which first convened in February 2010 and has continued to meet on a regular basis through to January 2012. The Standards Council of Canada provided three guiding principles for the Task force work and its fundamental goals are to:

- 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 insure Canadian Smart Grid priorities are identified and incorporated into the IEC's work plan, and
- Coordinate standards develop in such a way as to avoid national and regional differences as much as possible (unless appropriately identified and understood as necessary).

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 working towards IEC standards on Smart Grid technology having the widest possible acceptance in Canada and its trading partners;
- *Assessing and providing feedback* on the effectiveness of the CNC/TF-SGTS 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);
- *Providing recommendations* to CNC/IEC on potential new fields of activity in Smart Grid technology and standards.

Membership in the Task Force consists of members representing the entire spectrum of Smart Grid stakeholder sectors, including

- Generation and transmission utilities
- Distribution field equipment vendors
- Building infrastructure experts
- Enterprise- and consumer-level equipment manufacturers
- Federal, provincial and municipal regulators
- Standards development organizations (SDOs)

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1 SCC: http://www.scc.ca/en/home

[2] *CNC/IEC Responsibilities and Procedures, Section E-2, Canadian Convenors of IEC Working Groups*, **CAN-P-2009**, March 2006.

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 will provide a brief overview for all stakeholders of Canada's Smart Grid policy, legislative and regulatory environment. The roles played by the federal and provincial governments are highlighted in section 2. Key smart grid initiatives are described. Section 3, 4, 5 and 6 summarize the key recommendations 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) focuses on transmission and distribution standards;
- Working Group 3 (WG3) focuses on Smart Grid security and privacy issues, particularly with respect to cybersecurity as it affects both consumers and utilities.

4. Metering Systems Standards

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 U.S.) having many years of useful service life left in them. This holds true for:

- metering field systems,
- metering control systems, and
- metering head-end systems

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", which pre-date (at times by more than ten years) emerging or contemporary interoperability standards such as the ANSI[3] C12 protocols suite and NEMA[4] upgradeability standards. Table 2 provides a list of key standards referenced in electricity metering requirements or Canadian legislation.

A schematic describing the "Smart Grid Advanced Metering Infrastructure Architecture" is presented in Figure 4. It provides an expanded view of the AMI/AMR Customer Domain Field Area Network (FAN) and Premises Area Network (PAN). From communications standpoint, the Customer AMI Domain (depicted in the top left corner of Figure 4) is divided internally into three security perimeters:

a. the Utility owned (or delegated) and controlled Facility Area Network zone (**FAN zone**) component of the AMI;

b. the Customer control and trusted Premises Area Network zone (**trusted PAN zone**); and

c. the Customer control and untrusted Premises Area Network zone (**untrusted PAN zone**).

The untrusted segment of the Premises Area Network can communicate with Markets, Service Providers and the Utility operations via the premises gateway using any available network. Information and control messages may be exchanged between the utility Head End Systems (HES) and the utility owned meters, customer owned devices (such as in-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 center and a gateway or a bridge to the Premises Area Network.

When the customer domain devices act as Distributed Energy Resources (DER) that allows the flow of energy to and from the electrical grid, it may need to be controlled by the utility (or its agents), as specified by existing or new regulation. This should be accomplished through direct and managed communication among the utility operations, transmission distributions and bulk generation systems, as depicted in Figure 4, through the Field Area Network and its gateways (i.e. the utility's Customer Facility Gateway), linking the customer to generation, storage and DER equipment to the utility operation, transmission, distribution and bulk generation facilities (domains).

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 of the Utility backhaul networks (these include Metering / AMI and T&D managed networks) from the, PAN (that include appliances, EMSs, and consumer technology), through the use of TEGs while maintaining the co-generation storage technologies (such as PEVs) 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.

3 ANSI: http://www.ansi.org/default.aspx
4 NEMA: http://www.nema.org/

Figure 4 – Smart Grid Advanced Metering Infrastructure Logical Architecture – Exhibited elements include only meters and the assets that are in front and behind the meter

