Final report

of the CEN/CENELEC/ETSI Joint Working Group on

Standards for Smart Grids

Status: approved by the CEN/CENELEC/ETSI Joint Presidents Group (JPG) on 4 May 2011, subject to the formal approval by 2011-06-05 by the individual ESOs

Foreword

< to be added>

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1. Executive summary

Europe is committed to the 20-20-20 targets to reduce carbon emissions and to secure energy supply. Energy efficiency and renewable energy are seen as key to reach this goal. Both measures call for changes in our energy supply system leading to smart grids as key enablers for the required innovation. To promote this transformation the European Commission has taken a number of actions including a mandate on standardization.

Standardization of smart grids is not "*business as usual*". The huge number of stakeholders, the necessary speed, the many international activities and the still changing solutions make it a difficult task for the European Standardization Organizations (ESOs). This report investigates the status of smart grids standardization in Europe. It does not duplicate the extensive work already done in other regions. Its main focus is the organization of standardization in Europe.

The present version of the report focuses on the smart electricity grid, keeping it aligned with the scope of the European Commission's Smart Grids Task Force Expert Groups 1, 2 and 3.

High level recommendations:

- **Use a top down approach**
  The different applications to be deployed over time need to fit together. This can only be assured by strong coordination.
- **Build up a flexible framework of standards**
  Market business models, players and technical solutions are still changing. A flexible model or architecture must be available to map services and use cases.
- **Agree on a European set of use cases**
  Establish a single repository of use cases to systematically identify existing and future standardization needs.
- **Align with international standards**
  Cooperate with international and relevant national smart grid standardization activities. Base European standards on existing international standards and promote European results to the international level.
- **Don't reinvent the wheel**
  Reuse existing mature standards whenever appropriate.
- **Adapt the organization and processes for standardization**
  Smart grids are a system issue rather than a product issue. The CEN/CENELEC/ETSI Joint Working Group will promote this approach in close collaboration and cooperation with the existing TCs and structures.

The aim of this document is to provide a strategic report which outlines the standardization requirements for implementing the European vision of smart grids, especially taking into account the initiatives by the Smart Grids Task Force of the European Commission. It provides an overview of standards, current activities, fields of action, international cooperation and strategic recommendations. Section 2 presents an introduction to the political and technical background of smart grids in Europe and the current standardization activities around the world. Section 3 describes the scope of the report and the procedure followed in its development. Section 4 states general recommendations addressed to the European Standardization Organizations. Section 5 provides details of the current status of standardization in cross-cutting and domain-specific topics. Finally, Section 6 deals with the next steps to be taken.

In summary, the report identifies the necessary steps to be taken and proposes recommendations concerning standardization of smart grids. A prioritization of actions still needs to be performed and the content will be influenced continuously by external events. This is especially true for the standardization mandate. The content and spirit of the mandate need to be included in later versions of the report. It is therefore planned to revise this document regularly. It is now up to all of us to play an active part in the further implementation and development of standardization of smart grids in Europe in order to put the vision into practice. A large amount of standardization work has already been done and a vast set of important and mature standards is already in place. Smart grids implementations based on these standards can already start from this level and from the work already in progress. Reduction of the known gaps and overlaps is underway. In addition, longer term improvements are necessary to provide a coherent and future-safe framework and processes for standards development. The report addresses both aspects in its recommendations which are listed in full in Annex 1.

2. Introduction

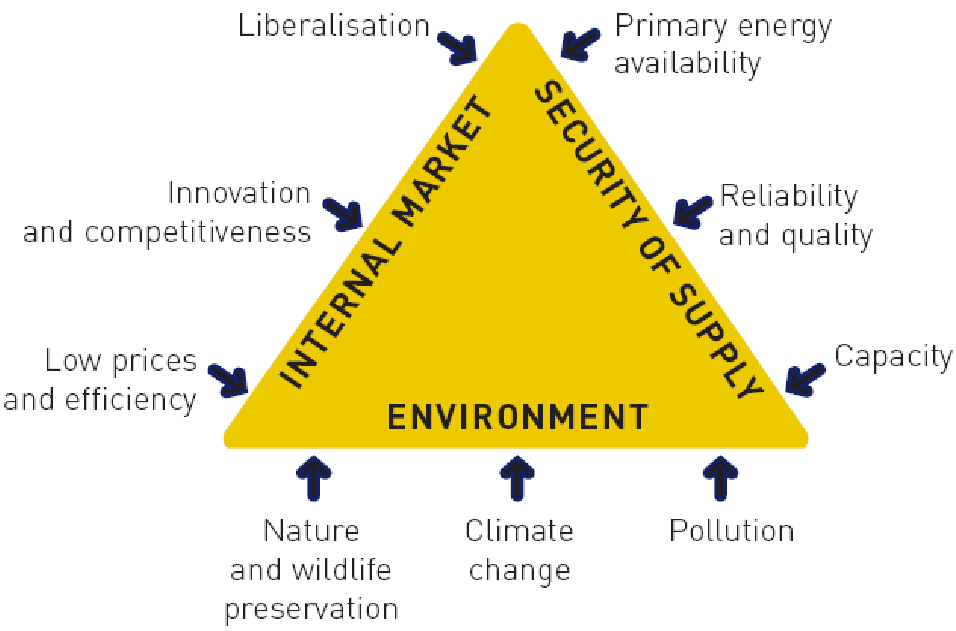
Europe's electricity networks have provided the vital links between electricity producers and consumers with great success for many decades. The fundamental architecture of these networks has been developed in most member states to meet the needs of large, predominantly carbon-based generation technologies.

Now the networks will have to integrate decentralized and renewable power generation (on-shore/off-shore wind, photovoltaic, combined heat & power), also with many small suppliers, as well as supplying power to an increasing number of electric vehicles. More flexible transport of power is needed in response to new energy markets and energy trading, and to the trend towards location of bulk generation far from load.

The energy challenges that Europe is now facing are changing the whole electricity supply chain - from generation, transmission and distribution to the customer and consumption side. In a further step, energy optimization crossing the domains of electricity, gas and heat will be a further challenge.

The drive for certain lower-carbon generation technologies, combined with greatly improved efficiency on the demand side, requires customers to be more active and to have more interaction with the networks. More customer-centric networks are the way ahead, but these fundamental changes will significantly impact network design and control.

In this context, the European Technology Platform (ETP) Smart Grids was set up in 2005 to create a joint vision for the European networks of 2020 and beyond. It has identified clear objectives and proposed an ambitious strategy to make a reality of this vision for the benefit of Europe and its electricity customers. The vision of a smart grid in Europe was further developed following a 2006 Green Paper "A European Strategy for Sustainable, Competitive and Secure Energy" [1] and the paper "Vision and Strategy for Europe's Electricity Networks of the future" [2] by the European Technology Platform (ETP) Smart Grids. The key elements of each energy supply system are sustainability, competitiveness and security of supply. Those overall aspects have to be interpreted for the new era of intelligent energy supply.



Source: [2]

Figure 1 – Key elements of a sustainable energy system

The European Commission Directorate-General (DG) for Energy mandated a group of experts to examine the conditions for a successful deployment of smart grids (or smarter grids) in Europe and created a Smart Grids Task Force. This task force highlighted the importance of standards for a successful deployment together with a need for change and improvement of the existing standards. In addition, the group of experts identified the risk of too many standardization bodies providing an inconsistent set of standards.

