D4.1.4.4: Smart Grid Standardization Analysis

Revision History

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Abstract

This document analysis standardization activities related to Smart Grid. The focus of this analysis is on the standardization of Information and Communication Technologies (ICT) for the Smart Grid (e.g. communication, automation and control, management, customer care, billing, business processes). Specific areas like Smart Metering and electrical vehicle charging are also covered under the wider Smart Grid scope.

Starting from Smart Grid standardization roadmap activities the document identifies the various standardization bodies and industry fora involved and identifies standardization work from the physical communication layer to data models and applications. Regulation, policy and legislation issues and trade and lobbying activities for Smart Grid are also briefly covered by the document as they often interact with standardization activities.

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1 Preface

This report was done as a part of the Finnish national research project "Smart Grid and Energy Market" SGEM. It was funded by Tekes – Finnish Funding Agency for Technology and Innovation and the project partners.

The report was generated based on an analysis of the Smart Grid standardization landscape performed during 2010 at Nokia Siemens Networks. Major information for this study were provided by the various Smart Grid Standardization roadmap documents, namely from IEC [7], NIST [3] and DKE [32].

The VTT Publication “Interfaces of consumption metering infrastructures with the energy consumers - Review of standards” [1], which was prepared within the TEKES funded INCA project provided a lot of useful information on standardization in the Smart Meter and home and building automation area. Especially for the home and building automation and communication one should refer to this publication as the information is only referenced, but not repeated in this document.

I would like to thank all my colleagues who contributed to the initial study and preparation of the document with specific information and valuable comments, namely these are Atte Länsisalmi, Markus Hakaste, David Francisco, Hui Bin Lin, Richard Wu, Mehmet Ersue, Juergen Merkel, Reinhard Gloger and Kiyohisa Wakabayashi.

2 Abbreviations

3GPP	Third Generation Partnership Project
3GPP2	Third Generation Partnership Project 2
6lowpan	IPv6 over Low power WPAN
ADR	Automated Demand Response
AEIC	Association of Edison Illuminating Companies
AHG	Ad-hoc Group
AMI	Advanced Metering Infrastructure
ANSI	American National Standards Institute
APEC	Asia-Pacific Economic Cooperation
API	Application Program Interface
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers
ATIS	Alliance for Telecommunications Industry Solutions
b2g	building-to-grid
BnP	business and policy
CCSA	China Communications Standards Association
CEFACT	Centre for Trade Facilitation and Electronic Business
CEN	European Committee for Standardization
CENELEC	European Committee for Electrotechnical Standardization
CEPRI	China Electric Power Research Institute
CHAdeMO	CHArge de Move
CIGRE	International Council on Large Electric Systems

CIM	Common Information Model
CoAP	Constrained Application Protocol
core	Constrained RESTful Environments
COSEM	COmpanion Specification for Energy Metering
CRM	Customer Relationship Management
DER	Distributed Energy Resources
DIN	Deutsches Institute für Normung
DKE	Deutsche Kommission für Elektrotechnik (German Commission for Electrical, Electronic & Information Technologies)
DLMS	Device Language Message Specification
DNP	Distributed Network Protocol
DOE	Department of Energy
DR	Demand Response
DSL	Digital Subscriber Line
DSO	Distribution System Operator
EDSO-SG	European Distribution System Operators for Smart Grid
EISA	Energy Independence and Security Act
eman	Energy Management
EMP	Embedded Mobile Program
EMS	Energy Management System
EN	European Norm
ENSG	Electricity Networks Strategy Group
ENTSO-E	European Network of Transmission System Operators for Electricity
EPS	Electric Power System
EREG	European Regulators Group for electricity and Gas
ERM	EMC and Radio Spectrum Matters
ES	Energy Storage
ESMIG	European Smart Meter Interest Group
ETP	European Technology platform
ETSI	European Telecommunications Standards Institute
EU	European Union
EUTC	European Utilities Telecom Council
EV	Electrical Vehicle
FCC	Federal Communications Commission
FERC	Federal Energy Regulatory Commission
GSM	Global System for Mobile Communication
GSMA	GSM Association
h2g	home-to-grid
HGI	Home Gateway Initiative
HV	High Voltage

i2g	industry-to-grid
IAB	Internet Architecture Board
ICT	Information and Communication Technologies
ICT4EE	ICT for Energy Efficiency
ICT4SMARTDG	ICT for Smart Distributed Generation
IEA	International Energy Agency
IEC	International Electrotechnical Commission
IED	Intelligent Electronic Device
IEEE	Institute of Electrical and Electronics Engineers
IESG	Internet Engineering Steering Group
IETF	Internet Engineering Task Force
IMS	IP Multimedia Subsystem
IP	Internet Protocol
IPSO	IP for Smart Objects Alliance
ISGAN	International smart Grid Action Network
ISO	International Organization for Standardization
ITU	International Telecommunication Union
ITU-T	ITU Telecom Standardization Sector
JTC	Joint Technical Committee
LAN	Local Area Network
LLN	low power and lossy networks
LTE	Long Term Evolution
LV	Low Voltage
M2M	Machine-to-Machine
MAN	Metropolitan Area Network
METI	Ministry of Economy, Trade and Industry
MIB	Management Information Base
MUC	Multi Utility Controller
MV	Medium Voltage
NAESB	North American Energy Standards Board
NARUC	National Association of Regulatory Utility Commissioners
NEMA	Association of Electrical and Medial Imaging Equipment Manufacturers
NERC	North American Electric Reliability Cooperation
NGN	Next Generation Network
NIMTC	Network Improvements for Machine Type Communication
NIST	National Institute for Standards and Technologies
OASIS	Organization for the Advancement of Structured Information Standards
ODVA	Open DeviceNet Vendor Association
OSCRE	Open Standards Consortium for Real Estate
OSI	Open System Interconnection

PAP	Priority Action Plan
PEV	Plug-in Electrical Vehicle
pevtg	pevtg
PLT	PLT
PMU	Phasor Measurement Unit
RAP	Regulatory Assistance Project
RFC	Request for Comment
roll	Routing Over Low power and Lossy networks
RTU	Remote Terminal Unit
SAE	Society of Automotive Engineers
SC	Study Committee
SCADA	Supervisory Control And Data Acquisition
SCP	Smart Card Platform
SDH	Synchronous Digital Hierarchy
SDO	Standard Development Organization
SEP	Smart Energy Profile
SET-Plan	Strategic Energy Technology Plan
SG	Study Group
SGAC	Smart Grid Architecture Committee
SGIP	Smart Grid Interoperability Panel
SGTCC	Smart Grid Testing and Certification Committee
SIP	Session Initiation Protocol
SMB	Standardization Management Board
SMCG	Smart Meter Coordination Group
SME	Small and Medium Enterprise
SONET	Synchronous Optical Network
TC	Technical Committee
TF	Task Force
TIA	Telecommunications Industry Association
TISPAN	Telecommunications and Internet converged Services and Protocols for Advanced Networking
TnD	Transmission and Distribution
TSO	Transmission System Operator
TTC	Telecommunication Technology Committee
UCAiug	UCA International Users Group
UMTS	Universal Mobile Telecommunications System
UN	United Nations
UL	Underwriters Laboratories
UTC	Utilities Telecom Council
WAN	Wide Area Network

WG	Working Group
WiFi	Wireless Fidelity
WiMAX	Worldwide Interoperability for Microwave Access
WPAN	Wireless Personal Area Networks

3 Introduction

The Smart Grid is the future sustainable and reliable generation, transmission, distribution, storage and consumption of electrical energy based on advanced energy and ICT solutions. Governments world wide are driving Smart Grid in order to achieve their policies on energy efficiency, energy independents and reliable and cost-effective energy supply to the whole community. Billions of Euros are provided for research, development and deployment of Smart Grid solutions. For wide spread cost effective deployment, interoperability and open interfaces for future extensions standardized solutions are a necessity. Smart Grid standardization is therefore also driven by government's world wide. Furthermore many standardization bodies and industry fora from the ICT and energy industry consider Smart Grid as a priority issue. Due to this hype a lot of activities on Smart Grid standardization have been started.

This report can therefore only provide a snapshot of the current situation and focuses on the major Smart Grid standardization activities in the ICT an Energy industry. As the activities in standardization bodies and industry fora often is often done in a closed manner the report is generated based on publicly available information. This means that not always the latest status and details are available. The report also doesn't claim to provide the complete picture as so much is happening in this area around the world.

In addition to standardization activities also regulation and policies for Smart Grid are briefly analyzed and related trade and lobbying activities are considered. They are important to further push the way for a future Smart Grid and interact with standardization activities.

4 Smart Grid Standardization roadmap activities

Due to the strong interest in and push for Smart Grids from governments and the industry and the resulting need to come up with standards in a fast and coordinated way in order to ensure interoperability Smart Grid standardization roadmaps have been defined by several national and international bodies.

4.1 International Electrotechnical Commission (IEC)

www.iec.ch/smartgrid

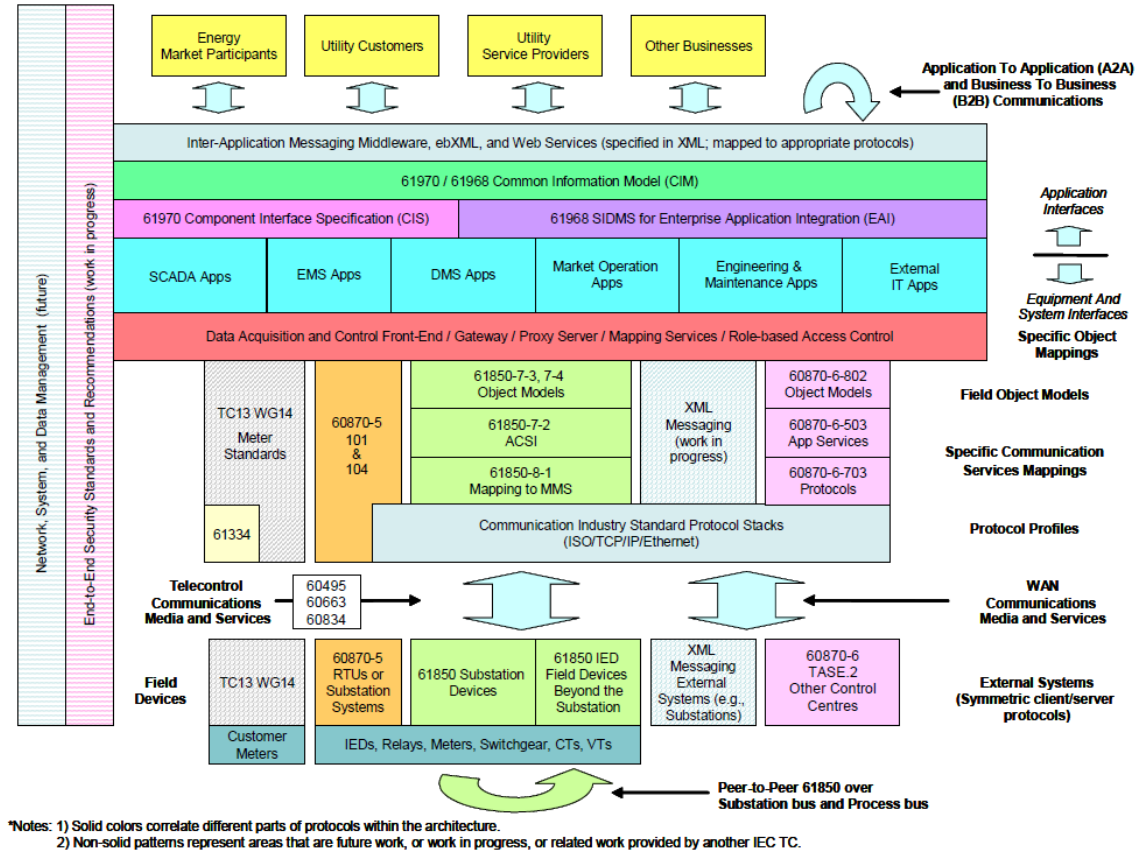
IEC is the leading international body for electrotechnical standardization. A dedicated Smart Grid strategy group has been setup in 2008 by the IEC Standardization Management Board to guide and coordinate the Smart Grid standardization in IEC. This strategy group has developed a framework for IEC Smart Grid Standardization which includes protocols and model standards to achieve interoperability of Smart Grid devices and systems. The results of this work were published as the IEC Smart Grid Standardization Roadmap[7] in June 2010. In addition to the identification of completed or nearly-completed IEC standards for the Smart Grid, gaps are identified and recommendations are provided on how to fill these gaps and to streamline and align the Smart Grid standardization activities in IEC.

The base of the IEC framework is the seamless integrated architecture as defined in IEC 62357 [18] and shown in Figure 1. Its scope is the convergence of data models, services and protocols for efficient and future-proof system integration for all applications. The framework comprises

communication standards including semantic data models, services and protocols for the intersystem and subsystem communications in Smart Grids.