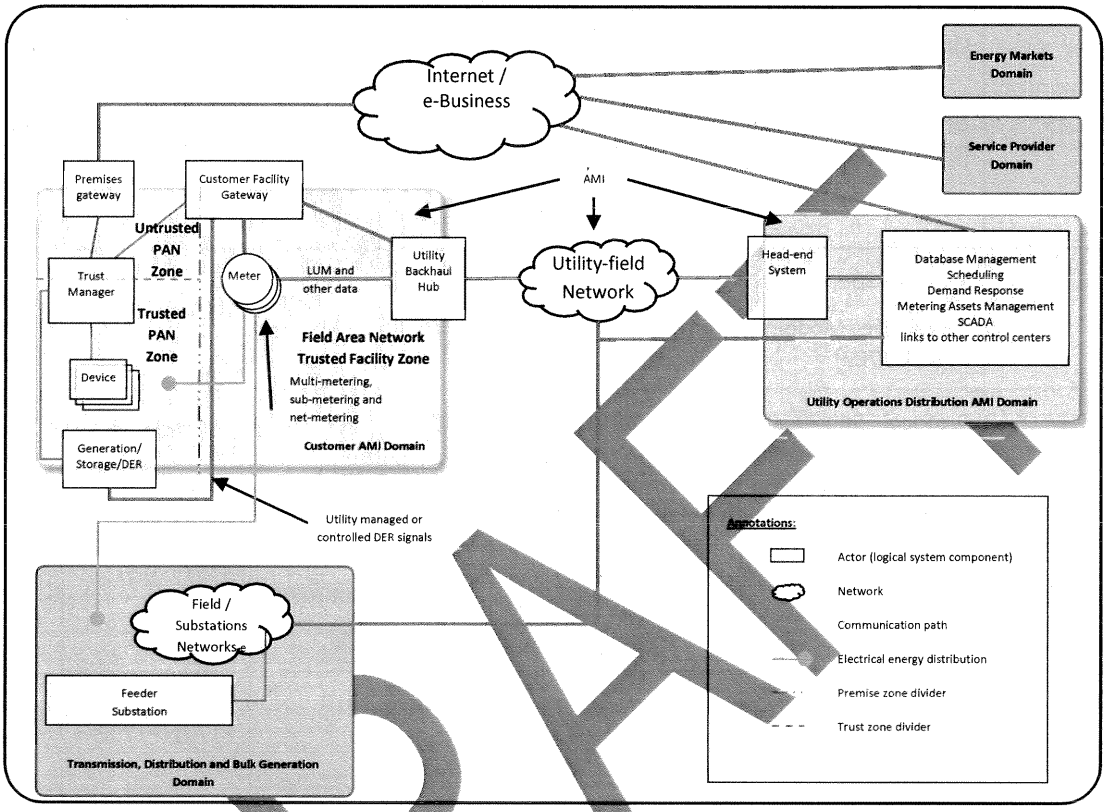

Table 1 - List of Standards used in North America Electricity Metering

Standard	Title	Status	TC/SC/WG
ANSI C12.18	Protocol Specification for ANSI Type 2 Optical Port [same as IEEE 1701]	V1.0 Pub. 1996 V2.0 Pub. 2006	ASC12 SC17 WG4*
ANSI C12.19	Utility Industry End Device Data Tables [same as IEEE 1377]	V1.0 Pub. 1997 V2.0 Pub. 2008 V2.1 Ballot 2011	ASC12 SC17 WG2*
ANSI C12.21	Protocol Specification for Telephone Modem Communication [same as IEEE 1702]	V1.0 Pub. 1999 V2.0 Pub. 2006	ASC12 SC17 WG4*
ANSI C12.22	Protocol Specification For Interfacing to Data Communication Networks [same as IEEE 1703]	V1.0 Pub. 2008 R1.0 Draft 2011	ASC12 SC17 WG2*
IEEE 1377	Standard for Utility Industry Metering Communication Protocol Application Layer (End Device Data Tables) [same as ANSI C12.19]	V1.0 Pub. 1997 V2.1 Approved Ballot 2010	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	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]	R1.0 Approved Ballot 2011	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

Standard	Title	Status	TC/SC/WG
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	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
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	ITU-X
RFC 6142	ANSI C12.22, IEEE 1703, and MC12.22 Transport Over IP	Pub. 2011	IETF
AEIC 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.	V1.0 Pub. 1998 V2.0 Pub. 2010	AEIC / AMTI , and NIST/SGIP PAP5

Standard	Title	Status	TC/SC/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	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	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	NIST

Recommendation M1:

The recommended Canadian AMI architecture shown in Figure 4 exposes the interfaces and the demarcation zones in a manner that will assist regulators, utilities and implementers enact requirements, such as security, privacy of information, grid safety, interoperability, reliability and the like. This Canadian AMI architecture is an overarching recommendation in that it represents at the highest level the overall thrust of the Smart Grid standardization effort. It highlights the technology and service elements that need to be addressed in order to reach the standards environment required to support a fully functional Smart Grid. It should be recognized that reference to standards, the use of open standards and the call for interoperability are very important aspects for an effective multi-vendor environment of the Smart Grid.