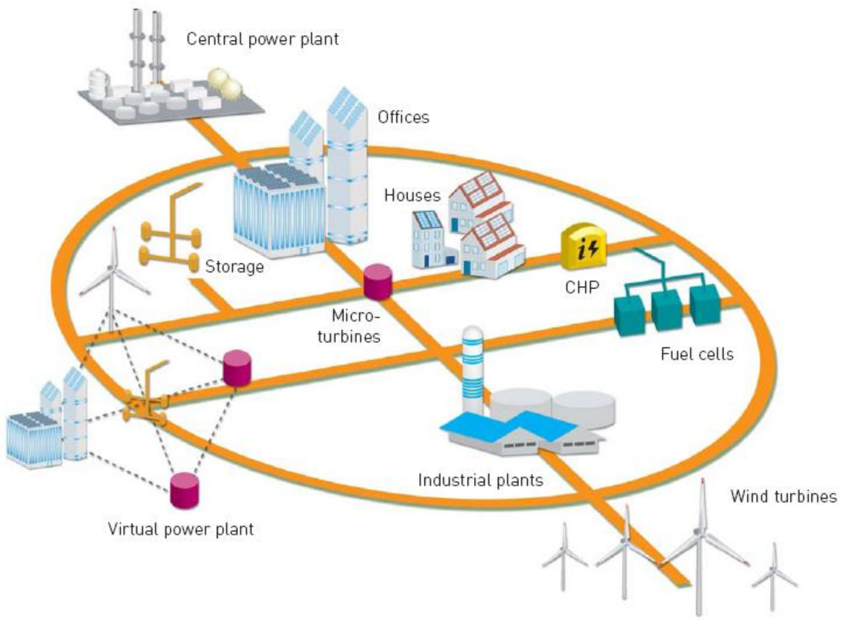
The Expert Group 1 of the EC Smart Grid Task Force concluded there was a need for a joint CEN/CENELEC/ETSI Group on standards for smart grids, to deal more intensively with establishing detailed recommendations to selected standardization bodies.

2.1 Basic idea of smart grids

The idea of smart grids in Europe is described in detail in the publications by the European Technology Platform Smart Grids and in the Strategic Deployment Document (SDD) [3].The content is only summarized here to the extent that it is necessary for new concepts and responses by the European standardization system.

Europe's electricity networks must be flexible, accessible, reliable and economical. Furthermore, solutions must be scalable, increase capacity for power transfers, reduce energy losses, heighten efficiency and security of supply and be backwardly compatible to include the installed base. Developments in communications, metering and business systems will open up new opportunities at every level of the system to enable market signals to drive technical and commercial improvements as well as energy efficiency.

Major elements of the vision are collected in a toolbox of proven technical solutions, harmonized regulatory and commercial frameworks, shared technical standards and protocols, information, telecommunication systems and the successful interfacing of new and old designs of grid equipment.



Source: [1]

Figure 2 – Future network

In the report of the Smart Grids Task Force Expert Group 1 [4], a smart grid is defined as follows:

> "A smart grid is an electricity network that can cost efficiently integrate the behaviour and actions of all users connected to it – generators, consumers and those that do both – in order to ensure economically efficient, sustainable power system with low losses and high levels of quality and security of supply and safety."

A smart grid will also provide a framework for innovative services.

The European regulators use and support the approach of the ETP Smart Grids, but emphasize that investments in smarter networks must result in user value and direct benefits to all network users.

The challenges and opportunities addressed include:

- User-centric approach
- Electricity networks renewal and innovation
- Security of supply
- Liberalized markets
- Interoperability of European networks
- Distributed energy resources (DER) and renewable energy sources (RES)
- Central generation
- Environmental issues
- Demand response and load management

The vision and the scope of smart grids bring together a vast group of stakeholders. These are described in detail in the report of the Smart Grids Task Force Expert Group 3 [5]. Co-ordination between actors is essential in maintaining a secure supply, an efficient network operation and a transparent market. Common technical rules and tools need to be adopted by the different players with regard to data exchange, modelling grids, ancillary services and their users.

Within this vision and as a basis for implementation a lot of work needs to be done and many issues need to be addressed by standards. Standards are an ideal instrument to achieve a number of objectives such as

- seamless interoperability,
- harmonized data models,
- compact set of protocols, communication and information exchange,
- improved security of supply in the context of critical infrastructure,
- robust information security, data protection and privacy
- adequate safety of new products and systems in the smart grid.

Joint technical standards are an explicit goal of the European smart grid strategy. They can also help to promote the European smart grid solutions in a worldwide market.

The European standardization organizations CEN, CENELEC and ETSI are ready to address these issues.

2.2 Current political background in Europe

In March 2006, the European Commission put forward its analysis [1] of the main energy challenges that the EU will be facing in the coming years. The Commission proposed to address these challenges through a new comprehensive European energy policy built on three main pillars: sustainability, competitiveness and security of supply. Among other things, research into energy efficiency and renewables and development and deployment of new energy technologies were identified as political priorities.

The roll-out of smart meters and implementation of smart grids in Europe are an integral part of these policy priorities. When the Commission unveiled its proposal for a Third Energy Package in September 2007, it made the implementation of smart metering systems an obligation for the Member States in both the Electricity and the Gas Directives [6]. Member States must carry out a cost-benefit analysis of the smart meters implementation by September 2012 and ensure the deployment of the smart electricity meters to at least 80% of the households by 2020. The progress towards the smart grid development is also supported by a body of European energy efficiency legislation. The Directive on Energy End-use Efficiency and Energy Services from 2006 lists deployment of smart metering systems as one of the main cross-sectoral measures considerably improving energy efficiency [7]. Likewise, the recently revised Directive on Renewable Energy obliges the Member States to take appropriate steps to develop intelligent transmission and grid infrastructure [8]. The Energy Performance of Buildings Directive strongly supports decentralized energy supply systems based on renewable energy and calls on the Member States to encourage the introduction of smart metering systems whenever a building is constructed [9].

To facilitate the implementation process on the technical level, the Commission issued a standardization mandate concerning smart meters to the standardization organizations CEN, CENELEC and ETSI in 2009. The standardization bodies are now involved in the development of an open system architecture for utility meters involving communication protocols that enable interoperability, and they will present the results in 2012.

If smart grids implementation is to succeed in Europe, support from industry is key. This is why the Commission established the European Strategic Energy Technology Plan (SET-Plan) in 2007. As the technology pillar of the EU's energy and climate policy, the Commission, together with industry and the research community drew up technology 'roadmaps' identifying key low carbon technologies with strong potential at EU level in six areas: wind, solar, electricity grids, bioenergy, carbon capture and storage (CCS) and sustainable nuclear fission. On this basis the Commission, together with industry stakeholders, launched four industrial initiatives, including one on electricity grids in June 2010. The European Electricity Grid Initiative (EEGI) has already published a detailed roadmap for 2010-2018 outlining the process towards the implementation of smart grids in Europe [10].