The document covers general standardization issues on communication, security and planning and the following specific application areas:

- Smart transmission systems, Transmission Level Applications
- Blackout Prevention / Energy Management Systems
- Advanced Distribution Management
- Distribution Automation
- Smart Substation Automation – Process bus
- Distributed Energy Resources
- Advanced Metering for Billing and Network Management
- Demand Response / Load Management
- Smart Home and Building Automation
- Electric Storage
- E-mobility
- Condition Monitoring
- Renewable Energy Generation



Source: IEC Smart Grid Standardization Roadmap , June 2010 [7]

Figure 1: IEC Seamless Integration Reference Architecture

One cornerstone of the IEC Smart Grid standardization is the Common Information Model (CIM) for Distribution and energy management as defined in the IEC 61968 [13] and 61970 [14] series of standards. The CIM shall be the base for all future IEC data models and alignment of the substation and meter communication data models with the CIM shall be achieved.

The focus of the roadmap is on IEC internal activities. External standardization activities are only considered in case cooperation with such external standardization bodies is needed.

Some general recommendations from the document are:

- Focus on the standardization of interfaces, void standardizing applications and business models.
- Promote the already existing excellent work on Smart Grid standardization.
- Seek closer cooperation with stake holders from the market domain as this is vital for an extension of the Smart Grid with market information.
- Establish a close cooperation with NIST Smart Grid Interoperability roadmap activities.
- Build an integrative model which covers production control and enterprise management.

The IEC roadmap document provides a good overview on existing IEC standards and ongoing and new standardization activities in IEC.

4.2 National Institute for Standards and Technologies (NIST)

www.nist.gov/smartgrid/

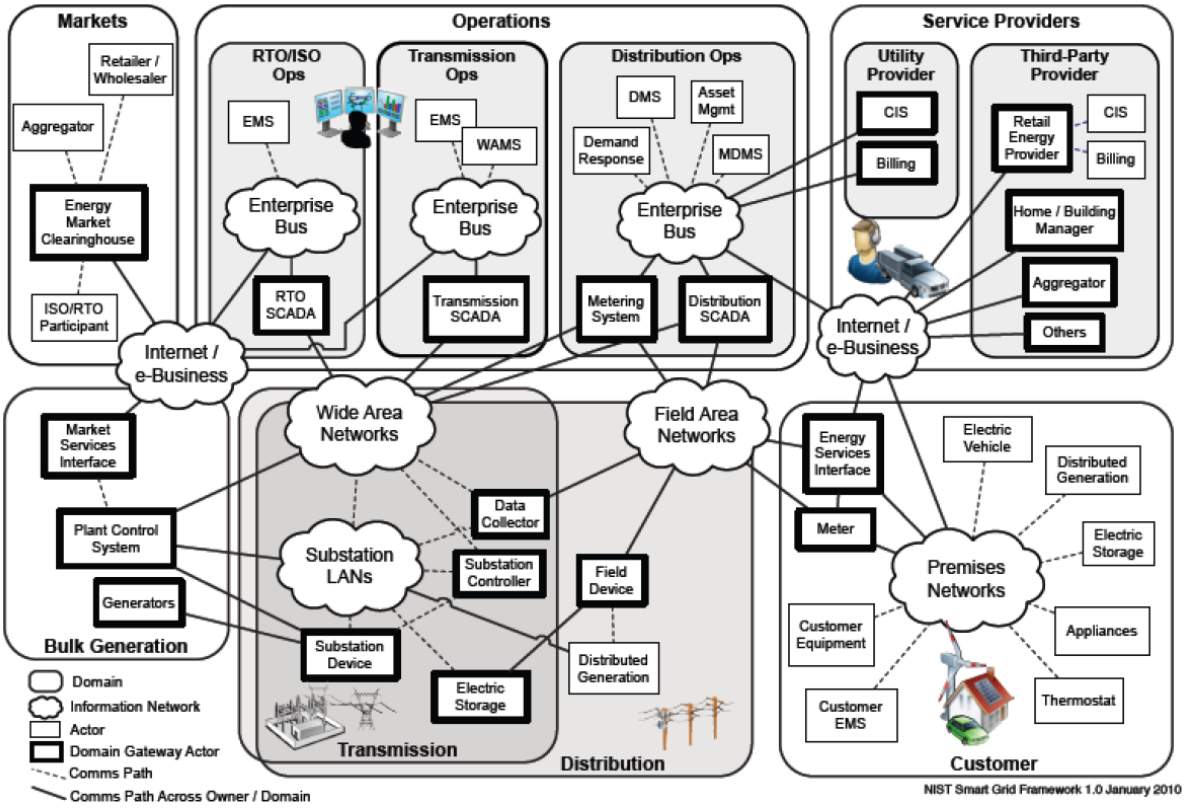
Under the US Energy Independence and Security Act of 2007 (EISA) [2], NIST has been assigned the “primary responsibility to coordinate development of a framework that includes protocols and model standards for information management to achieve interoperability of Smart Grid devices and systems…” (EISA [2],Title XIII, Section 1305]). NIST started an extensive consultation with the industry and an analysis of Smart Grid related standardization activities. This resulted in the NIST Framework and Roadmap for Smart Grid Interoperability Standards [3] which was published in January 2010. The document describes a high-level conceptual reference model for the Smart Grid, identifies existing standards that are applicable for the Smart Grid and specifies gaps and harmonization issues for which new or revised standards and requirements are needed. Specific priority action plans (PAPs) are defined to address these gaps together with designated standards-setting organizations.

The Smart Grid conceptual reference model as shown in Figure 2 identifies the domains and major functional blocks of Smart Grids. It provides a means to analyze use cases and to identify interfaces for which standards are needed to ensure interoperability.

The following eight areas are identified as high priority for standardization:

- Demand Response and Consumer Energy Efficiency
- Wide-Area Situational Awareness
- Energy Storage
- Electric Transportation
- Advanced Metering Infrastructure
- Distribution Grid Management
- Cyber Security
- Network Communications

25 standards and standard sets are identified as highly important for the deployment of Smart Grids. These standards range from communication network protocols, to home and building automation, meter reading, substation automation, management data models and security. Additional 50 standards and standards sets are listed which need further consideration. Figure 3 shows the identified standardization bodies. Note that several standardization bodies contribute with more than one standard to the Smart Grid development.



Source: NIST Framework and Roadmap for Smart Grid Interoperability Standards 1.0, January 2010 [3]

Figure 2: NIST Smart Grid Conceptual Reference Diagram

As a result of the gap analysis the following Priority Action Plans and targets for completion are defined:

- Smart meter upgradeability standard
- Common specification for price and product definition
- Common scheduling mechanism for energy transactions
- Common information model for distribution grid management
- Standard demand response signals
- Standards for energy use information
- DNP3 Mapping to IEC 61850 Objects
- Harmonization of IEEE C37.118 with IEC 61850 and precision time synchronization
- Transmission and distribution power systems models mapping
- Guidelines for use of IP protocol suit in the Smart Grid
- Guidelines for use of wireless communications in the Smart Grid
- Energy storage interconnection guidelines
- Interoperability standards to support plug-in electric vehicles
- Standard meter data profiles
- Harmonize power line carrier standards for appliance communications in the home

In addition longer lasting activities on architecture, security and various interfaces to the grid (home, building, industry and electrical vehicle) are required. Harmonization of standards and standardization activities for the same technology area in different standardization bodies is one of the major goals.

The framework and roadmap document is the first step of the NIST plan for Smart Grid Interoperability standards. As second step the Smart Grid Interoperability Panel (SGIP) (see 5.2) was established in early 2010 to drive the work on Smart Grid standards and the identified PAPs. Figure 3 shows the relation of SGIP to NIST and the Smart Grid standardization bodies identified by NIST. As the last step a framework for conformity testing and certification will be developed and implemented.

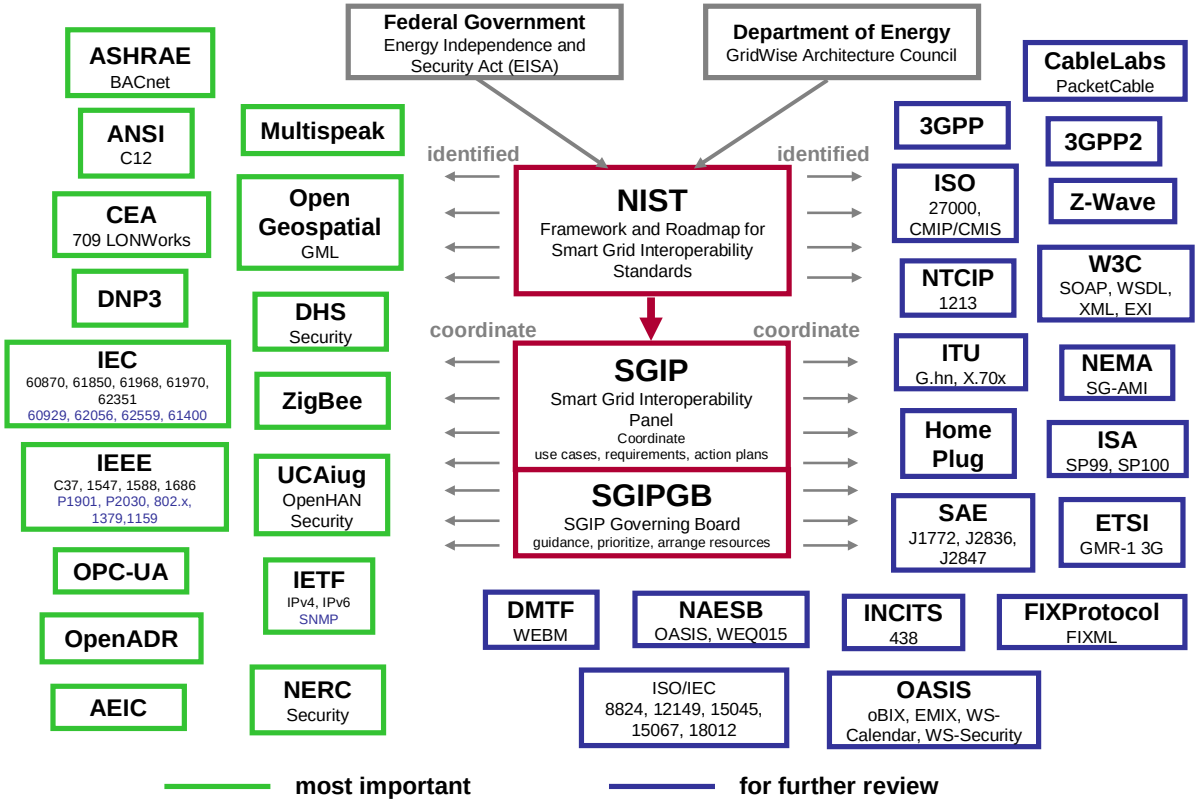


Figure 3: NIST Smart Grid Standardization landscape

The NIST activities have a strong US focus, however one goal is to drive for international interoperability.

Work on a Smart Grid Cyber Security Strategy and Requirements was initiated and handed over to SGIP for completion. The activity provides risk assessments for the various Smart Grid use cases to select and tailor the security requirements. Existing standards are evaluated against these requirements and areas for research and development for Smart Grid Cyber Security are identified.

In October 2010 NIST identified the first set of foundational standards for Smart Grid:

- IEC 61970 [14] and IEC 61968 [13]: Providing a CIM necessary for exchanges of data between devices and networks, primarily in the transmission (IEC 61970 [14]) and distribution (IEC 61968 [13]) domains.

- IEC 61850 [11]: Facilitating substation automation and communication as well as interoperability through a common data format.
- IEC 60870-6 [9]: Facilitating exchanges of information between control centers.
- IEC 62351 [17]: Addressing the cyber security of the communication protocols defined by the preceding IEC standards.

The NIST framework and roadmap document provides a good overview on Smart Grid standards, standardization bodies and the interactions and alignments need to provide interoperability.

4.3 ISO/IEC JTC1

jtc1smartgrid.org

ISO/IEC JTC 1 is a joint ISO and IEC activity for ICT standards for business and consumer applications. They have set up a special working group on Smart Grids to analyze Smart Grid market requirements and identify standardization gaps to especially promote JTC1 standards for Smart Grids and encourage JTC1 work on such standards. Results shall be provided to the JTC1 plenary in November 2010.

4.4 CEN, CENELEC and ETSI focus group on standards for the Smart Grid

A joint CEN, CENELEC and ETSI focus group on standards for the Smart Grid has been formed in May 2010 with the objective to provide a European Smart Grid standardization overview and roadmap document by the end of 2010. It is expected that this document will be an input for the definition of a European Smart Grid standardization mandate by the European Commission in early 2011.

4.5 German Commission for Electrical, Electronic & Information Technologies (DKE)

www.dke.de/de/std/KompetenzzentrumE-Energy/

DKE is the leading German body for electrical, electronic and information technology standardization. It is the national mirror body for IEC and CENELEC. DKE has established a center of expertise for Smart Grid (E-Energy) to coordinate the Smart Grid standardization work in cooperation with the E-Energy research projects promoted by the Federal Ministry of Economics and Technology. The German Roadmap for E-Energy/Smart Grid [32] was developed by this expertise centre to provide a strategic, nevertheless technically oriented roadmap to represent the standardization requirements for the German vision of the Smart Grid.