> Therefore, the CNC-IEC should recommend to Utilities and Regulators that there should be a clear and unambiguous separation (demarcation) between "Utility-owned" equipment and services; and "Customer-owned" equipment and services.

Recommendation M2:

Most smart Meters today do meet the necessary legislation and policies as they should to ensure that Measurement Canada approved Smart Meters communicate LUM to the billing systems. However, currently there are Smart Meters that do not communicate LUMs and may require external calculations to yield LUMs.

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:

a) Communicate Legal Unit of Measure (LUM) to the billing systems, just as they do for their local meter display; and

b) that Source Legal Unit of Measure (SLUM) are also tested for the accuracy of the start/end/duration of the time periods (TOU) that were used to measure the SLUM communicated by the meter to the billing systems for the purpose of computation of a Process Legal Unit of Measure (PLUM); and

c) Communicated interval or period-based Legal Unit of Measure (LUM) for demand measurement are tested for the accuracy of the demand measurement and are also tested for accuracy of the start/end/duration of the demand interval time for the intervals or periods of the LUMs that are reported by the meter to the billing systems.

Recommendation M3:

Currently Utilities and the Authorities having Jurisdiction set their own standards of practices and 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 traceable directly and indirectly to information and that is communicated by Measurement Canada approved meters (LUMs) to the billing systems.[5]

> Therefore, the CNC-IEC should recommend that Smart Grid regulation and policies be established to harmonize provincial and interprovincial practices.

Recommendation M4:

Currently there is no common 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 traceable directly and indirectly to information and that is communicated by

[5] 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.

Measurement Canada approved meters (LUMs) to the billing systems. Currently, Utilities and Public Utility Commission's (PUCs) set their own standards of practices.

> The CNC/IEC should recommend that Smart Grid legislation, 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 M5:

In order to provide support for micro-grid (co-generation and storage including Electric Vehicle) sub-metering and multi-metering is necessary. It is known that many of the Smart Grid Standards provide such capabilities, but these have yet to be enacted or implemented in the meters and in the Head-end systems.

> The CNC-IEC should recommend to Utilities, Regulators, Measurement Canada and Meter Manufacturers to develop strategies and requirements for micro-grid and related sub-metering and multi-metering applications at the Customer's Domain.

Recommendation M6:

Electric Vehicle standards are still at the early stages of being developed, within an initial focus on charging stations, physical connections to the vehicle and safety. In some areas, competing standards are being debated and 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 and provide various ancillary services to the smart grid. The concept of roaming, in addition to the traditional thinking, also applies to PANs where the home/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 FG with the Utilities. These already have the design framework to carry on the task in published standards.

> Therefore, the CNC-IEC should recommend to Utilities to deploy AMI and networks for the Smart Grid in a manner that does not operate in isolation and create islands, communication wise. Having such a capability it is also predicated the enactment of Utility-to-Utility roaming operations, communication, micro-grid and resource usage agreements.

Recommendation M7:

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 SC12 and SC17 and participate in the effort of the "North American End Device Registry Authority". In addition, Canada is an active participant in the international standards on Interconnection of Information Technology (IT) equipment being led by the ISO/IEC JTC 1/SC 25 that has a new focus on home and building energy management and connection to the smart grid. This committee is responsible for IT standards for home electronic systems, customer premises cabling, and relevant ICT communication interfaces. It produced international standards for the "Home Electronic System", including the control of equipment for heating, lighting, audio/video, telecommunications, security, residential gateways between 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 meters.

> Therefore, 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.