However, addressing the technology aspects of smart grids is not enough to make smart grids a reality in Europe. Important questions regarding data protection and interaction between different actors and regulators need to be clarified, and funding issues addressed. To this aim, the Commission established a Smart Grids Task Force in November 2009. It is to advise the Commission on the policy/regulatory directions at European level, coordinating first steps towards the implementation of smart grids recommended in the Third Energy Package. The Smart Grids Task Force is led by the Commission's Directorate-General for Energy Policy (DG ENER) in collaboration with six Directorates and about 25 European associations representing all relevant stakeholders. The task force is to deliver recommendations on a number of relevant issues towards the middle of 2011. The Expert Groups that are to identify the need for further smart grid standards have already expressed a positive view and recommended the Commission to initiate drafting of a standardization mandate so that it can be issued by early 2011. In this context, the establishment and the work of the CEN/CENELEC/ETSI Joint Working Group on standards for smart grids is extremely useful and instrumental in achieving the European Commission's policy objectives regarding smart grids.

2.3 Aim of a European standardization report

The aim behind this document is to draft a strategic and nevertheless technically orientated report which represents the standardization requirements for the European vision of the smart grid, taking specially into account the ETP (European Technology Platform), SDD (Strategic Development Document), SMCG (Smart

Metering Coordination Group), EU Focus Group on Electric Vehicles and the Smart Grids Task Force of the European Commission initiatives. In addition, it provides an overview of standards in that context, and of current activities, necessary fields of action, international cooperation and strategic recommendations.

In doing this, the document aims to respond to the first conclusions of the Expert Group (EG1) of the European Commission Smart Grids Task Force, which request the establishment of a Standardization roadmap [11].

<<start of EG1 report extract>>

For efficient deployment, it is necessary to coordinate all these changes within a coherent framework road map.

The report should address:

- Devices;
- Interfaces;
- Communication;
- Cyber security and system integrity;
- System model(s);
- Network and system management;
- Grid codes and Industry rules;

and must take into account the market rules.

According to this a harmonization of models and standards is highly desirable. Technical standards have to be defined clearly and fast; if not the desired effect will not occur in the expected time frame. Due to this reason it is necessary to prioritize some key issues and define “fast track” solutions for the core set of standards (see below).

The different domains (Energy Market, Transmission and Distribution, DER, E-Mobility) need to define common interfaces through telecommunication and service standardized and interoperable architectures.

Use cases and standards in development under the Mandate M/441 for smart metering shall be taken into account to ensure coexistence of smart meters and smart grids applications.

<<end of EG1 report extract>>

The report summarizes international and national activities in standardization taking into account the specific European requirements derived from the European smart grid vision. This European standardization report describes standards of a future electrical power supply system, states their importance and areas of application, and presents the resulting opportunities, challenges and effects. At this point it is not intended to narrow down the lists of standards to those which are most relevant – this will be left to a later phase. The procedure for doing this is described in the last section of the report.

The report should support European manufacturers and enhance their international reputation in the areas of power engineering, automation technologies and ICT business.

The concept of the smart grid is receiving attention from many stakeholders. For this reason, CEN, CENELEC and ETSI formed a Joint Working Group on standards for smart grids, which is open to all interested European associations, national standardization organizations as well as interested Technical Committees. It is intended to establish CEN, CENELEC and ETSI as the voice for smart grid standardization, especially in the light of the policy framework and the standardization mandate on smart grids by the European Commission.

2.4 Standardization activities around the world

Smart Grids have received considerable attention worldwide in recent years. The concepts differ greatly in the main regions and this is also reflected in the respective roadmaps and studies. However for CEN/CENELEC and ETSI there are some standardization organizations which by virtue of mutual agreements are in the focus of the European activities. This is especially true of ISO, IEC and ITU-T as well as the national standardization organizations in Europe. The results from these organizations need to be considered with top priority, since they influence the work at the European level. In addition, co-operation with ISO, IEC or 3GPP is our main lever to internationalize European standardization work[1)]. There are of course further standardization organizations which have to interact in the networks of the smart grid technologies. ISO/IEC JTC 1 and 3GPP on the international level, NIST, KATS, JISC on the regional level and all relevant organizations at national level (e.g. German DKE for the standardization roadmap) are especially worthy of mention.

The following is a short overview of various studies:

- **European Standardization Mandate M/441 and the Smart Meter Co-ordination Group**
  The European Union has issued a mandate to the organizations CEN, CENELEC and ETSI for the standardization of smart meter functionalities and communication interfaces for use in Europe for the electricity, gas, heat and water sectors. The results of Mandate M/441 are to be standards or technical documents. Standards in this context are voluntary technical specifications and general technical rules for products or systems on the market. The aims are to facilitate the deployment of smart metering systems, to secure interoperability, protect the customers and ensure system reliability. Above all, the following six aspects of smart metering are considered and the prevailing standards examined.
  - Reading and transmission of measurements
  - Two-way communication between the meter and a market participant (e.g. billing, energy related services)
  - Support by the meter for various tariff models and payment systems
  - Remote meter deactivation and start/finish of supply
  - Communications to support remote load management applications
  - Support of a display or interface in the household for display of the meter data in real time

  The meters do not always have to support all the functionalities; this can be arranged from country to country. Within the "Smart Meters Co-ordination Group" (SMCG), existing standards are classified in relation to these six functionalities and responsibilities delegated to individual standardization committees of CEN, CENELEC and ETSI.

- **ETSI M2M Smart grid**
  Smart Grid Use Cases in European Telecommunication Standards Institute M2M Technical Committee (ETSI M2M TC)
  While elaborating technical specifications for a generic functional architecture and appropriate high-level interfaces (APIs) facilitating and optimizing the end-to-end delivery of M2M services, ETSI M2M TC checks that main vertical applications match with these generic specifications expected for the 1st semester of 2011. After having considered the Smart Metering Use Cases in relation to the M/441 Mandate, which resulted in the publication of the ETSI Technical Report TR102691 "Machine-to-Machine communications (M2M); Smart Metering Use Cases" in May 2010, the M2M TC is now treating, among other Work Items, the Smart Grid Use Cases through a Work Item created in July 2010. The latter is drafting a Technical Report (Draft ETSI TR 102 935) on "Machine-To-Machine Applicability of M2M architecture to Smart Grid Networks, Impact of Smart Grids on M2M platform" describing the Smart Grid Use Cases of interest for further analysis by the M2M TC when establishing the generic M2M specifications.

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1) For example via the Vienna and Dresden Agreements between CEN/ISO and CENELEC/IEC respectively.

- **German Standardization Roadmap E-Energy / Smart Grid** [12]
  In close cooperation by DKE, the German Commission for Electrical, Electronic & Information Technologies of DIN and VDE, with the German "E-Energy" research projects funded by the Federal Ministry of Economics and Technology and the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety, a position paper on German Smart Grid Standardization was drafted by all relevant stakeholders and experts in combination with a public hearing and a public opportunity to comment on the draft version. Based on a description of the basic concepts of smart grids and an overview of relevant standards, current studies and activities, the position paper provides recommendations for necessary fields of action, international cooperation and strategy. The main result was the finding that a lot of standards already exist in spite of some public perception of a lack of standards. Existing international standards, especially those established by IEC TC 57, should be used as far as possible and should be the basis for further developments. New developments are seen mainly in the cooperation between different standardization organizations and different Technical Committees due to the broad system approach needed for smart grids, ranging from generation, transmission and distribution to electrical devices like smart appliances in households. Furthermore, experts pointed out that the system approach has to include and consider other media such as gas, heat or water (multi-utilities) as well as other domains: In a smart home, for instance, functions of Energy Management, Home Automation and Ambient Assisted Living (AAL) might merge. The paper is publicly available in German and English.