Various national and international Smart Grid standardization roadmap and research activities are taken into account with a strong focus on the IEC work.

Recommendations are provided for horizontal areas:

- Regulation and legislation;
- Information security, data protection and privacy;
- Communication;
- Architecture, communication and power system management systems;
- Safety, reliability and durability of products;

and for vertical domains:

- Distribution Systems;

- Smart Meters,
- Electro-mobility,
- Storage;
- Load Management 7Demand Response;
- Building and in-house automation;
- Distributed generation;
- Transmission systems.

Some of the general recommendations are:

- Use of international standards for national implementations.
- Involvement of German exerts in international standardization especially at IEC, but also setup of liaisons and cooperation with NIST SGIP, CIGRE, UCAiug and others. Especially for the European Smart Meter standardization German specifications like the Multi Utility Controller (MUC) shall be promoted.
- Safety, security and resilience of core functions are important issues for the Smart Grid.
- Setup of a national coordination committee for the implementation of the Smart Grid and support of the market launch by providing skilled specialists and achieving confidence of the user in the new technologies.

The German roadmap document adds national aspects to the international roadmap activities especially from IEC. It should be noted that it is a living document which will be updated over time.

4.6 Related activities

Work on Smart Grid roadmap and vision documents covering standardization aspects has been done or are under way in various other national and international bodies.

- The Spanish Smart Grid platform FutuRED issues recommendations in the areas of regulation, political support and technical progress.
- The Austrian Smart Grid roadmap defines fields of technology in which technical progress is needed.
- The British Electricity Networks Strategy Group (ENSG) examines how a Smart Grid supports the government's target on CO_2 and cost reduction. They have defined a Smart grid Routemap [44] as a high level description of the way a UK Smart Grid could be delivered. Standardization is one aspect of that routemap.
- The Japanese Smart Grid strategy group setup by the Ministry of Trade and Industry is looking on Japan's role in Smart Grid standardization.
- CIGRE develops a vision for the architecture of the next energy and market management systems.

4.7 E-Mobility standardization roadmap activities

In addition to the Smart Grid standardization activities also roadmap activities for E-Mobility have started. E-Mobility overlaps with Smart Grid in the area of charging of plug-in electrical vehicles (PEVs) and therefore these activities are of interest for the Smart Grid standardization. It should be noted that some of the Smart Grid roadmaps also consider PEV charging (i.e. NIST).

Similar to the CEN/CENELEC/ETSI Focus Group on Smart Grid standards a CEN/CENELEC Focus Group on Electrical Vehicle standards has been setup in May 2010 with the goal to provide an initial overview and roadmap document in fall2010.

In Germany the definition of a standardization roadmap for E-Mobility has been started in 2010 by the National Platform E-Mobility.

5 Standardization bodies and fora

In this section Smart Grid related standardization activities in the various Standardization Development Organizations (SDOs) and industry fora are analyzed. Due to the high political important and huge amount of investments expected over the next years Smart Grid standardization is a kind of hype area. Therefore a lot of established SDOs and fora have initiated Smart Grid related activities, dedicated bodies for Smart Grid standardization have been founded and new activities are popping up frequently. This analysis therefore can only be a snapshot of the smart grid standardization landscape.

5.1 International Electrotechnical Commission (IEC)

www.iec.ch

IEC (International Electrotechnical Commission) is the leading international standardization organization for the electrical industry. They have been active on ICT standards for electrical grids already for years defining for example standards for substation control (IEC 61850), energy (IEC61970) and distribution management (IEC 61968) and meter reading (IEC62056). These standards will be used and evolve for Smart Grid applications. They have initiated a dedicated Smart Grid activity starting from the IEC Smart Grid roadmap (see section 4.1) developed by a dedicated Smart Grid strategy group under the IEC steering board. Various IEC technical committees have started to extend exisiting standards and define new standards for Smart Grid applications. The base for the IEC work is the Seamless Integration architecture as defined by in IEC62357 [18] and shown in Figure 1.

Participation in the IEC activities has to be done via national mirror committees like SESKO in Finland and DKE in Germany.

Exisiting core IEC standards for the Smart Grid are listed at the IEC Smart Grids portal (http://www.iec.ch/zone/smartgrid/grid_relevantstds.htm). From an ICT point of view the most important standards are:

- IEC 62357 [18] Reference architecture for object models, services and protocols:
  Overall reference architecture for management and automation of energy transmission and distribution systems
- IEC 61970 [14] Energy management system application program interface:
  Information models and APIs for Transmission Network management
- IEC 61850 [11] Communication networks and systems in substations:
  Protocols for supervisory control and data acquisition (SCADA) for sub stations and related equipment
- IEC 61968 [13] System Interfaces for Distribution Management:
  Information models and APIs for Distribution Network management
- IEC 62351 [17] Data and communications security:
  Security for the ICT parts of energy systems
- IEC 62056-53 [15] Data exchange for meter reading, tariff and load control:
  Smart meters (DLMS/COSEM)
- IEC 61400-25 [10] Communications for monitoring and control of wind power plants

It is assumed that the IEC 60870 [8] specifications on RTU and substation communication will not play a relevant role in future Smart Grids as they are superseded by IEC 61850 [11] except for IEC 60870-6 [9] which defines inter control center communication.

IEC committees which are relevant for Smart Grid are also listed on the IEC Smart Grid portal (http://www.iec.ch/zone/smartgrid/grid_relevanttcs.htm). From that list the most important activities from an ICT point of view are:

- **SG3 Strategy group on Smart Grid**

  SG 3 (Strategic Group) on Smart Grid, set up by the IEC SMB (Standardization Management Board), provides advice on fast-moving ideas and technologies likely to form the basis for new International Standards or IEC TCs (Technical Committees) in the area of Smart Grid technologies. They have defined the IEC Smart Grid roadmap (see section 4.1). Currently they are collecting use cases and defining a reference architecture.

- **TC8 Systems aspects for electrical energy supply**

  TC8 emphasis is on overall system aspects of electricity supply systems and acceptable balance between cost and quality for the users of electrical energy. They have defined the IntelliGrid Methodology for Developing Requirements for Energy Systems (IEC 62559 [19]).
  TC8 consists of the following working groups:
  - WG 1 - Terminology
  - WG 2 - HV systems and transmission aspects
  - WG 3 - MV/LV electricity distribution aspects
  - WG AHG 4 - Smart Grid Requirements
  - WG AHG 5 - High Voltage Direct Current systems aspects

  They are currently working on Smart Grid terminology and definitions and have started to collect use cases as a basis for the definition of requirements.

- **TC13 Electrical energy measurement, tariff- and load control**

  TC13 does standardization in the field for metering equipment and systems, including smart metering systems for electrical energy measurement, tariff- and load control, customer information and payment, for use in power stations, along the network, and at energy end users, as well as to prepare international standards for meter test equipment and methods
  - WG 11 - Electricity metering equipment
  - WG 13 - Dependability of electricity metering equipment
  - WG 14 - Data exchange for meter reading, tariff and load control
  - WG 15 - Electricity metering - Payment systems

  TC13 has defined the DLMS/COSEM (IEC 62056-53 [15]) specification for electricity metering and consider updates based for example on the activities of the European Smart Meter Coordination group (section 5.9). They are working on mapping between DLMS/COSEM objects (IEC 62056-53 [15]) and the CIM model (IEC 61968 [13]). A future issue is the support of DLMS/COSEM objects in IEC 61850 [11].

- **TC38 Instrument transformers**

  TC38 works in the field of AC and/or DC current and/or voltage instrument transformers, including their subparts like (but not limited to) sensing devices, signal treatment, data conversion and analog or digital interfacing.
  They are starting work on smart current and voltage sensors with IEC 61580 based interfaces.

- **TC57 Power systems management and associated information exchange**

  TC57 prepares international standards for power systems control equipment and systems including EMS (Energy Management Systems), SCADA (Supervisory Control And Data Acquisition), distribution automation, teleprotection, and associated information exchange for real-time and non-real-time information, used in the planning, operation and maintenance of power systems. Power systems management comprises control within control centers, substations and individual pieces of primary equipment including telecontrol and interfaces to equipment, systems and databases, which may be outside the scope of TC 57.

  It consists of the following working groups:
  - WG 3 - Telecontrol protocols
  - WG 10 - Power system IED communication and associated data models (i.e. IEC61850 [11])
  - WG 13 - Energy management system application program interface (EMS - API) (i.e. IEC61970 [14])
  - WG 14 - System interfaces for distribution management (i.e. IEC61968 [13])
  - WG 15 - Data and communication security (i.e. IEC 62351 [17])
  - WG 16 - Deregulated energy market communications (i.e. IEC 62325 [16])
  - WG 17 - Communications Systems for Distributed Energy Resources (DER)
  - WG 18 - Hydroelectric power plants - Communication for monitoring and control
  - WG 19 - Interoperability within TC 57 in the long term
  - WG 20 - Planning of (single-sideband) power line carrier systems

  Extensions of the CIM (IEC 61968 [13], 61970 [14]) and communication for power utility automation (IEC 61850 [11]) standards to support new Smart Grid functionalities like Demand Response Management and interaction with EV chargers are under preparation. WG19 has a Smart Grid task force to coordinate the Smart Grid activities in TC57.

- **TC69 Electric road vehicles and electric industrial trucks**

  TC69 defines standards for road vehicles, totally or partly electrically propelled from self-contained power sources, and for electric industrial trucks.
  - WG 4 - Power supplies and chargers
  - PT 61851-23 - Electric vehicle charging station (IEC 61851 [12])

  TC69 participates in the joint ISO/IEC activities on vehicle to grid communication (see also section 5.5)

IEC already plays an important role in standardization for energy systems including ICT. The existing standards are widely accepted and NIST has identified five of them as foundational standards for Smart Grid (section 4.2). IEC will continue to play a major role for Smart Grid standards.

5.2 Smart Grid Interoperability Panel (SGIP)

collaborate.nist.gov/twiki-sggrid/bin/view/SmartGrid/SGIP

The Smart Grid Interoperability Panel (SGIP) has been initiated by NIST based on the NIST Framework and Roadmap for Smart Grid Interoperability Standards [3] (section 4.2). It is a membership-based organization to provide an open process for stakeholders to participate in providing input and cooperating with NIST in the ongoing coordination, acceleration and harmonization of standards development for the Smart Grid. The SGIP reviews use cases, identifies requirements and architectural reference models, coordinates and accelerates Smart Grid testing and certification, and proposes action plans for achieving these goals. The SGIP does

not write standards, but serves as a forum to coordinate the development of standards and specifications by many standards development organizations. Close interaction with these SDOs is therefore essential for SGIP.

The SGIP is managed and guided by a Governing Board that approves work programs for the SGIP to carry out its work efficiently and effectively, prioritizes work, and arranges for the necessary resources. The Governing Board's responsibilities include facilitating a dialogue with standards development organizations to ensure that the action plans can be implemented.

All SGIP outputs will be delivered to the public through the NIST Smart Grid Collaborative Wiki (http://collaborate.nist.gov/twiki-sggrid/bin/view/SmartGrid/WebHome#Priority_Action_Plans_PAPs) and the online Interoperability Knowledge Base (IKB) (http://collaborate.nist.gov/twiki-sggrid/bin/view/SmartGrid/InteroperabilityKnowledgeBase).

SGIP is organized in several long standing committees and working groups and specific task forces, called priority action plans (PAPs) which work on specific issues identified as most important for Smart Grid interoperability.

Working Groups and Committees:

- **Smart Grid Architecture Committee (SGAC)**
  SGAC is responsible for creating and refining a conceptual reference model, including lists of the standards and profiles necessary to implement the vision of the Smart Grid.
- **Smart Grid Testing and Certification Committee (SGTCC)**
  SGTCC creates and maintains the necessary documentation and organizational framework for compliance, interoperability and cyber security testing and certification for SGIP-recommended Smart Grid standards.
- **Cyber security coordination task group (CyberSecurityCTG)**
  The group's primary goal is to develop an overall cyber security strategy for the Smart Grid that includes a risk mitigation strategy to ensure interoperability of solutions across different domains and components of the infrastructure. The group builds on the NIST work on Smart Grid Cyber Security Strategy and Requirements. The first versions of the Guidelines for Smart Grid Cyber Security, Volume 1-3 [4][5][6] were released in August 2010.
- **transmission and distribution (TnD)**
  The group will look on utility transmission and distribution operations as well as interactions with other producer/users on the grid.
- **home-to-grid (h2g)**
  The group is investigating communications between utilities and home devices to facilitate demand response programs that implement energy management.
- **building-to-grid (b2g)**
  The group is looking on commercial building interaction with the electric grid, including the energy service provider as well as other grid-side service partners.
- **industry-to-grid (i2g)**
  The group is Interoperability and interaction between the electric grid and industrial facilities, including electric power generation

- **plug-in electrical vehicle-to-grid (pevtg)**
  The group shall make clear the PEV business objectives and prioritize corresponding PEV-grid interactions. Identify the service interfaces and standards needed (syntax and semantics of information transfer, service interface protocols, cross-cutting issues, business and policy level). Then prepare an action plan for addressing the interoperability issues that stand in the way of achieving the desired smart grid future.