7. Acronyms – definition of abbreviations

Table 2 - Acronyms - definitions and abbreviations

ACSE - Association Control Service Element	MDMS - Meter Data Management System
AES - Advanced Encryption Standard	MGI - Modern Grid Initiative
AMI - Advanced Metering Infrastructure	MIB - Management Information Base
AMR - Automated Meter Reading	MIME - Multipurpose Internet Mail Extensions
ANSI - American National Standards Institute	MFR - Multi-level Feeder Reconfiguration
API - Application Program Interface	MMS - Manufacturing Messaging Specification
ASD - NII DoD CIO - Assistant Secretary of Defense - Networks & Information Integration - CIO Office	NAESB - North American Energy Standards Board
ASHRAE - American Society of Heating, Refrigerating and Air Conditioning Engineers	NARUC - National Association of Regulatory Utility Commissioners
BAS - Building Automation System	NEMA - National Electrical Manufacturers Association
CA - Contingency Analysis	NERC - North American Electric Reliability Corporation
CEIDS - Consortium for Electric Infrastructure to Support a Digital Society	NIST - National Institute of Standards and Technology
CM - Configuration Management	NSM - Network and System Management
CIM - Common Information Model	OASIS - Organization for the Advancement of Structured Information Standards
CIGRE - International Council On Large Electric Systems	OGC - Open Geospatial Consortium
CIP - Critical Infrastructure Protection	OID - Object Identifier
CIS - Customer Information System	OMG - Object Management Group
CPP - Critical Peak Pricing	OMS - Outage Management System
CSCTG - Smart Grid Cyber Security Coordination Task Group	OpenSG - Open Smart Grid
CSRC - Computer Security Resource Center	OSI - Open Systems Interconnection
DA - Distribution Automation	OWASP - Open Web Application Security Project
DDNS - Dynamic Domain Name System	PEV - Plug-in Electric Vehicles
DER - Distributed Energy Resources	PMU - Phasor Measurement Unit
DES - Data Encryption Standard	QoS - Quality Of Service
DEWG - Domain Expert Working Group	RTO - Regional Transmission Operator
DGM - Distribution Grid Management	RTU - Remote Terminal Unit
DHCP - Dynamic Host Configuration Protocol	SCADA - Supervisory Control and Data Acquisition
DHS - Department of Homeland Security	SCC - Standard Council of Canada
DLC - Direct Load Control	SCL - Substation Configuration Language
DMS - Distribution Management System	SCP - Secure Copy Protocol
DNS - Domain Name System	SDO - Standards Development Organization
DOD - Department of Defense	SOA - Service-Oriented Architecture
DOE - Department of Energy	TCP - Transport Control Protocol
DP - Dynamic Pricing	TOU - Time-of-Use
DR - Demand Response	UCA - Utility Communications Architecture
DRCEE - Demand Response & Consumer Energy Efficiency	UML - Unified Modeling Language
	WAMS - Wide-Area Measurement System

DWML - Digital Weather Markup Language

ECWG - Electronic Commerce Working Group

EDL - Exchange Data Language

EISA - Energy Independence and Security Act

EMCS - Utility/Energy Management and Control Systems

EMS - Energy Management System

EPRI - Electric Power Research Institute

ES - Energy Storage

ESP - Energy Service Provider

EUMD - End Use Measurement Device

EV - Electric Vehicle

EVSE - Electric Vehicle Supply Equipment

FBI - Federal Bureau of Investigation

FCC - Federal Communications Commission

FERC - Federal Energy Regulatory Commission

FIPS - Federal Information Processing Standards

FTP - File Transfer Protocol

GHG - Greenhouse Gases

GID - Generic Interface Definition

GIS - Geographic Information System

GOOSE - Generic Object-Oriented Substation Event

GSA - General Services Administration

GWAC - GridWise Architecture Council

HTTP - Hyper Text Transfer Protocol

HVAC - Heating Ventilating and Air Conditioning

IATFF - Information Assurance Technical Framework Forum

ICS - Industrial Control Systems

IEC - International Electrotechnical Commission

IECSA - Integrated Energy and Communications System Architecture

IED - Intelligent Electronic Device

IEEE - Institute of Electrical and Electronic Engineers

IETF - Internet Engineering Task Force

IHD - In-Home Display

IRM - Interface Reference Model

IOSS - Interagency OPSEC Support Staff

IP - Internet Protocol

ISO - International Organization for Standardization, Independent Systems Operator

IT - Information Technology

KPI - Key Point of Interoperability

WAN - Wide Area Network

XML - Extensible Markup Language

PAN – Personal Area Network / Premises Network (managed by the customer)

LAN – Local Area Network

FAN – Facility Area Network and/or Field Area Network (managed by the utility)

IB – Interface Bus for middleware (a computer system internal component)

WAN – Wide Area Network

LUM – Legal Unit of Measure (defined by E&G Act and managed by MC in Canada)

IP – Internet Protocol

GSR – Co-Generation/Storage and roaming electrical vehicles (attached to the utility supply side, may include electric vehicles as storage, solar or wind generators etc.)

FG – Facility Gateway (bridges between the Utility managed FAN and the Customer managed TEG)

PG – Premises (or Personal area) Gateway (connects the customer to the Internet)

TEG – Trust, Enrolment and Granularity Management (for the PAN)

EM – Electricity Meter

CD – Customer Device (an appliance, energy monitoring device, load control module, demand response module, vehicle etc.)

HUB – A bridge or data concentrator that links the utilities' metering Head-end system to meters and Facility Gateways

SIG – Special Interest Group (non-accredited SDO)

EV, PEV – Electric Vehicle / Plug-in Electric Vehicle

"+" – the plus sign represents one or more occurrences of an item (e.g. EM+, means one or more electric meters)

LAN - Local Area Network LMS - Load Management System	