- **IEC Strategic Group 3 "Smart Grid Report"** [13]
  The Standardization Management Board (SMB) of IEC resolved the establishment of a Strategic Group on "Smart Grids" (Strategic Group 3), which submitted an initial roadmap for its own standards and 11 high level recommendations to the SMB in February 2010. The roadmap has been officially available on the IEC webpage since June 2010. This work and these recommendations are especially relevant to the European standardization roadmap. The IEC has already developed numerous suitable standards. Its aim is therefore to disseminate these further and to draw attention to them. A total of over 100 IEC standards were identified, described and prioritized by SMB SG3. Twelve application areas and six general topic blocks were examined by SG3, and 44 recommendations for a smart grid from the aspect of standardization issued. Existing IEC core standards – especially IEC TC 57 standards – serve as the basis for further smart grid standards to be developed. Other standards such as those of IEC TC8, IEC TC13, etc are also very relevant. Currently the IEC group is focusing on use cases and general requirements for a smart grid reference architecture, developing a so-called Mapping Tool to support smart grids project managers (http://www.iec.ch/smartgrid).

- **ITU-T Smart Grid Focus Group**
  In February 2010, the Telecommunication standardization sector of the International Telecommunication Union (ITU-T) established a Focus Group on Smart Grids (FG Smart). This Group aims at collecting and documenting ideas that would be helpful for developing recommendations to support the smart grid from a telecommunication/ICT perspective. The objective is limited to the telecommunication/ICT aspects of the smart grid, identifying potential impacts on standards development, investigating future ITU-T study items and related actions, familiarizing ITU-T and standardization communities with emerging attributes of the smart grid, and encouraging collaboration between ITU-T and smart grid communities (including other SDOs and consortia).
  The Focus Group is planned to operate until June 2011, and will present its first draft of the deliverables at the February meeting of its parent group. In its draft overview document, it proposes the following role for the ICT perspective in the smart grid: "Information and communication system is the fundamental of achieving intelligent management and control in the grid. It builds up two-way information channel between grid and consumer to achieve interaction, such as demand response, real-time price, home energy management. The automation level of grid is improved by implementing ICT for auto-collecting and analyzing grid information."

- **NIST Interoperability Framework** [14]
  Empowered by the Energy Independence and Security Act (EISA) of 2007, the Department of Commerce in the USA devolved the main responsibility for the coordinated development of a framework for the achievement of interoperability of smart grid systems and devices, taking especial account of protocol and data model standards for information management, to NIST [15]. Various pieces of equipment, such as smart meters for the US smart grid, are already being evaluated in field trials. NIST also emphasizes that large investments in a smart grid will not be sustainable without standards.

NIST has therefore established a phase plan intended to accelerate identification of the standards required for the smart grid. The document is the result of the first phase in compilation of the framework. It describes an abstract reference model of the future smart grid and in doing so identifies almost 80 essential standards which directly serve the smart grid or are relevant to its development on a meta-plane. In addition, 14 key areas and gaps are identified, in which new or revised standards are needed, especially in the field of security. NIST further establishes plans of action with aggressive timetables and coordinates the standardization organizations to the extent that they support its plans to close the gaps in achieving smart grid interoperability in the near future.

- **Japanese Industrial Standards Committee (JISC) roadmap to international standardization for smart grid** [16]
The Japanese approach to standardization in the context of smart grids is highly similar to the approach of NIST in the USA: Starting with an initiative by the Ministry of Economy, Trade and Industry (METI), a strategy group was founded in August 2009 with the aim of promoting Japanese activities in international standardization in the smart grids field. Standards are seen in that context as a fundamental element in the achievement of the required interoperability. The flexibility and expandability of the future smart grid can, according to the strategy group, only be achieved with an appropriate degree of standardization. A first report was completed by January 2010, providing for the establishment of a roadmap in close cooperation with other standardization organizations and countries. On the basis of a general picture of the future smart grid, seven main fields of business (Wide-Area Awareness in Transmission, Supply-Side Energy Storage, Distribution Grid Management, Demand Response, Demand-Side Energy Storage, Electric Vehicles and AMI Systems) were identified, to which 26 Priority Action Areas are assigned. Special core aspects for the Japanese economy were also identified. The topics are to be addressed in cooperation with IEEE, IEC and CEN/CENELEC. The recommendations are therefore also congruent with the previous recommendations from those organizations.

- **The State Grid Corporation of China – SGCC Framework** [17]
The State Grid Corporation of China (SGCC) has defined an own smart grid standardization roadmap which will have some influence on vendors and markets since China will be one of the largest markets for the upcoming smart grid which is expected to be based mainly on open standards. The first version of the SGCC framework defines eight domains, 26 technical fields and 92 series of standards and takes into account several existing standardization roadmaps.
The SGCC framework states that after the age of information we will see an upcoming age of intelligence where the integration of clean energy requires a strong and smart grid which is considered to tackle climate change as well as environment deterioration and to optimize the allocation of energy resources. The strong and smart grid is defined as an intelligent power system encompassing power generation, transmission, transformation, distribution, consumption and dispatching. According to the SGCC definition, the grid itself will no longer be a simple carrier of transmission and distribution of electricity, but will be more an integrated and intelligent platform for the internet of things, internet network, communication network, radio and TV networks. The sharp line between generation-side and demand-side will blur.
SGCC has worked out a fast paced three stage plan. For the first batch of smart grid standards, SGCC has identified 22 standards overall, 10 domestic ones and 12 international ones. Those standards have also been in the scope of IEC SG3, containing their 5 core standards.

A lot of further activities and roadmaps could be mentioned as well, such as those of Austria, Spain, the United Kingdom, the Netherlands, France, Korea and others. Furthermore, R&D projects, forums and consortiums can provide relevant input,.

In the area of international standardization and interoperability roadmaps, a relevant document is already available in the form of the IEC roadmap. The standards from IEC TC 57, Seamless Integration Architecture, (IEC TR 62357) are worthy of particular mention in this context. The IEC's roadmap represents a good basis, which can exert influence on standardization in the field of smart grids on an international level. The IEC focus however means that areas which may be relevant to Europe are missing and cannot be adopted from the study (e.g. market communication and ICT).

The work of NIST refers in part to North American standards such as those from ASHRAE or IEEE, which are less widespread in the European context. Nevertheless, many of the recommendations from the international IEC roadmap are picked up in the national North American roadmap.

In the area of standardization for the smart grid in Europe, the Smart Grids Task Force reports commissioned recently by the European Commission are especially significant. The EG1 Report [4] focuses on services and functionalities, while the EG2 Report [18] focuses on data handling, security and consumer protection. They both state recommendations for standardization.