- **business and policy (BnP)**
  The group shall serve state & federal policy makers, & trade organizations considering smart grid policies. Form a structured approach to implementing smart grid policies for use across the Nation. Clearly define smart grid policy interoperability implications and their benefits.

- **Terminology**
  The group collects existing and new terms and definitions used within the SGIP work products

- **Electromagnetic Interoperability Issues (EMIWG)**
  The focus is to address these electromagnetic compatibility issues and to develop recommendations for the application of standards and testing criteria to ensure EMC for the Smart Grid, with a particular focus on issues directly related to interoperability of Smart Grid devices and systems, including impacts, avoidance, generation and mitigation of and immunity to electromagnetic interference.

Priority action plans:

- **PAP00: Meter Upgradability Standard**
  The PAP has defined requirements for firmware upgrade of Smart Meters.
  Involved SDOs: NEMA
  Completed

- **PAP01: Role of IP in the Smart Grid**
  The PAP studies the suitability of Internet networking technologies for smart grid applications. They investigate the capabilities of protocols and technologies in the Internet Protocol Suite to determine the characteristics of each protocol for smart grid application areas and types. So far an evaluation of the core set of IP protocols is done (draft-baker-ietf-core-08 [48]).
  Involved SDOs: IETF, NEMA, IEEE, UCAiug Open SG
  Target completion: 12/2010

- **PAP02: Wireless Communications for the Smart Grid**
  The PAP investigates the strengths, weaknesses, capabilities, and constraints of existing and emerging standards-based physical media for wireless communications. The approach is to work with the appropriate standard development organizations (SDOs) to determine the characteristics of each technology for Smart Grid application areas and types. Results are used to assess the appropriateness of wireless communications technologies for meeting Smart Grid applications. Detailed analysis of the various communication relationships in the Smart Grid and the related requirements is done together with UCAiug Open SG and a Wireless Technology Guidelines document is generated.

Involved SDOs: IEEE, WiMAX Forum, ATIS, 3GPP, 3GPP2, NEMA, TIA, UCAiug Open SG
Target completion: 12/2010

- **PAP03: Develop Common Specification for Price and Product Definition**
  The PAP shall drive the development of a common specification for price communication including product characteristics like delivery schedule, quality, environmental characteristics, and regulatory characteristics. Based on input from this PAP OASIS (section 5.14) has published a draft UML model for price and product information.
  Involved SDOs: OASIS, NAESB, ZigBee
  Target completion: 12/2010

- **PAP04: Develop Common Schedule Communication Mechanism for Energy Transactions**
  The PAP shall drive the development of a common schedule specification for energy transactions for coordination of supply and demand over domains like utilities, enterprises, homes and markets.
  Based on input from this PAP OASIS (section 5.14) has generated a draft web service calendar specification.
  Involved SDOs: IETF, ZigBee, OASIS
  Target completion: 12/2010

- **PAP05: Standard Meter Data Profiles**
  The PAP shall defined profiles of the ANSI C12.19 [20] end device (meter) table which will meet the needs of most utilities and simplify the meter procurement process. Use cases, requirements and a gap analysis are done.
  Involved SDOs: AEIC, ANSI, IEEE, IEC, NEMA
  Target completion: 12/2010

- **PAP06: Common Semantic Model for Meter Data Tables**
  The PAP shall translate the ANSI C12.19 [20] end device (meter) data tables to and from a common form that will allow the semantics of this and End Device models in other standards (i.e. IEC 61850 [11], IEC61968 [13], Multispeak [23]) to be more readily harmonized. Use cases and requirements are under discussion.
  Involved SDOs: ANSI, IEEE, AEIC, IEC, MultiSpeak, UCAiug
  Target completion: 01/2011

- **PAP07: Energy Storage Interconnection Guidelines**
  The PAP shall work on coordinated, consistent, electrical interconnection standards, communication standards, and implementation guidelines for energy storage devices (ES), power-electronics-connected distributed energy resources (DER), hybrid generation-storage systems (ES-DER), and the ES-DER aspects of plug-in electric vehicles (PEV). This includes updates and extensions to IEEE 1547 [26] and IEC 61850 [11]. IEC 61850 [11] object models are in final preparation.
  Involved SDOs: IEEE, IEC
  Target completion: 11/2011

- **PAP08: CIM/61850 for Distribution Grid Management**
  The PAP shall extend standardized object models, such as the CIM (IEC 61968 [13]) and IEC 61850 [11], to enable the rapid integration of wind, solar, and other renewable resources, and to achieve greater reliability and immunity to grid instabilities resulting from

their wide-scale deployment that is radically changing how the power system must operate. Requirements are in preparation.
Involved SDOs: IEEE, IEC, Multispeak
Target completion: 11/2011

- **PAP09: Standard DR and DER Signals**
  The PAP shall drive the development of a common semantic model for standard DR signals. The effort shall ensure that DR & DER signal standards support load control, supply control, and environmental signals. Requirements will be provided to OASIS section 5.14).
  Involved SDOs: OASIS, LonMark, ZigBee, NAESB, UCAiug, ASHRAE, IEC, IEEE
  Target completion: 04/2011

- **PAP10: Standard Energy Usage Information**
  The PAP shall drive for a standardized information model for broader exchange of energy usage information across domains. Requirements are in preparation.
  Involved SDOs: UCAiug, EISA, ANSI, OASIS, IEC, IEEE, ASHRAE, LonMark, ODVA, OSCRE
  Target completion: 12/2010

- **PAP11: Interoperability Standards to Support Plug-in Electric Vehicles**
  The PAP shall ensure inoperability standards for Plug-in Electric Vehicles (PEV) that will encourage the broad adoption of electric vehicles in the society. The common object models shall support pricing and settlement, charging control, selling PEV electricity back into the grid and roaming. Use cases were generated and requirements are in preparation.
  Involved SDOs: IEC, UL, NEC, NEMA, SAE, IEEE, ZigBee, UCAiug
  Status: target completion 10/2010

- **PAP12: Mapping IEEE 1815 (DNP3) to IEC 61850 Objects**
  The PAP shall develop DNP3 [24] and IEC 61850 [11] mapping documents including guidelines for achieving interoperable integration of equipment using DNP3 [24] with equipment using IEC 61850 [11]. The document has been generated and submitted to IEEE and IEC. Work on test plans has been initiated.
  Involved SDOs: IEEE, IEC, UCAiug, DNP
  Target completion: 08/2011

- **PAP13: Harmonization of IEEE C.37.118 with IEC 61850 and Precision Time Synchronization**
  The PAP shall integrate phasor measurement unit (PMU) and phasor data concentrator (PDC) data and information as defined by IEEE C37.118 [31] into IEC61850 [11]. Further implementation profiles and guidelines for common time synchronization based on IEEE1588 [27] shall be defined. A draft has been send to IEEE.
  Involved SDOs: IEEE, IEC
  Target completion: 06/2011

- **PAP14: Transmission and Distribution Power Systems Model Mapping**
  The PAP shall define strategies for integrating standards across the transmission and distribution domain to support different real-time and back-office applications. Modeling of the electric power system, multifunctional IEDs, and definition of standard methods for

reporting events and exchanging relay settings will be needed. The work is focusing on key use cases and standards gaps for requirement creation.
Involved SDOs: IEEE, IEC
Target completion: 12/2010

- **PAP15: Harmonize Power Line Carrier Standards for Appliance Communications in the Home**

  The PAP shall drive to harmonize the various power line communication (PLC) standards (i.e. ITU G.9960 [47], IEEE 1901 [29], ANSI/CEA 709.2 [22]). Focus of the activity is on co-existence of the various solutions so that they do not interfere with each other. Requirements for narrow band are complete. Work on broad band has started.
  Involved SDOs: IEEE, IEC, ISO, ITU-T
  Target completion: 2011

- **PAP16: Wind Plant Communications**

  The PAP shall drive for the adoption of IEC 61400-25 [10] for wind power plant communication. Best practices for the application in the US shall be defined and enhancements to the standard shall be considered taking US requirements into account. Some additional requirements have been identified.
  Involved SDOs: IEC
  Target completion: 11/2011

- **PAP17: Facility Smart Grid Information Standard**

  The PAP will lead to development of a data model standard to enable energy consuming devices and control systems in the customer premises to manage electrical loads and generation sources in response to communication with the Smart Grid. It will be possible to communicate information about those electrical loads to utilities, other electrical service providers, and market operators. Work on use cases and requirements has started.
  Involved SDOs: ASHRAE
  Target completion: 07/2011

SGIP Governing Board Working Groups:

- **Communications, Marketing & Education Working Group (CME)**

  The CME WG Charter is to promote awareness, understanding and value of SGIP and SGIPGB activities and knowledge base to the smart grid stakeholder community by disseminating information and announcements

- **Bylaws and Operating Practices Working Group**

  The group further develops the SGIP bylaws and operating procedures

SGIP is the most important body for Smart Grid standardization in the US. So they don't make standards of their own, they strongly drive the standardization activities in the partner organizations. SGIP also has impact on international standardization as international harmonization is one goal of the SGIP activities and they interact with international bodies like IEC, IETF and ITU.

5.3 Institute of Electrical and Electronics Engineers (IEEE)

www.ieee.org

IEEE is an international professional organization for scientific and standardization work in various fields of electricity. Many parts of IEEE organization address Smart Grid. For example the Power and Energy society has been developing standards for the electricity grid for decades, and the needs of Smart Grid has been taken into account in the latest work. Likewise, many standards developed in the Communication Society have been adapted for the Smart Grid purposes. IEEE lists over 60 completed standards and recommendations to be relevant for Smart Grid, and well over 30 new or updated documents are in the works. These lists are available on IEEE's dedicated Smart Grid website at smartgrid.ieee.org. Table 1 lists some of the IEEE Smart Grid related standards.

Table 1 Major IEEE Smart Grid related standards and activities

Group	Standards & Activities	Status
SASB/SCC21 Fuel Cells, Photovoltaic, Dispersed Generation, and Energy Storage	P2030 Smart Grid Interoperability	See below
	P1547 Standard for Interconnecting Distributed Resources with Electric Power Systems	-
SASB/SCC31 Automatic Meter Reading and Energy Management	P1377, 1701-1705 Utility Industry Metering Communication End Device Data Tables, communication protocols and compliance	IEE 1377 [25] is currently update and aligned with the guidelines defined by SGIP PAP5
PE/PSC/Wireless_ WG	P1777 Recommended Practice for Using Wireless Data Communications in Power System Operations	-
C/LM/802 Local and Metropolitan Area Networks	Various standards for the Ethernet family, Token Ring, Wireless LAN (802.11 -> WiFi), Wireless PAN (802.15.4 -> ZigBee), Wireless MAN (802.16 -> WiMAX), Bridging and Virtual Bridged LANs	See below
SASB/SCC40/WG _P1809 Electrical Systems Greenhouse Gas Emissions Reduction Working Group	P1809 Grid Infrastructure for Electric Sourced Transportation	Work started in spring 2010

Group	Standards & Activities	Status
COM/SC/LF NB PLC WG Narrow Band Powerline Working Group	P1901.2 Standard for Low Frequency (less than 500 kHz) Narrow Band Power Line Communications for Smart Grid Applications	Work started in summer 2010
COM/SC/BPLPHM AC Broadband Over Power Lines PHY/MAC Working Group	P1901 Broadband over Power Line Networks: Medium Access Control and Physical Layer Specifications	IEEE 1901 [29] approved in fall 2010
PE/T&D/Dist-DNP3 Distributed Network Protocol (DNP3) Working group	P1815 Standard for Electric Power Systems Communications - Distributed Network Protocol (formalizing DNP3 [24] as IEEE standard)	IEEE 1815 [28] approved in summer 2010

Furthermore the IEEE Power& Energy Society has various activities on the use of ICT for power system communication, automation and control.

The role of IEEE standards in Smart Grid has been acknowledged by NIST SGIP, as many have been listed in their list of relevant Smart Grid standards. IEEE and SGIP also work together in this area.

- **SCC21 P2030 Smart Grid Interoperability**

  In late 2008 IEEE initiated a cross society activity for Smart Grid Interoperability. Work involving the Power and Energy society, Communications Technology society, and Information Theory society started during 2009. The group is working on a standard with the title "*IEEE P2030 Draft Guide for Smart Grid Interoperability of Energy Technology and Information Technology Operation with the Electric Power System (EPS), and End-Use Applications and Loads*" The document is planned to be sent for ballot within IEEE membership in March 2011. It is anticipated that the project will continue to produce new revisions after the completion of this ballot.
  The work is divided into three Task Forces (TF), and each TF is further split into Sub/Study Groups (SG) as shown in Table 2 below. The approach is that each TF works on their area independently developing their interoperability requirements, and then the whole group discusses and documents the overall view.
  P2030 is starting a new sub project P2030.2 Storage Systems to work on system integration aspects of electricity storage. This work is looking at storage systems as part of the Smart Grid, and is complementary to many electricity storage technologies that are being developed elsewhere in IEEE.