It is agreed that the European Joint Working Group on standards for smart grids will be in close contact with the various standardization groups around the world. On the one hand this will help to formulate a worldwide approach and on the other hand help to establish European requirements and standards in a worldwide market. Liaisons are already established with IEC SG3, JISC and NIST. The national standardization organizations of Europe are in any case included in the overall setup of CEN, CENELEC and ETSI.

3. Description of the overall concept

3.1 Scope

The following document identifies existing standardization and potential gaps in the European standards portfolio which will be relevant for smart grid implementation. The report will advise on European requirements relating to Smart Grid standardization, and assess ways to address them.

The report builds on inputs from the Smart Grids Task Force of the European Commission. The European requirements are to be an integral part of the overall smart grid standardization philosophy. The report is not intended to repeat work already delivered by other organizations, of which an overview is provided in section 2.4. The report's focus is rather in determining the specific European requirements for standardization and it will make maximum reference to international work wherever this may already suffice for the implementation of smart grids in Europe. The report will initially focus on the smart electricity grid, but may extend its scope into other utilities (gas, water, heat), keeping it aligned with the scope of the European Commission's Smart Grids Task Force.

The report is designed to present an overview of specific European standardization requirements concerning the smart grid by taking due account of the emerging task force recommendations. It matches these requirements against existing international standards and all relevant work in progress in standardization bodies, and builds on existing international and European standardization work in order to make recommendations as to how missing issues should be covered by standardization. These recommendations will reflect the preference for global standards that also apply in Europe (e.g. via the IEC-CENELEC Dresden agreement or the ETSI participation to 3GPP).

The report is also seen as a basis for further investigation and developments in the light of the standardization mandate for smart grids from the European Commission.

3.2 Procedure

The following section is intended to describe the procedure taken to identify existing European standards and gaps which will need new standardization activities. The European Standardization Organizations (ESOs) CEN, CENELEC and ETSI have formed a Joint Working Group on standards for smart grids. It is open to the relevant European stakeholders and also covers further tasks specified in the terms of reference.

This document does not focus on an elaborated function and domain analysis. That is done by the Smart Grids Task Force Expert Groups, who have identified a number of basic functionalities of future European smart grids. High level use cases are derived from these functionalities in order to deduce the functional requirements. Whether the requirements are met by already existing standards or by standards yet to be developed will be analyzed and recommendations for further work will be given. These recommendations may address different levels of the organization of the ESOs, from the top management councils like the Joint Presidents Group, to the more technical work in TCs, SCs and the respective working groups.

The JWG has structured the complex area of smart grid standardization in the following way:

Section 4 will focus on the European standardization landscape concerning the regulatory and political framework as well as aspects like marketing or types of deliverables appropriate for smart grids. It will furthermore elaborate on a suitable organization of standardization work within the ESOs.

Section 5 will describe the recommendations in specific areas. It is divided in three subsections.

- The first subsection covers topics which are of a general nature and apply to all domains of smart grids. It consists of terminology, systems aspects, reference architecture, communication, information security and other cross cutting issues.

- The second subsection covers topics which are relevant to a certain domain. The report for each domain will follow the same procedure. First of all a short description of the relevant functionalities and if necessary some of their high level use cases will be given. This is followed by the necessary requirements to implement such functions. Then – if already existing – a number of possible candidate standards published by ESOs will be presented. The remaining gaps are described and the necessary standardization work or missing standards are outlined.
- The third subsection addresses the roles and responsibilities of the various actors in the electricity supply chain and electricity market.

Each subsection will end with recommendations addressed to the ESOs and – where appropriate – other stakeholders.

Section 6 covers further activities to be performed, activities oriented towards the mandate on smart grids, and the actions to be taken to issue a second version of the report.

Annex 1 provides an overview of all the recommendations made in the different sections.

4. European standardization and regulation landscape

4.1 General recommendations

The following general recommendations G-1 to G-6 should be considered as strategic recommendations summarizing the discussions on detailed topics in order to provide a management framework.

G-1 Further development of the report
This report should be further developed with regard to the focal topics identified, in cooperation with the corresponding professional groups and stakeholders. Topics such as energy storage, security of supply and micro-grid may also be included.

G-2 International standards as a basis for promoting EU industry
Standardization of smart grids must be based on existing international work, to avoid reinventing the wheel, to accommodate solutions which are already standardized and applied for practical purposes and to secure the interests of European manufacturers who are operating globally. This document recognizes that work and therefore builds upon the globally recognized smart grid standards as identified in Section 5.

G-3 Speed of implementation – reuse existing systems
There are already a number of quite advanced initiatives around the world which are described in section 2.4. In order to secure European interests in the implementation in Europe and around the world, existing mature domain communication systems should be used. The ESOs should further standardize necessary interfaces and product requirements and must avoid standardizing applications and solutions. The focus must be on standard development according to the R&D and deployment priorities of the EU given in the Smart Grids Task Force reports, the ETP and the SDD.

G-4 Concentrate on future proof standardization
Smart grids is a highly dynamic technical field. Standards must therefore be generic and open to include future developments from R&D and pilot projects. It is therefore recommended to concentrate on generic standards which flexibly mirror market needs and technological development.

G-5 Build up a SINGLE repository for smart grid use cases
The descriptions of functionalities / use cases represent an important basis for the further work, including that on standardization. It is therefore recommended to collect use cases as a base to start detail work on standards. Supply this repository with at least

- the M/441 set of use cases,
- active liaisons with all European smart grid projects,
- the EG1 to EG3 reports of the Smart Grids Task Force of the European Commission, and
- experience from the national committees.

Check if the re-use of use cases coming from other countries or regions may lead to single worldwide use-case definition.

Define the methodologies: templates, classification, organization, harmonization of use cases, publication, etc.

G-6 Adapt standardization processes
Define the processes needed to match the lack of maturity of many smart grid applications. As stated in the EG1 report, "smart grids deployment will be a continuous learning process" and standardization should propose a clear set of processes to cope with this learning process. For instance use an electronic form of communicating standards in order to enable seamless integration of standard data models. Define open and transparent quality processes attached to smart grid standards, covering the whole life cycle of such standards, including how to collect issues, to treat/fix issues, and then to validate and test.

G-7 - Relationship between legislative requirements and standardization
A proven concept, described as New Approach and further developed as New Legislative Framework (NLF), has been the legislative definition of essential requirements. Related to the legislative document (e.g. directive or regulation), harmonized standards from the European Standardization Organizations (ESOs) describe further technical details. Following the harmonized standards it can be assumed that the essential requirements of the legislative document are fulfilled (presumption of conformity).
For the system approach of the Smart Grid no essential requirements from legislation are currently available. The relationship between the standards produced by the ESOs under the standardization mandate and future legislative initiatives at the European level needs further consideration in due course, once the latter are defined.

4.2 European Standardization Organizations (ESOs)

Several facts indicate that there is an increased need for cooperation between the European Standardization Organizations on the topic of smart grids. Some of the detail topics within this report cannot be expected to be finalized during the course of a first version given the timeframe set in the terms of reference. Therefore additional work as stated in the respective individual sections and their recommendations is required. The JWG is seen as an ideal tool to handle and follow up on these still open issues. Furthermore, smart grids are a highly dynamic field, where major changes must be expected and accommodated. And finally, a mandate received from the European Commission has to be worked on. All these factors demand a structure or organization within the ESOs to cover these tasks.

O-1 Extend timeframe and scope of JWG Smart Grids
The JWG scope and duration should be adapted to the wider needs of further tasks, coordination of responses to an EC mandate and a further investigation of the ever changing environment in the smart grids area.

O-2 Marketing of ESO work on Smart Grids
ESOs must highlight their work on the markets, and promote the work already done on international and various regional levels. This is necessary to maintain the high level of influence on international standardization and therefore on solutions. Funding of the external representation of the ESOs should be investigated as international activities indicate that the roles of the US and Asia are growing due to high public funding of the respective standardization organizations. Although this might conflict with the traditional role of European standardization, the short time frame for action in order to participate within the ongoing debate at international level and the need to standardize in areas where R&D still is needed, public funding might be justified for some stakeholder groups like R&D institutes or SMEs. Any solution should be based on the co-operation with national standardization organizations and their experts and expertise.

O-3 Mandates in relation to Smart Grids
Concerning the different mandates that are or will be issued in the context of smart grids, consistency and coherence must be ensured by the Technical Boards of CEN and CENELEC and by the ETSI Board, by taking account of and building on the results of the work carried out already as far as possible.

5. Status of standardization

5.1 Cross cutting topics

5.1.1 Terminology, object identification and classification

5.1.1.1 Terminology

Terminology and a glossary are prerequisites for dealing with smart grids since each smart grid domain has its own language: electrical and telecom industries, network operators, regulators, power traders, …. There is a need for a standardized language allowing easy exchange of information between all domain players. In order to achieve this, it is necessary to unify disparate descriptions and to make acronyms explicit. This must be done– as far as possible – by definitions which are neutral in terms of technology .

5.1.1.1.1 Existing standards

Based on the roadmap structure, the following table lists dictionaries, glossaries and standards which are sources of definitions related to smart grids.

Table 1 – Classification of the terminology publications

Roadmap structure	Content	Source of definitions
General, architecture, concepts	Smart grid Use case methodology and template Architecture	IEV 617 IEC PAS 62559 IEC SG3 Roadmap
Communication	Telecontrol Communication systems in substations Interface for distribution management Energy market communication Data exchange with metering equipment Data communication	IEC 60870-1-3, IEV 371 IEC 61850-2 IEC 61968-2 IEC 62325 IEC 62051-1 IEC 62056 ISO/IEC 2382-9 ITU Terms and definitions database Other telecom glossaries to be added
Information security		IEC/TS 62351-2 NIST key security terms IETF Internet security glossary – RFC 4949 Other telecom glossaries to be added
System aspects and other cross cutting issues	Dependability and quality of service EMC Connection to the grid	IEV 191 IEV 161 IEV 617
Generation, transmission, distribution	Substations, planning, operation	IEV 601, 602, 603, 604, 605

Roadmap structure	Content	Source of definitions
Smart metering		SMCG Technical Report and Glossary IEC 62051
Industry, energy management	Energy management	CEN/CENELEC TR 16103 IEC 61970-2
In house automation	Home Electronic System (HES) Building automation Intelligent home	ISO/IEC 15044 ISO 16484 ISO/IEC 29108 (CD)
Market and actors	Tariffs for electricity	IEV 617 IEV 691

NOTE List of Terminology publications related to smart grids

- IEC 60050(617), International Electrotechnical Vocabulary – Part 617: Organization/Market of Electricity
- IEC 60050(161), International Electrotechnical Vocabulary – Part 161 :Electromagnetic compatibility
- IEC 60050(191), International Electrotechnical Vocabulary – Part 191: Dependability and quality of service
- IEC 60050(371), International Electrotechnical Vocabulary – Part 371: Telecontrol
- IEC 60050(601), International Electrotechnical Vocabulary – Part 601: Generation, Transmission and Distribution of electricity – General
- IEC 60050(602), International Electrotechnical Vocabulary – Part 602: Generation, Transmission and Distribution of electricity – Generation
- IEC 60050(603), International Electrotechnical Vocabulary – Part 603: Generation, Transmission and Distribution of electricity – Power system planning and management
- IEC 60050(604), International Electrotechnical Vocabulary – Part 604: Generation, Transmission and Distribution of electricity – Operation
- IEC 60050(605), International Electrotechnical Vocabulary – Part 605: Generation, Transmission and Distribution of electricity – Substations
- IEC 60050(691), International Electrotechnical Vocabulary – Part 691: Tariffs for electricity
- IEC/PAS 62559, IntelliGrid Methodology for Developing Requirements for Energy Systems
- IEC TR 60870-1-3, Telecontrol equipment and systems – Part 1:General considerations – Section 3: Glossary
- IEC TS 61850-2, Communication networks and systems in substations – Part 2:Glossary
- IEC TS 61968-2, Application integration at electric utilities – System interfaces for distribution management – Part 2: Glossary
- IEC 62325, Framework for energy market communications
- IEC TR 62051, Electricity metering – Glossary of terms
- IEC TR 62051-1, Electricity metering – Data exchange for meter reading, tariff and load control – Glossary of terms – Part 1: Terms related to data exchange with metering equipment using DLMS/COSEM
- IEC 62056, Electricity metering – Data exchange for meter reading, tariff and load control
- IEC 61970-2, Energy management system application program interface (EMS-API) – Glossary
- CEN/CENELEC TR 16103, Energy management and energy efficiency – Terminology
- IEC TS 62351-2, Power systems management and associated information exchange – Data and communications security –Part 2: Glossary of terms
- ISO/IEC 2382-9, Information technology – Vocabulary – Part 9: Data communication
- ISO/IEC TR 15044, Information technology – Terminology for the Home Electronic System (HES)
- ISO 16484, Building automation and control systems
- ISO/IEC 29108 (CD), Information technology – Terminology for intelligent homes

5.1.1.1.2 Gaps

This section lists disparate definitions and a first list of terms to be defined or revised.

There is as yet no internationally unified definition of a smart grid, but work is ongoing on a future amendment 1 to IEC 60050(617), which will encompass several basic terms:

- smart grid, intelligent grid

  electric power system that utilizes information exchange and control technologies, distributed computing and associated sensors, for purposes such as :
  - to integrate the behaviour and actions of the network users and other stakeholders,
  - to efficiently deliver sustainable, economic and secure electricity supplies.
- smart metering
- demand side management
- demand response

Further possible terms to be added and defined in IEC 60050(617) are:

- intelligent/smart charging (of an electric vehicle)
- Distributed Energy Resources (DER)
- intermittent energy source
- prosumer
- aggregator
- Virtual Power Plant (VPP)
- microgrid
- self healing network
- etc.

Part 691 of IEC 60050 ,"Tariffs for electricity" needs to be revised.

Building domain definitions are missing.

5.1.1.1.3 Recommendations

Overview of existing glossaries to be augmented with telecom domain terms.

Term-1 : Harmonization of glossaries
Establish a process for harmonizing smart grid vocabulary over different domains.

5.1.1.2 Object Identification, Product Classification, Properties and Documentation

The following paragraph is added for information only, since it does not differ from the IEC SG3 roadmap [13]

<<start of IEC SG3 roadmap extract>>

Identification of objects, classification of objects and properties associated with the objects are essential working areas, influencing the full scope of business activities, from procurement, engineering, maintenance, service and phasing out of operation.