Table 2 IEEE P2030 Groups

Task Force 1: Power Engineering Technology	Task Force 2: Information Technology	Task Force 3: Communications Technology
SG1 Energy Sources	SG1 Power	SG1 Architecture
SG2 Transmission	SG2 Architecture	SG2 Use Cases
SG3 Substation	SG3 Modeling	SG3 Existing Standards
SG4 Distribution	SG4 Security	SG4 TF1 & TF2 Questions
SG5 Loadside	SG5 Communications	
SG6 Cybersecurity		

- **IEEE 802**

  IEEE 802 and its sub-groups are developing standards for Local Area Networks as well as Metropolitan Area Networks both with wired and wireless applications, and have been doing so for 30 years. The well known Ethernet, WLAN and Bluetooth technologies belongs to this family of standards. Many 802 technologies are likely candidates for use in Smart Grid communication. The following lists the 802 standards activities in action today. In addition there are disbanded groups and groups in hibernation. Note also that this is the top level structure, and each group may have several sub-groups:
  - 802.0: Executive Committee
  - 802.1: Higher Layer LAN Protocols Working Group
  - 802.3: CSMA/CD (Ethernet) Access Method
  - 802.11: Wireless Local Areas Networks
  - 802.15: Wireless Personal Area Networks
  - 802.16: Broadband Wireless MANs
  - 802.17: Resilient Packet Rings
  - 802.18: Radio Regulatory Technical Advisory Group
  - 802.19: Wireless Coexistence Working Group
  - 802.20: Mobile Broadband Wireless Access Working Group
  - 802.21: Media Independent Handover Services
  - 802.22: Wireless Regional Area Networks
  - 802.23: Emergency Services

  Many of these communication technologies that mainly address the lower layers of the ISO OSI model, may be used without any modification for Smart Grid related communication. At least the following activities relate specifically to Smart Grid:
  - 802.11 has organized an ad-hoc group to comment to NIST SGIP PAP02 Wireless Technology, where a method to evaluate wireless technologies for Smart Grid was developed. Also the relevant 802 radio technologies were submitted to the evaluation process.
  - 802.11 has launched the new task group ah: Amendment: Sub 1 GHz license-exempt operation. This amendment will establish standard channel widths and center frequencies for OFDM PHY operations below 1 GHz.
  - 802.15.4 Low-Rate Wireless Personal Area Networks (LR-WPANs) [30] is known by its marketing name ZigBee, and it is Smart Energy profile is specifically suited for Smart Grid application (see section 5.12).

5.4 Internet Engineering Task Force (IETF)

www.ietf.org

IETF is the de-facto and accepted SDO for the standardization of Internet protocols with global participation. IETF and IAB (Internet Architecture Board) make sure that IP protocol family is aligned and can be used to build the Internet as a network of networks and to execute services and applications on top of the IP network infrastructure.

The IP protocol suite will play a major role in Smart Grid communication as it is a proven, scalable, secure, cost-effective, and interoperable foundation for the communications networks around the world. Enhancement of this protocol suite is especially needed for the communication with "constraint" devices (i.e. sensors) which have limited processing capabilities, low energy consumption and are not always on. Such sensor and actor device will play a major role in Smart Grid and also in other areas. Monitoring and management of the power consumption of network equipment is of general interest to reduce the CO_2 footprint of communication networks. IETF has setup several activities to cover these issues:

- **Smart Power Directorate**

  Established in January 2010 the Smart Power Directorate shall provide review and coordination on the use of Internet protocols to provide smart grid communications. The goal is to point other organizations to relevant IETF documents and provide review of documents from other organizations that depend upon Internet protocols. If the directorate identifies a gap that requires new work in the IETF, the directorate will raise the issue with the IESG (Internet Engineering Steering Group) . The directorate will not develop new protocols or enhance existing ones. It closely interacts with SGIP PAP1.

- **IPv6 over Low power WPAN (6lowpan)**

  6lowpan defines the use of the IP protocols suite over wireless personal area networks, especially IEEE802.15.4 [30]. The working group has defined the mapping of IPv6 to IEEE802.15.4 (RFC4944 [49]) and is currently working on the necessary documents to ensure interoperable implementations of 6LoWPAN networks. They will define the necessary security and management protocols and constructs for building 6LoWPAN networks, paying particular attention to protocols already available.

- **Routing Over Low power and Lossy networks (roll)**

  This working group focuses a IPv6 routing solutions for use in low power and lossy networks (LLNs) with many embedded devices with limited power, memory, and processing resources. There is a wide scope of application areas for LLNs, including industrial monitoring, building automation connected homes and urban sensor networks (e.g. Smart Grid). The group has defined a set of requirements for various application areas (RFC5548 [50], RFC5673 [51], RFC5826 [52], RFC5867 [53]), evaluated existing routing protocols and is now defining a dedicated routing solution as the existing solutions do not satisfy the requirements.

- **Constrained RESTful Environments (core)**

  The core workgroup will define a framework for resource-oriented applications intended to run on constrained IP networks. This framework is going to address applications, which deal with the manipulation of simple resources on constrained networks, e.g. applications monitoring simple sensors (e.g. temperature sensors, light switches, and power meters), or

controlling actuators (e.g. light switches, heating controllers, and door locks), but also managing devices.
As part of the framework for such applications, the WG will define a Constrained Application Protocol (CoAP) for the manipulation of Resources on a device. CoAP will be designed for use between devices on the same constrained network, between devices and general nodes on the Internet, and between devices on different constrained networks both joined by an Internet.
The WG will furthermore coordinate on requirements from organizations including OpenSG/NIST, ZigBee/HomePlug, IPSO Alliance, OASIS, SENSEI, ASHRAE/BACnet.

- **Energy Management (eman)**

  This working group was founded based on discussions and internet drafts in the OPSAWG on MIB modules for monitoring energy consumption and power states of energy-aware devices. Compared to usual management tasks energy management has the additional focus on cases where energy consumption of a device is not measured at the device itself but reported by a different place.
  eman workgroup plans to work on the management of energy-aware devices by defining requirements and a framework for energy management. They will analyze the management information (MIB) which is needed for energy management like power consumption and generation, power state of devices and charge status of batteries. Furthermore the relationship between the various devices, the measurement data and measurement points has to be defined.
  eman workgroup plans to investigate existing standards such as from IEC, ANSI, DMTF and others, and reuse existing work as much as possible.

5.5 International Organization for Standardization (ISO) and joint ISO/IEC activities

www.iso.org

ISO is the world largest standards developing organization. They develop standards ranging from activities such as agriculture and construction, through mechanical engineering, to medical devices, to the newest information technology developments. For the Smart Grid standardization the activities in the joint ISO and IEC technical committee JTC1 on information technologies and in the technical committee TC22 on road vehicles are of main interest. A joint ISO and IEC technical committee on Energy efficiency and renewable energy sources (JTC2) has been setup in 2009, however the focus of that is on common terminology only.

Participation in ISO has to be done via national mirror bodies like DIN in Germany.

- **JTC1 Information technology**
  - Special working group on Smart Grids:
    see chapter 4.24.3
  - WG8 Sensor Networks:
    This is a newly formed group to cover sensor networks in general. They have started an activity on sensor networks for Smart Grids.
  - SC25 Interconnection of information technology equipment:
    WG1 is working on home electronic systems (HES) for the control of equipment for heating, lighting, audio/video, telecommunications and security in the home and

commercial buildings. A new specification on Energy Management and the interface to Smart Grids is currently in final preparation.
    - SC27 Security techniques:
      SC27 defines standards for the protection of information and ICT. This includes generic methods, techniques and guidelines to address security and privacy aspects, such as Management of information and ICT security, Cryptographic and other security mechanisms, Security aspects of identity management, biometrics and privacy and Security evaluation criteria and methodology.

- **TC22 Road vehicles**
    - SC3 Electrical and electronic equipment:
      Has started a joint working group with IEC TC69 on vehicle to grid communication (ISO15118) and is working together with IEC SC23H on plugs and socket-outlets for charging of electrical vehicles (IEC 62196).
    - SC21 Electrical propelled road vehicles:
      Is looking on safety, operational, performance and energy storage (batteries) issues for electrical vehicles. They are working together with IEC 69 on charging systems for electrical vehicles (IEC 61851)

- **TC205 Building environment design**
    - WG3 Building control systems design:
      Has defined building automation systems standards (ISO16484 based on BACNET). Integration with building energy management and Smart Grids will be an issue.

The TC22 activities on electrical vehicle charging and vehicle to grid communication are mostly important and recognized by various other bodies (e.g. SAE, SGIP). The impact of the JTC1 Smart Grid activities still has to be seen.

5.6 European Committee for Standardization (CEN) and European Committee for Electrotechnical Standardization (CENELEC)

www.cen.eu

www.cenelec.org

CEN is the European mirror body for ISO. CENELEC is the European mirror body for IEC. Both bodies have therefore mirror groups for several of the IEC and ISO groups listed in chapter 5.1 and 5.5.

Table 3 CEN/CENELC activities

CEN/CENELEC body	Activity	Related ISO/IEC body
CEN TC247 Building Automation, Controls and Building Management	Defines standard for building automation	ISO TC205

CEN/CENELEC body	Activity	Related ISO/IEC body
CEN TC294 Communication systems for meters and remote reading of meters	Has defined a bus system for meter reading (EN 13757, M-Bus) for all kind of fluids and energies except electricity.	
CEN TC301 Road vehicles	WG 4 defines „Vehicle interactions with infrastructure and environment, during charging“	ISO TC22
CENELEC TC205 Home and Building Electronic Systems	Concentrates on home control solutions	ISO/IEC JTC1 SC25
CENELEC TC8x System aspects of electrical energy supply	Works on general system aspects and requirements for electrical systems	IEC TC8
CENELEC TC13 Equipment for electrical energy measurement and load control	Works on smart meter standards	IEC TC13
CENELEC SR69 Electric road vehicles and electric industrial trucks	Works on charging infrastructure for EVs	IEC TC69

A CENELEC mirror body to the IEC work on distribution management, substation and IED communication, security and electronic market place communication (TC57) is currently established.

CEN and CENELC participate in the European Smart Meter Coordination group (chapter 5.9) and in the focus group on standards for the Smart Grid (chapter 4.4) and Electrical Vehicles (4.7). They received a European Commission mandate for standardization of charging for electrical vehicles in June 2010 (M/468) [35] together with ETSI. Concrete activities out of that mandate have to be seen.

5.7 European Telecommunications Standards Institute (ETSI)

www.etsi.org

The ETSI produces globally-applicable standards for Information and Communications Technologies (ICT), including fixed, mobile, radio, converged, broadcast and internet technologies.

Smart Grid is a strategic topic for ETSI, especially looking on the communication use cases and requirements. A dedicated board champion’s team has been setup to drive Smart Grid work. ETSI has several technical committees which deal with Smart Grid issues and participates in the European Smart Meter Coordination Group (SMCG) (section 5.9), the CEN, CENELC and ETSI focus group on standards for the Smart Grid (section 4.4), CEN/CENELEC/ETSI Focus Group on Electrical Vehicle standards (section 4.7) and has received a mandate for standards for charging of Electrical Vehicles together with CEN and CENELEC from the European Commission [35].

The following technical committees have Smart Grid related activities:

- **Machine-to-Machine Communication (M2M)**
  TC M2M is the lead body for Smart Grid standardization in ETSI. They represent ETSI in SMCG. M2M is responsible for identifying requirements for M2M communication, defining a high level architecture and service enablers. Use cases for various usage areas including Smart Metering [45] have been collected and requirements [46] have been defined. Currently work is going on for the Release 1 architecture and interface specifications, which shall be finalized in the first and second quarter 2011. For Release 2 support of general Smart Grid applications is planned.

- **Telecommunications and Internet converged Services and Protocols for Advanced Networking (TISPAN)**
  TISPAN is the core competence center for Next Generation Networks (NGN). They define wireline NGN solutions based on IMS (IP Multimedia Subsystem). They have a study item on the applicability of NGN for Smart Grid.

- **Powerline Telecommunications (PLT)**
  PLT is responsible for standardization of the networks, their elements and interfaces for providing communications on electrical wires. They have initiated work on a Power Line Communication solution for Smart Meters.

- **EMC and Radio Spectrum Matters (ERM)**
  ERM is responsible for Electro-Magnetic Compatibility (EMC) and radio spectrum parameters. Further more they may define radio equipment and systems. They work on a wireless mesh solution (presumably based on IEEE802.15.4 [30]) for Smart Meters adapted to for the European market.

- **Access, Terminals, Transmission and Multiplexing (ATTM)**
  TC ATTM studies the applicability and implementation of ISO / IEC / CENELEC as well as ITU / ETSI drafts and deliverables related to the Residential, Professional, Industrial and Operators' premises including communication equipment. They focus on energy efficiency of wireline access solutions (DSL, cable, fiber).

- **Smart Card Platform (SCP)**
  SCP is responsible for the development of multi-application and application independent Integrated Circuit (IC) Card platform for general telecommunication purposes. Thus IC cards might be used in M2M applications including Smart Grid for identification of devices and users.

Furthermore ETSI has general activities on security.

5.8 International Telecommunication Union (ITU)

www.itu.ch

ITU is the longstanding body for universally-recognized telecommunication standards. It has started a Smart Grid Focus Group (http://www.itu.int/en/ITU-T/focusgroups/smart/Pages/Default.aspx) in May 2010 with the aim to

- identify potential impacts on standards development;
- investigate future ITU-T study items and related actions;
- familiarize ITU-T and standardization communities with emerging attributes of smart grid, and
- encourage collaboration between ITU-T and smart grid communities;

The Focus Group will collaborate with worldwide smart grid communities (e.g., research institutes, forums, academia) including other SDOs and consortia. The objective of the Focus Group is to collect and document information and concepts that would be helpful for developing Recommendations to support smart grid from a telecommunication/ICT perspective. To achieve this objective the group has started to work on terminology, use cases, requirements and architectures. They are establishing liaisons with various relevant SDOs and consortia like IEC, ETSI and SGIP to receive input especially on use case and requirements. First documents are expected early 2011. The focus group will not define recommendations, but identify gaps, initiate work in ITU-T Study Groups and coordinated with other SDOs and consortia. The lifetime of a focus group is limited to 1 – 2 years. Afterwards the work will be handed over to ITU-T study groups. It still has to be seen which impact the focus group will have on Smart Grid standardization.

In general a lot of the ITU activities like Next Generation Networks, Ubiquities Networks, Transport Networks, Home Networks and Security can play a role especially in Smart Grid communication. However no dedicated Smart Grid activities are currently under way except for the activities on a low complexity profile for the ITU-T Home Network Communication Standard (G.9960) [47] which is specifically target on Smart Grid devices in the home like Smart Meters and home energy management. This work is done in working group 4 of study group 15.

5.9 European Smart Meter Coordination Group (SMCG)

The Smart Meter Coordination Group has been setup based on the European Commission standardization mandate for utility meters to CEN, CENELEC and ETSI (M/441) [34]. In addition to CEN, CENELEC and ETSI some other stakeholders like the European Smart Metering Industry Group (ESMIG), the OPEN meter project, EURELECTRIC, EUROGAS and others participate or contribute. The work will cover all kind of utility meters and is not limited to electricity meters.

The participating CEN, CENELEC and ETSI groups are:

- CENELEC TC13 Electrical Meters
- CENELEC TC205 Home & building electronic systems
- CEN TC294 Communication system for meters and remote reading of meters (Non-electricity meters)
- ETSI M2M Machine-to-machine communication; also other ETSI groups contribute via M2M

SMCG consist of 2 working groups:

- **WG1 Communication**

  Focuses on the communication layer protocols from the application layer to the physical layer for the home, access and wide area communication

- **WG2 Functionality**

  Focuses on Smart Meter functionality like variable tariffs, pre-payment, power quality supervision, limitation of power consumption, control of consumption and generation (DER)

WG1 is working on a technical report listing use cases, defining reference architecture and identifying relevant standards. This report shall be finalized end of 2010. Afterwards work on specific recommendations will start.

Final specifications shall become available in 2011/12. During the preparation of the specifications national standardization activities in the EU member states shall be on hold.

5.10 Deutsche Kommission für Elektrotechnik (DKE)

www.dke.de

DKE is the German organization responsible for the elaboration of standards and safety specifications covering the areas of electrical engineering, electronics and information technology. They are the national mirror body for IEC and CENELEC and a major contributor to the Smart Grid standardization activities in these bodies. They have setup a center of competence for Smart Grid (Kompetenzzentrum E-Energy; www.dke.de/de/std/KompetenzzentrumE-Energy) to coordinate the standardization activities and especially interact with Smart Grid related research activities in Germany.

DKE is the maintainer of the German Smart Grid standardization roadmap (see section 4.5). A steering committee is responsible for the implementation of this roadmap.

They have mirror groups for all relevant IEC and CENELEC TCs. A dedicated working group follows and contributes to the Smart Grid standardization roadmap and coordination activities in IEC (SG3), ISO/IEC JTC1 (Special working group on Smart Grid) and CEN/CENELEC/ETSI (Joint working group Smart Grid). Focus areas of the DKE Smart Grid activities are:

- Integration of DERs and load management
- Smart Meter
- Distribution network automation
- In-house automation
- Information and data security
- Data models and semantics

These focus areas are either handled by dedicated working groups or handled within the relevant IEC and CENELEC mirror groups.

5.11 Third Generation Partnership Project (3GPP)

www.3gpp.org

3GPP is a collaborative project of several SDOs for the production of evolved Third Generation and beyond Mobile System specifications. 3GPP maintains the GSM specifications, has defined and maintains the UMTS and IMS specifications and develops the LTE specifications.

3GPP has no dedicated Smart Grid standardization activities, but considers Smart Grid use cases in its work on Network Improvements for Machine Type Communication (NIMTC). Release 10 will focus on issues which arise due to the support of many machine-type devices in a network like congestion, addressing, security, identifiers, subscriptions.

The involved 3GPP working groups are:

- SA1 Services
- SA2 Architecture
- RAN2 Architecture & Protocol Aspects (3G radio)

- GERAN2 Protocol Aspects (GSM radio)

5.12 ZigBee

www.zigbee.org

The ZigBee alliance is an association of companies working together to enable reliable, cost-effective, low-power, wirelessly networked, monitoring and control products based on an open global standard. The base of the ZigBee work is the IEEE 802.15.4 [30] specification for wireless personal area networks, which is extended with application layer protocols for various solution areas like home and building automation and energy management in the home. They are currently defining version 2 of the Smart Energy Profile (SEP 2.0) together with the Home Plug Alliance. This protocol will support Smart Meter, Demand Response, DER control and PEV charging use cases. The protocol is considered by SAE for the vehicle to grid communication.

5.13 International Council on Large Electric Systems (CIGRE)

www.cigre.org

CIGRE aims to:

- Facilitate the exchange of information between engineering personnel and specialists in all countries and develop knowledge in power systems.
- Add value to the knowledge and information exchanged by synthesizing state-of-the-art world practices.
- Make managers, decision-makers and regulators aware of the synthesis of CIGRE's work, in the area of electric power.

More specifically, issues related to planning and operation of power systems, as well as design, construction, maintenance and disposal of HV equipment and plants are at the core of CIGRE's mission. Problems related to protection of power systems, telecontrol, telecommunication equipment and information systems are also part of CIGRE's area of concern. CIGRE generates best practice documents and no standards. CIGRE develops technical knowledge using two main methods:

- Conferences and meetings, where papers are produced and discussed,
- Permanent studies carried out by the 16 Study Committees, each dealing with a specific technical field and publishing reports.

From these study committees the following deal more or less with ICT issues:

- **B3 Substations**

  B3 works on design, construction, maintenance and ongoing management of substations and electrical installations in power stations, excluding generators.

- **B5 Protection and Automation**

  B5 defines principles, design, application and management of power system protection, substation control, automation, monitoring and recording – including associated internal and external communications, substation metering systems and interfacing for remote control and monitoring.

- **C2 System Operation and Control**
  C2 works on technical and human resource aspects of operation of power systems : methods and tools for frequency, voltage and equipment control, operational planning and real time security assessment, fault and restoration management, performance evaluation, control centre functionalities and operators training.

- **C4 System Technical Performance**
  C4 defines methods and tools for power system analysis in the following fields: power quality performance, electromagnetic compatibility, lightning characteristics and system interaction, insulation coordination, analytical assessment of system security.

- **C5 Electricity Markets and Regulation**
  C5 does analysis of different approaches in the organization of the Electric Supply Industry: different market structures and products, related techniques and tools, regulations aspects.

- **C6 Distribution Systems and Dispersed Generation**
  C6 works on assessment of technical impact and requirements which new distribution features impose on the structure and operation of the system: widespread development of dispersed generation, application of energy storage devices, demand side management, rural electrification.

- **D2 Information Systems and Telecommunications**
  D2 defines principles, economics, design, engineering, performance, operation and maintenance of telecommunication and information networks and services for Electric Power Industry; monitoring of related technologies.

5.14 Organization for the Advancement of Structured Information Standards (OASIS)

www.oasis-open.org

OASIS is a not-for-profit consortium that drives the development, convergence and adoption of open standards for the global information society. The consortium produces Web Services standards along with standards for security, e-business, and has standardization efforts in the public sector and for application-specific markets.

They have setup the OASIS Blue Member Section (www.oasis-blue.org) to advance open standards for smart energy grids and intelligent buildings. The member section oversees the work of the following technical committees:

- **Energy Interoperation**
  Enabling the collaborative and transactive use of energy, this TC's work is based on OpenADR, with an enterprise focus for easy application to and from micro grids, within facilities and business enterprises, and from aggregators to clients.

- **Energy Market Information Exchange (eMIX)**
  Supporting more efficient markets, this TC defines open standards for exchanging energy price and product characteristics--including availability and schedules--to support the free and effective exchange of information.

- **Web Services Calendar (WS-Calendar)**
  Defining a cross-domain standard for passing schedule and interval information between and within services, this TC applies the common scheduling model in IETF's iCalendar specification with needed semantics for energy and building use.

Another related activity is the work oBIX (Open Building Information Exchange) Enabling mechanical and electrical control systems in buildings to communicate with enterprise applications. Also the OASIS work on web services and related security if of general interest.

5.15 UCA International Users Group (UCAiug)

www.ucauig.org

UCAiug is a not-for-profit corporation consisting of utility user and supplier companies that is dedicated to promoting the integration and interoperability of electric/gas/water utility systems through the use of international standards-based technology. The Users Group does not write standards, however works closely with those bodies (notably IEC TC57) that have primary responsibility for the completion of standards. The mission of the UCA International Users Group is to enable utility integration through the deployment of open standards by providing a forum in which the various stakeholders in the utility industry can work cooperatively together as members of a common organization.

UCAiug has sub-committees for IEC61850, the IEC CIM and Smart Grid. The later looks on system, security, communication and conformity aspects of a Smart Grid and actively supports the work of SGIP. The communications group for example has analyzed the various communication relationships in Smart Grids and provided requirements for wireless communication to SGIP PAP2.

5.16 Society of Automotive Engineers (SAE)

www.sae.org

SAE is the premier membership society dedicated to advancing mobility engineering worldwide. The main focus however is on the US market. They work on several specifications for the interface between the charging station and the PEV:

- J2293 Requirements specification for the bi-directional grid to electric vehicle interface
- J1772 Electrical couplers supporting communication channel
- J2836/2847 Recommended Practice for Communication between Plug-in Vehicles and the Utility Grid communication protocol
- J2931 Power Line Carrier Communications for Plug-in Electric Vehicles

5.17 Others

In addition to the organizations listed above various other standardization bodies and industry fora have developed specifications relevant for Smart Grid and/or have ongoing work:

- **Third Generation Partnership Project 2 (3GPP2)**
  www.3gpp2.org
  3GPP2 defines third-generation CDMA based wireless communication solutions for the U.S and Asian market. They have a study item on M2M communication including Smart Grid applications.

- **NEMA (Association of Electrical and Medial Imaging Equipment Manufacturers)**
  www.nema.org
  NEMA is responsible the ANSI C.12 [20] series of recommendations for Electricity Meters in the US market. They work together with SGIP to update and extend the specifications for Smart Grid applications.

- **ASHRAE (American Society of Heating, Refrigerating and Air-Conditioning Engineers)**
  www.ashrae.org
  ASHRAE has defined the BACNet specification [21] for building automation. They have started a new activity on a Facility Smart Grid Information Standard together with SGIP PAP17.

- **UN CEFACT (United Nations Centre for Trade Facilitation and Electronic Business)**
  www.unece.org/cefact
  UN CEFACT has defined the EDIFACT specifications for Electronic Data Interchange for Administration, Commerce and Transport. Specific subsets for example for the electrical industry have been defined and play a major role in market communication. Together with OASIS they have defined the ebXML specification for XML based electronic business.

- **Multispeak**
  www.multispeak.org
  The Multispeak Initiative maintains the Multispeak Specification [23] which is an industry-wide software standard that facilitates interoperability of diverse business and automation applications used in electric utilities. Multispeak was defined by the National Rural Electric Cooperative Association (NRECA) as a management information model for smaller utilities and electric cooperatives. The latest version however is scalable and not limited to smaller utilities. As part of the SGIP work alignment with the IEC CIM is considered.

- **DNP3 (Distributed Network Protocol) User Group**
  www.dnp.org
  The DNP3 protocol [24] is a specification for communication between substation computers, RTUs (Remote Terminal Units), IEDs (Intelligent Electronic Devices) and master stations (except inter-master station communications) for the electric utility industry. It is maintained by the DNP3 User Group and has been adopted by IEEE as IEEE 1815 . As part of the SGIP (section 5.2) work alignment with the IEC 61850 [11] is considered.