From a smart grid perspective the most important features are:

- the identification of the objects (from HV breaker to metering equipment in a household) within the grid considered; this requires the use of a common identification system for the objects including all grids participating in the smart grid;
- a classification of the objects used in the grid;
- If the relevant object is clearly identified, the technical data associated with the object need to be computer-interpretable.

These items are absolute prerequisites, for example, for any asset management applications, which must be able to include different vendor equipment. For this equipment the same technical properties must be made available by the supplier of the products.

Another issue is documentation. In order to support consistency and common understanding, general guidelines and electronic product descriptions must be present.

Existing standards

Identification of objects:

EN 81346-1, *Industrial systems, installations and equipment and industrial products – Structuring principles and reference designations – Part 1: Basic rules*

EN 62507-1, *Requirements for identification systems enabling unambiguous information interchange – Part 1: Principles and methods – Proposed as horizontal standard* (under preparation by TC 3)

EN 61666, *Industrial systems, installations and equipment and industrial products – Identification of terminals within a system*

EN 61175, *Industrial systems, installations and equipment and industrial products – Designation of signals*

Classification of objects:

EN 81346-2, *Industrial systems, installations and equipment and industrial products – Structuring principles and reference designations – Part 2: Classification of objects and codes for classes*

NOTE For the objects managed within the smart grid no further classification activities as in IEC 81346-2 are required.

Electronic product description activities:

EN 61360-1, *Standard data elements types with associated classification scheme for electric items – Part 1: Definitions–- Principles and methods*

EN 61360-2, *Standard data element types with associated classification scheme for electric components – Part 2: EXPRESS dictionary schema*

ISO 13584, *Industrial automation systems and integration – Parts library* (PLIB).
PLIB is developed and maintained by the ISO TC 184 (Technical Industrial automation systems and integration), SC 4 (Industrial data).

NOTE ISO 13583 [sic] and IEC 61360-2 are identical.

EN 61360-4, *Standard data element types with associated classification scheme for electric components – Part 4: IEC reference collection of standard data element types and component classes*

EN 61360-5, *Standard data element types with associated classification scheme for electric components – Part 5: Extensions to the EXPRESS dictionary schema*

IEC/PAS 62569-1, *Generic specification of information on products – Part 1: Principles and methods*

IEC/PAS 62569-2, *Generic specification of information on products – Part 2 – Structure of specifications* (under preparation in IEC TC 3)

Gaps

The work on the CIM (Common Information Model) and other specific work such as IEC 61850-7-420 (DER) already specifies technical properties of objects used in the data models. Currently these models are not aligned to the principles of IEC 61360.

<<end of IEC SG3 roadmap extract>>

5.1.1.2.1 Recommendations

PPC-1 Electronic Data models
Align glossaries as much as possible with Electronic Data Models (TC 57/SC 3D)

5.1.2 Reference architecture

5.1.2.1 Description

Without trying to make a new definition of the smart grid, it is reasonable to view it as an evolution of the current grid to take into account new requirements, to develop new applications and to integrate new state-of-the-art technologies, in particular Information and Communication Technologies (ICT). Integration of ICT in smart grids will provide extended applications management capabilities over an integrated secure, reliable and high-performance network.

This will result in a new architecture with multiple stakeholders, multiple applications and multiple networks that need to interoperate: This can only be achieved if those who will develop the smart grid (and in particular its standards) can rely on an agreed set of models allowing description and prescription. These models are referred to in this section as Reference Architecture.

In essence, the purpose of a Reference Architecture is to allow for a *separation* of a complex system (which a smart grid definitely is) into *entities* that can be isolated from each other according to some *principles*, thus making possible the description of the whole system in terms of the separate entities and their relationships. Such a separation principle requires that entities and relationships are handled in a coherent manner by the working groups in charge (e.g. by working jointly on common information model elements or common interface descriptions).

From this standpoint, there are several ways to consider the smart grid and make separations. At least the following ones are relevant in the process of building a Reference Architecture:

- *Conceptual Architecture*. A high-level presentation of the major stakeholders or the major (business) domains in the system and their interactions.
- *Functional Architecture*. An arrangement of functions and their sub-functions and interfaces (internal and external) that defines the execution sequencing, the conditions for control or data flow, and the performance requirements to satisfy the requirements baseline. (IEEE 1220)
- *Communication Architecture*. A specialization of the former focusing on connectivity.
- *Information Security Architecture*. A detailed description of all aspects of the system that relate to information security, along with a set of principles to guide the design. A security architecture describes how the system is put together to satisfy the security requirements.
- *Information Architecture*. An abstract but formal representation of entities including their properties, relationships and the operations that can be performed on them.
- *Service-Oriented Architecture.* An architecture that is technology-independent and organizes the discrete functions contained in internal or third-party applications & network elements into interoperable, standards-based services that can be combined and reused quickly to meet enterprise business needs.

All these architectures are necessary, in various degrees, to the complete description of a smart grid. A presentation of the available architectures for smart grids as well as an evaluation of their current status is made below, together with recommendations.

It has to be clear up front that such a set of architectures cannot be defined once and for all. It will have to evolve over time together with the progress in the smart grid business, use cases and functionality.

5.1.2.1.1 Conceptual Architecture

The major challenge to the smart grid is the need to interconnect a variety of (electricity and communication) networks that will have to support, over time, the business needs of a variety of stakeholders and ensure that the networks are interoperable, separately evolvable, as well as offering a very high level of security.

NIST has developed such a model, noting that “It is not only a tool for identifying actors and possible communications paths in the smart grid, but also a useful way for identifying potential intra- and inter-domain interactions and potential applications and capabilities enabled by these interactions”.(Ref. NIST Framework and Roadmap document).

The model below, whose development has started in the context of the European Smart Grid and of the EU 20/20/20 objectives, is descriptive and not prescriptive. In particular, it is not intended to impose any design or implementation choices.

It will also evolve together with the need to integrate new actors, for example Electric Vehicles.

It encompasses the following aspects illustrated in Figure 3 below:

- The set of major actors (and associated roles) in the European smart grid. The Smart Grids Task Force Expert Group 3 (EG3) has identified a list of Roles and Responsibilities from which the actors/roles as given below are extracted (see also Section 5.1.3):
    - *Markets*. They play a role in the extension of the business capabilities within smart grids by enabling a diverse set of intermediations. EG3 identifies several roles for these actors, like Power Exchange, Trader, etc.
    - *Service providers*. In this role, a variety of actors offer technology, products and services to other actors in the model. Examples of service providers identified by EG3 are Ancillary Services Providers, Metering Operators, ICT Service Providers, Electric Power Grid Equipment Vendors, etc.
    - *Home/building customers*. This refers to residential consumers as well as private or business buildings. Like all customers they can be involved in contract based demand response.

  - *Industrial customers*. In addition to the previous customers, this refers to large consumers of electricity in an industrial and manufacturing industry, in particular consumers of electricity providing transport systems.
  - *DER*. Distributed Energy Resource systems provide an alternative to or an extension or enhancement of the traditional electric power systems using small-scale power generation technologies.
  - *Transmission/distribution*. From a standardization standpoint, transmission and distribution require the same set of activities and do not need to be differentiated.
  - *(Bulk) generation*. Refers to generation of electricity, active contribution to voltage and reactive power control, required to provide the relevant data (information on outages, forecast, actual production) to the energy marketplace.
  - *Grid operations*. Refers to the undertakings of operating, building, maintaining and planning the electric power transmission and distribution networks.