- **Broadband Forum**
  www.broadband-forum.org
  The Broadband Forum is the central organization driving broadband wireline solutions and empowering converged packet networks worldwide to better meet the needs of vendors, service providers and their customers.
  They consider using its device management protocol (TR-69 [54]) for energy management in the home by managing none TR-69 devices like home control and energy management via a proxy.

- **HGI (Home Gateway Initiative)**
  www.homegatewayinitiative.org
  HGI's core mission is to translate Broadband Service Providers' near and mid-term service plans into published requirements for home network equipment and technologies The HGI addresses the home gateway and all the digital home building blocks: the hardware and software in the digital home that connect consumers and services.
  HGI is working on Requirements for Home Energy Management and Control Services to be supported by home gateways.

- **SIP Forum**
  www.sipforum.org
  SIP Forum's mission is to advance the adoption and interoperability of IP communications products and services based on SIP. They have formed a Smart Grid interest group to evaluate the appropriateness of using SIP as a protocol for Smart Grid communication.

- **NGN and IMS Forum**
  www.imsforum.org
  NGN Forum and IMS Forum are a global non-profit industry association dedicated to the advancement of IP Multimedia Subsystem applications and services interoperability.
  They have announced the launch of the Smart Energy Forum which will focus on IP services used to power the smart grid, home grids and alternative. It will explore all types of energy apps that employ IP services for the metering, billing and transport of energy. The Smart Energy Forum will develop guideline documents to help guide the industry in its adoption of this technology.

- **NERC (North American Electric Reliability Cooperation)**
  www.nerc.com
  NERCs mission is to ensure the reliability of the North American bulk power system. They define reliability standards including physical and cyber security of the grid.

- **OpenADR**
  www.openadr.org
  Open Automated Demand Response Communication Standards were defined by the Lawrence Berkeley National Laboratory Demand Response Research Center. It is a low cost communication solution for the reliable, robust and cost-effectiveness demand response communication in commercial buildings. OpenADR is now maintained by OASIS Energy Interoperation TC (section 5.14) and the UCAuig Smart Grid OpenADR task force (section 5.15).

- **PRIME ALLIANCE**
  www.prime-alliance.org
  The PRIME ALLIANCE (PRIME = PoweRline Intelligent Metering Evolution) focuses on the development of a new open, public and non-proprietary telecom solution which will support not only smart metering functionalities but also the progress towards the Smart Grid. They are working on an open single specification and standard for narrowband powerline solution for Smart Grid products and services.

- **Deutsches Institute für Normung (DIN)**
  www.din.de
  DIN is the German mirror body for ISO. They have the task to coordinate the E-Mobility standardization in Germany. They have several ongoing activities for Electrical Vehicle standardization. From an ICT point of view the work on the communication interface between the car and the grid (NA 052-01-03-17 AK) which mirrors the joint ISO/IEC work on vehicle to grid communication (section 5.5) is of main interest.

- **TM Forum**
  www.tmforum.org
  TM Forum defines standards for Operational and Business Support Systems. They have established the Smart Energy community to investigate TM Forums role in Smart Grid standardization.

- **Open Mobile Alliance (OMA)**
  www.openmobilealliance.org
  OMA is the focal point for the development of mobile service enabler specifications, which support the creation of interoperable end-to-end mobile services. OMA drives service enabler architectures and open enabler interfaces that are independent of the underlying wireless networks and platforms. They initiated a M2M task force in February 2010 to establish a priority list of potential M2M work items to recommend to the OMA Board of Directors.

In the home, building and industrial automation and control area a large set of standards and industry solutions exist like LON Works, KNX and Modbus. This has been already analyzed in detail by the VTT study “Interfaces of consumption metering infrastructures with the energy - Review of Standards” [1] as part of the TEKES INCA project. Readers are referred to this document for further details.

5.18 Activities in China

Smart Grid standardization activities in China are currently not really transparent. The standardization activities are done by State Grid (the dominant utility in China), the Ministry of Science and Technology and China Electric Power Research Institute (CEPRI) with very limited information available to the public. It was announced at the beginning of 2010 that first standards should be available in spring 2010, however nothing is available in public yet.

China Communications Standards Association (CCSA) technical committee 10 is working on standards for Ubiquitous Networks which includes Smart Grid communication especially for sensor networks.

5.19 Activities in Japan

In Japan the Ministry of Economy, Trade and Industry (METI) is driving the Smart Grid standardization. They launched a Smart Grid Standardization Study Group in August 2009 and issued a report in January 2010. Four future initiatives were identified:

- Definite implementation of the international standardization roadmap (i.e. IEC)
- Collaborations with other countries (APEC, NIST, CENELEC)
- Uniform promotion of related policy studies and technical development with international standardization activities
- Examination of the need for an implementation body

In April 2010 the Japan Smart Community Alliance was established which serves as a national center for Smart Grid Strategy, Standardization, and Roadmap.

CHAdeMO (CHArge de Move) (www.chademo.com) is a Japanese association which has defined a protocol for fast DC charging of PEVs. The protocol is now promoted for international standardization to IEC.

The Telecommunication Technology Committee (TTC) has setup an Advisory Group on Smart Grid in October 2010 to advise TTC by investigating & analyzing both global and domestic SDOs/Forum activities on Smart Grid from ICT perspective, and making a proposal to TTC to establish a Committee for future standardization (Smart Grid) items/area if necessary. The advisory group consists of several working groups for:

- Networked Car
- Networked Residence
- Networked Smart Community
- Networked City

6 Regulation, legislation and policies

Governments world wide have identified the need to drive the development and implementations of Smart Grid technologies. Billions of Euros are worldwide directed to Smart Grid research and implementation. Setting the right regulative and legislative frameworks is important for the future uptake of Smart Grid technologies. While a certain level of regulation already has been done in specific areas like Smart Metering, general Smart Grid regulation is still outstanding as the development is in an early phase and the impact on the markets have to be seen.

6.1 European perspective

In Europe Smart Grid is driven by the energy policy of the European Commission and Parliament to have a 20% cut in greenhouse gas emission, 20% energy share from renewable resources and 20% increase in energy efficiency by 2020 (20-20-20) [33]. Overall a sustainable, reliable and cost-effective energy supply should be provided and a single European market for Energy shall be established. The European Strategic Energy Technology Plan (SET-Plan) was initiated to accelerate the development and deployment of cost-effective low carbon technologies. This plan comprises measures relating to planning, implementation, resources and international cooperation in the field of energy technology.

The Information Society of the EU Commission is specifically looking on how ICT will support these goals. In 2008 they did setup a high level advisory group from leading companies and research institutions to assist them in this activity. From that activity two reports were published, one on ICT for Smart Distribution Networks [39] and one on Smart Buildings [40]. Furthermore the Information Society issued several communications and recommendations related to ICT and energy efficiency [41][42][43].

The EU Commission has issued two mandates for Smart Grid related standardization, M/441 [34] is for Smart Meter standardization and M/468 [35] is for charging of Electrical Vehicles. A standardization mandate for Smart Grid is expected for early 2011. The Commission has setup a Smart Grid task force to advice them on policy and regulatory directions at European level and to coordinate the first steps towards the implementation of Smart Grids. The Task Force will take stock of technology visions and developments performed by other grouping of stakeholders in this area, including in the Smart Grids European Technology Platform, in the Smart Grids Forum and in the European Electricity Grids Initiative (EEGI), and should be in close contact with their further

developments. It should also take into account all the relevant standardization efforts being undertaken at EU level that are working on the functionality, inter-operability and standardization of Smart Meters. Participation is open to European associations and standardization bodies resenting the various stakeholders. The task force consists of a steering committee and three working groups:

- EG1 Functionalities for Smart Grids
- EG2 Regulatory recommendations for data safety, data handling and data protection
- EG3 Roles and responsibilities of actors involved in the Smart Grids deployment

They released first drafts of their studies [36][37][38] in summer 2010 for comments. The final studies are expected by October 2010.

The European Regulators Group for Electricity and Gas (EREG) launched a public consultation on its Position Paper on Smart Grids [55]. This paper outlines a number of views and proposals regarding the regulator aspects of electricity networks and seeks to further the discussion on the development of electricity grids and of their regulation in the future.

6.2 United States perspective

In the U.S. the Smart Grid activities are driven by the US Energy Independence and Security Act of 2007 (EISA) [2]. The U.S. Senate Committee on Energy and Natural Resources is responsible for the national energy policy. The US Department of Energy (DOE) has issued several requests for information and public comments (RFI) related to Smart Grid during 2010. RFIs on "Communications Requirements of Smart Grid Technologies" and ""Data Access and Privacy Issues Related to Smart Grid Technologies" were issued in May and final reports were released in October [56][57]. In September 2010 they issued an RFI on "Addressing Policy and Logistical Challenges to Smart Grid Implementation" [58].

The U.S. National Broadband Plan [59] issued by the Federal Communications Commission (FCC) in May 2010 has an entire chapter on Energy and Environment (chapter 12). I contains several recommendations concerning the use of commercial broadband communication for Smart Grid (reliability, security and general requirements), the availability of spectrum for wireless Smart Grid communication (e.g. use of 700 MHz public safety band) and various actions of federal, state and rural agencies to unleash innovation in Smart homes and Smart Buildings.

The U.S. Federal Energy Regulatory Commission (FERC) issued a Smart Grid policy statement [60] in July 2009. They closely follow the NIST (section 4.2) and SGIP (section 5.2) Smart Grid standardization activities. In October 2010 they initiated the first step in smart grid rulemaking process in which FERC may consider requiring compliance with the foundational Smart Grid standards identified by NIST in October 2010 (see section 4.2) under its Federal Power Act authorities.

The U.S. National Association of Regulatory Utility Commissioners (NARUC) (www.naruc.org) issued a resolution regarding Smart Grid [61] in July 2009. In summer 2010 they established a Smart Grid working group to analyze smart-grid issues that will interact with the federal government and other stakeholders. NARUC also maintains a web site for Smart Grid regulatory and policy information (http://www.naruc.org/SmartGrid/).

6.3 International perspective

At the Clean Energy Ministral in July 2010 ministers of several governments launched an International Smart Grid Action Network (ISGAN) to accelerate the development and deployment of smart electricity grids around the world. ISGAN will focus on high level government attention on

Smart Grid and will sponsor activities that accelerate smart grid deployment and addresses gaps in five key areas of engagement:

- Smart Grid policy, regulation and finance
- Standards policy
- Research, development, and demonstration of pre-competitive technologies
- Workforce skill and knowledge
- Engagement of Smart Grid users and consumers on all levels

Three initial activities were announced:

- Working with the IEA as it develops a global Smart Grid Technology Roadmap, Partners will inventory global smart grid initiatives and needs and identify opportunities for collaborative technology and policy development efforts. The Roadmap will be published in November 2010.
- They will establish a forum to discuss standards policy for infrastructure and charging related to plug-in electric vehicles, addressing a rapidly emerging need.
- The Partners will develop a series of in-depth, multimedia case studies, highlighting the experience of stakeholders such as regulators, utilities, SMEs (small and medium enterprises), local policymakers, and electricity consumers in early smart grid deployments.

ISGAN will closely work with the Global Smart Grid Federation (see section 7.11).

The International Energy Agency (IEA) (www.iea.org) is working on a Smart Grid Technology Roadmap to demonstrate future electricity system needs and solutions provided through the development and deployment of the Smart Grid in electricity generation, transmission, distribution and end-use sectors. The roadmap will estimate cost of the Smart Grid and CO_2 Emission reductions due to Smart Grid deployment. The roadmap shall be released end of 2010. For 2011 a policy and regulatory study on Smart Grids is planned.

The Regulatory Assistance Project (RAP) (www.raponline.org) is a global, non-profit team of experts that focuses on the long-term economic and environmental sustainability of the power and natural gas sectors, providing technical and policy assistance to government officials on a broad range of energy and environmental issues. They have issued various documents concerning regulatory and policy issues for Smart Grid.

7 Trade and lobbying activities

In addition to standardization, promotion, marketing and influencing of regulation, policies and funded research is needed to push the development and deployment of Smart Grid technologies in the society. Various bodies are working in this area specifically for Smart Gird or in a wider scope. Below only a short selection of related activities, with a strong focus on Europe, is listed.

7.1 DIGITALEUROPE

www.digitaleurope.org

DIGITALEUROPE is the pre-eminent advocacy group of the European digital economy acting on behalf of the information technology, consumer electronics and telecommunications sector. They represent the ICT industry in European legislation, policy and regulation activities. They are founding member of the ICT for Energy Efficiency ICT4EE Forum

(http://www.digitaleurope.org/index.php?id=1150). The objective of the ICT4EE Forum is to link digital technology more closely to EU climate and energy policies and economic development. From the three working groups, working group 2 is considering Smart Grid as they work on Enabling Energy Efficiency in Other Sectors.

7.2 European Smart Meter Interest Group (ESMIG)

www.esmig.org

ESMIG will give advice and provide its expertise to key stakeholders and actors, such as the European Union institutions, EU Member States governments and authorities, regulators, consumers and utilities on all aspects related to Smart Metering. The objectives of ESMIG are:

- the pan-European introduction and roll out of Smart Metering through harmonization and interoperability;
- the creation and implementation of consistent standards for metering and communications;
- the identification and promotion of best practice solutions for smart multi-utility metering.

ESMIG contributes to the Smart Meter standardization in SMCG (section 5.9).

7.3 European Technology Platform Smart Gird

www.smartgrids.eu

European Technology platforms provide a framework for stakeholders, led by industry, to define research and development priorities, timeframes and action plans on a number of strategically important issues where achieving Europe's future growth, competitiveness and sustainability objectives is dependent upon major research and technological advances in the medium to long term.

The ETP Smart Grid mission is:

- To foster and support the deployment of Smart Grids in Europe advising and providing coordination to the various Smart Grids Forum stakeholders (European Commission, TSO, DSO, Energy System and Component vendors, Energy Research Centers, Smart Metering Industry, Energy Consumers, Utilities Telecom Providers, Grid Regulators) among projects and parallel related initiatives.
- To link with relevant technology platforms dealing with energy matters that have an impact both at the generation and the demand side, on the future of the grid.
- To provide relevant input to the EU initiatives such as SET-plan and its European Industrial Initiatives.

7.4 European Network of Transmission System Operators for Electricity (ENTSO-E)

www.entsoe.eu

ENTSO-E is the European Network of Transmission System Operators for Electricity, representing 42 Transmission System Operators (TSOs) from 34 countries. ENTSO-E's mission is to promote important aspects of energy policy in the face of significant challenges:

- Security - it pursues coordinated, reliable and secure operations of the electricity transmission network.

- Adequacy - it promotes the development of the interconnected European grid and investments for a sustainable power system.
- Market - it offers a platform for the market by proposing and implementing standardized market integration and transparency frameworks that facilitate competitive and truly integrated continental-scale wholesale and retail markets.
- Sustainability - it facilitates secure integration of new generation sources, particularly growing amounts of renewable energy and thus the achievement of the EU's greenhouse gases reduction goals.

Together with EDSO-SG (section 7.5) they have prepared the European Electricity Grid Initiative (EEGI) Roadmap 2010-18 and Implementation Plan 2010-12 [63] which proposes a 9-year European research, development and demonstration (RD&D) program to accelerate innovation and the development of the electricity networks of the future in Europe.

7.5 European Distribution System Operators for Smart Grid (EDSO-SG)

EDSO-SG was founded to structure, lead and enhance, not for profit cooperation between European distribution system operators for electricity as well as to as-sure, manage, represent and promote their common interests, specifically on Smart Grids development and implementation.

Together with ENTSO-E (Section 7.4) they have prepared the European Electricity Grid Initiative (EEGI) Roadmap 2010-18 and Implementation Plan 2010-12 [63].

7.6 Eurelectric

www.eurelectric.org

EURELECTRIC is the sector association which represents the common interests of the electricity industry at pan-European level, plus its affiliates and associates on several other continents. Its mission is to contribute to the development and competitiveness of the electricity industry and to promote the role of electricity in the advancement of society.

They have defined 20 Steps toward 2020 [64], which show how the electricity industry will support he European 20-20-20 goals and the path to a carbon-neutral, secure and integrated European electricity market.

7.7 T&D Europe

www.tdeurope.eu

T&D Europe is the European Association of the Electricity Transmission and Distribution Equipment and Services Industry. Their aim is to promote and defend the common technical, industrial economic, environmental and political interests of the European electricity transmission and distribution manufacturing, and product derives solutions industry.

They have provided feedback for various public consultations of the EU Commission and related activities and issued a brief position statement on Smart Grid [65].

7.8 Utilities Telecom Council (UTC)

www.utc.org

The Utilities Telecom Council (UTC) is a global trade association dedicated to creating a favorable business, regulatory, and technological environment for companies that own, manage, or provide critical telecommunications systems in support of their core business. They especially lobby for

spectrum for private communication networks for U.S. utilities. In September 2010 they published a report on Utility Communications needs [62] which was done together with Verizon.

They have established the Smart Networks Council (www.smartnetworkscouncil.org) as an affiliate with the mission to:

- Help those responsible for advanced metering and demand response initiatives to select the best AMI / DR systems now and/or maximize their investments in existing AMI / DR systems.
- Coordinate activities of UTC members' state and federal regulatory representatives to ensure the most favorable regulations for utilities deploying AMI and distribution automation applications.
- Drive interoperability of AMI and DR technologies by coordinating standards activities of UTC member utilities and their technology partners.

They also have a Canadian (www.utccanada.org) and European (EUTC) (www.eutc.org) affiliate. The later is leading the European thematic network ICT for Smart Distributed Generation (ICT4SMARTDG).

7.9 GridWise Alliance

www.gridwise.org

The purpose of the GridWise Alliance is to transform the U.S. electric grid to achieve a sustainable energy future.

The GridWise Alliance is focused on new ways of thinking about how the United States generates, distributes, and uses energy. Using advanced communications and up-to-date information technology, the GridWise Alliance aims to improve coordination between supply and demand and enable a smarter, more efficient, secure, and reliable electric power system.

The GridWise Alliance's principles include:

- Empowered customers
- A productive, secure, and reliable electric power system
- Better customer rates and quality of service
- Equitable markets and increased business opportunities
- Environmental benefits.

7.10 GSM Association (GSMA)

www.gsmworld.com

GSMA represents the mobile communications industry, 3GPP technologies being the common nominator. The main target is to drive growth in this industry, by bringing the industry players together to discuss the opportunities and agree on common ways to solve any obstacles. Mobile operators form the main part of GSMA membership, but equipment vendors and other industry players are also involved in the work. GSMA does not create standards, but writes further definitions such as white papers and recommendations that are helpful in addition to standards defined in 3GPP and other SDOs.

GSMA does not have specific activity related to Smart Grid, but Machine to Machine (M2M) communication is one area where mobile technologies are likely to be applicable. The Embedded Mobile Program (EMP) within GSMA works to identify things that 3GPP industry needs to consider for M2M operation. On one hand GSMA is looking into enablers for M2M operation, such specific technical aspects as well as marketing and coordination activities for making M2M happen in an

optimized way in the marketplace. On the second hand, GSMA is looking into selected four market segments or verticals of M2M to assure the solutions address the needs of those use cases. Work is divided into Work Streams as listed below:

Market Enablers:

- Test & Certification
- Roaming, Fraud & Security
- Provisioning Requirements
- Guidelines White Paper
- Regulatory Work Stream

Vertical Markets:

- Transport & Automotive
- Utilities Requirements
- Mobile Health
- Consumer Electronics

Figure 4 shows the relationship of the work streams.

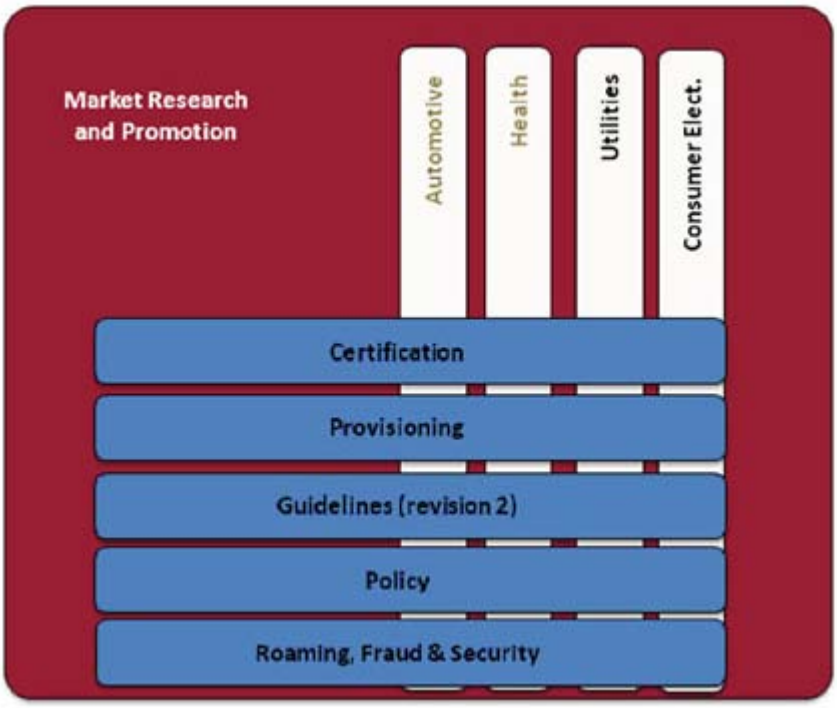


Figure 4: GSMA EMP Work Streams

While most of the work and the output documents are kept private to the GSMA members, one of the important output documents, the Embedded Mobile Guidelines White Paper has been made available to the general public (http://www.gsmworld.com/documents/GSMA-Embedded-Mobile-Guidelines-Rel1-White-Paper.pdf). This document summarizes the key findings of EMP, and gives

explicit recommendations for the development and implementation of devices containing an embedded cellular module, as well as the module itself. Also application and network level considerations are included. The first version was published in March 2010, and the work is on the way for an updated version in March 2011.

7.11 Global Smart Grid Federation

www.globalsmartgridfederation.org

The Global Smart Grid Federation is committed to creating smarter, cleaner electricity systems around the world. By linking the major public-private stakeholders and initiatives of participating countries, the federation will share best practices, identify barriers and solutions, foster innovation, and address key technical and policy issues. It was initiated together with ISGAN (section 6.3) at the Clean Energy Ministral in July 2010.

Members (as of October 2010) are various national Smart Grid associations:

- GridWise Alliance (United States) (section 7.9)
- India Smart Grid Forum
- Japan Smart Community Alliance
- Korean Smart Grid Association (http://www.k-smartgrid.org/)
- Smart Grid Australia (http://www.smartgridaustralia.com.au/)
- Smart Grid Canada
- Smart Grid Ireland (http://www.smartgridireland.org/)

8 Conclusion

Standardization for the Energy and ICT Industry, especially the telecommunication industry, has been done historically in different standardization organizations. ITU, ETSI, 3GPP, IETF are major standardization organizations for the telecommunication industry. IEC, CENELEC and various national mirror bodies are the major standardization organizations for the energy industry. With the strong integration of ICT in the Smart Grid these two worlds are coming together and extensive interactions between the relevant bodies (i.e. liaisons, joint activities) have to be established. SGIP is already pushing this by bringing the different organizations together in the PAPs.

It has to be recognized that ICT technologies have already been standardized for the electrical energy market by the energy standardization bodies. Prominent examples are the Common Information Model, substation communication and automation, control center communication and security standards defined by IEC and recognized as foundational standards for the Smart Grid by NIST. IEC plays also an important role in the Smart Meter and together with ISO in the Electrical Vehicle standardization. Replication of this work in telecommunication standardization bodies should be avoided. Instead the IEC work should be used as base for further developments.

For the widespread and cost-effective implementation of Smart Grids the use of widely accepted and implemented telecommunication standards is a prerequisite. For the network and application layers the use of IP technologies as defined by IETF is state of the art. Work on the necessary extensions for cost-effective support of constraint devices like sensors and actors is already under way in IETF. For WAN, MAN and LAN communication widespread wireline and wireless technologies like Ethernet, UMTS, LTE, DSL, Wifi, ZigBee, Powerline, SDH/SONET and Optical Networks provide a wide choice. Smart Grid specific solutions and extensions should be avoided as far as possible, except for mission critical applications which have specific requirements for example on latency and synchronization. An important issue is the efficient support of machine-to-

machine communication by these communication technologies. This however covers not only Smart Grid applications, but also various other usage areas like traffic management and e-health. A common approach for all these usage areas will result in cost-effective solutions and stimulated cross usage area applications. Standardization activities are currently going in various bodies with ETSI M2M leading the work for the m2m enablers.

For the back-end integration interfaces to pricing and billing, CRM, Identity Management, work force management, weather data, to the Energy Market and other applications have to be defined. These activities are often in an early stage or haven't been started. Further evaluation of the relevant bodies for such work (e.g. OASIS, TM Forum) is needed.

In the home area we have a wide range of automation, control and communication protocols. Co-existence (e.g. for Powerline and wireless solutions) and interworking are the major issues in this area. The ZigBee Smart Energy Profile 2.0 has some chances to be widely accepted as it will include support for various Smart Grid applications.

SGIP in the U.S. does a good job in bring together all the relevant standardization bodies and major stockholders and in identifying areas for urgent need for standards or alignment between standards. Even so it is U.S. focused it impacts also international standardization. At the European level such a coordinated approach is currently missing, expect for Smart Meter and EV charging standardization. With the EU Commission mandate for Smart Grid standardization, expected for early 2011 this may change, however a coordinated approach from the European Energy and ICT industry is needed to catch up. A European Smart Grid Initiative with participants from the whole Smart Grid eco-system instead of the various activities from dedicated stakeholders like DigitalEurope, ENTSO-E and EDSO-SG could be helpful.

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