  The list of roles used in this model does not encompass all the actors in smart grids identified by the EG3, although others, e.g. electricity installers/contractors will play a role.

- The underlying role of 'ICT Support', referring to the set of ICT capabilities (networks, software, applications, etc.) that will enable the business relationships between the actors;
- The relationship between actors seen from the standards angle, highlighting the need to develop the corresponding secure standards (and in particular interfaces);
- In addition, the diagram highlights two major domains in which actors are playing:
  - *Transaction domain*. In this domain, the vast majority of the interaction between actors takes place using ICT-based software, applications and solutions.
  - *Power domain*. In this domain, most of the interaction concerns control and optimization of the power flows.

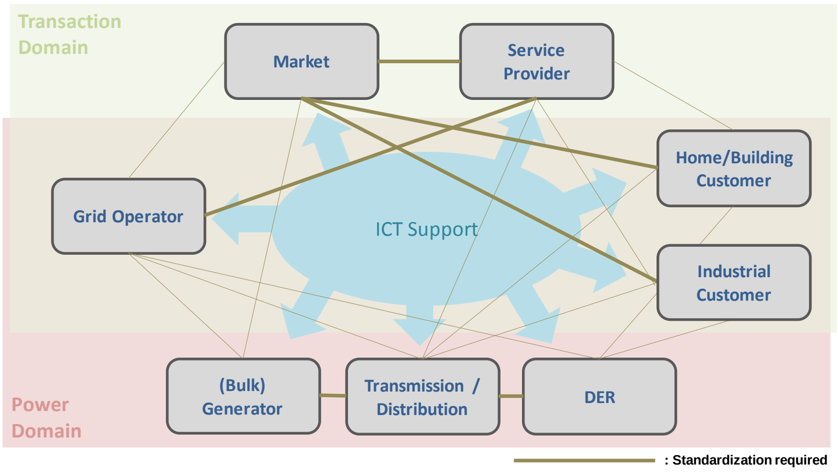

Figure 3 – A conceptual model for the European Smart Grid

Recommendation

Ref-1: **Conceptual Model**
Continue work on a Conceptual Model which describes the major stakeholders and their interactions taking into account the work of the Smart Grids Task Force

5.1.2.1.2 Functional Architecture

Based on the requirements (in particular security and performance) and – to a large extent – on the Conceptual Model, the role of this architecture is to arrange functions and interfaces in a way that makes it possible to understand the sequencing of execution and the conditions for control or data flow. Functions can in turn be divided into sub-functions and the interfaces refined to describe external and internal interfaces.

The Reference Architecture addresses the major applications (e.g. distributed energy resources, demand response or smart home automation) and the associated subsystems. A subsystem is a group of related functions that are a self-contained part of a larger system. These subsystems are linked by interfaces. They can be further refined by the description of their internal architecture and interfaces, thus leading to a more complete – and complex – overall architecture.

In this context, two important undertakings have to be drawn upon as input to the development of the Reference Architecture:

- IEC TC57 (and subsequently IEC SG3) has developed a Mapping Chart (and the associated tool[2]) that takes a similar approach, leading to the definition of sub-systems and interfaces. An extract from the Mapping Chart is provided in Figure 4 below, essentially for the purpose of showing a possible methodology;

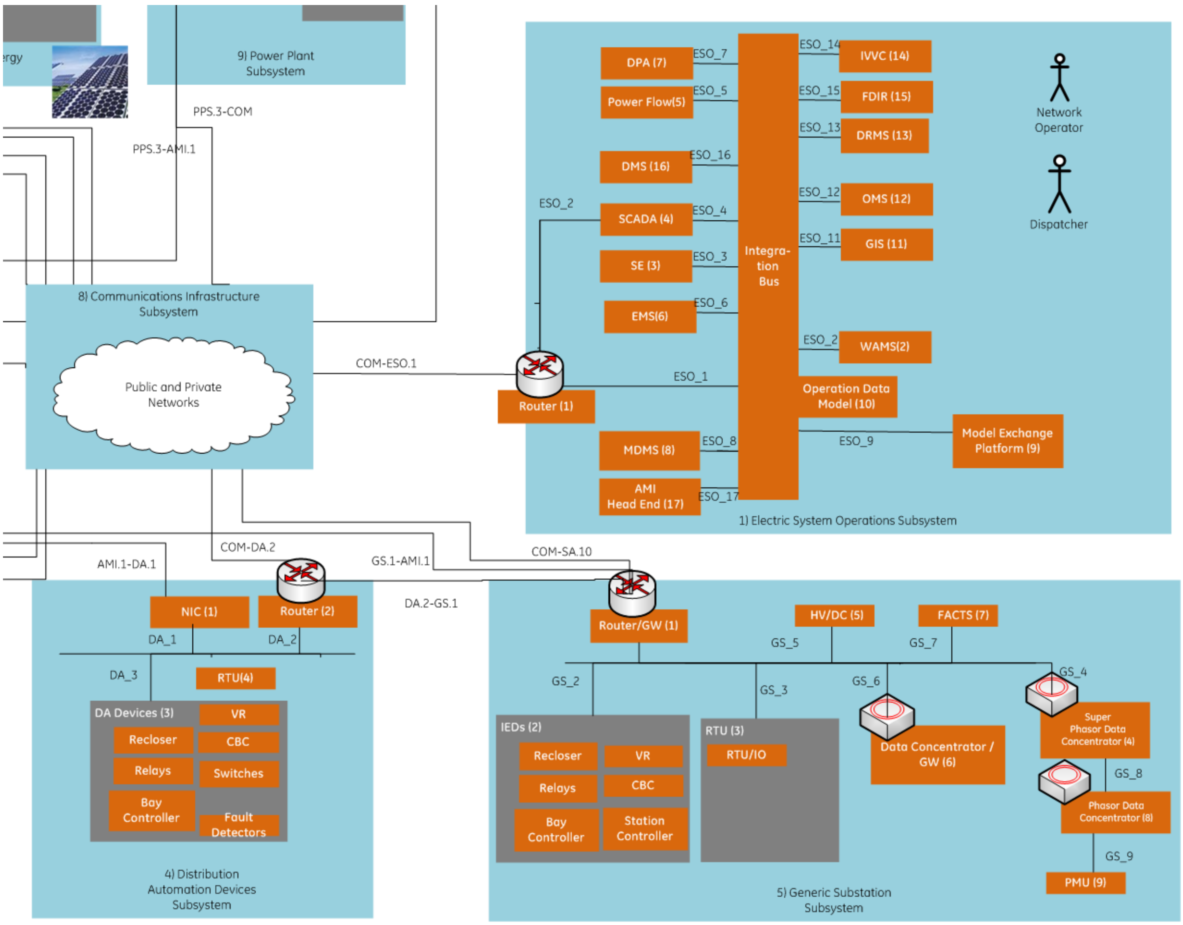

Figure 4 – An extract from the IEC SG3 functional architecture chart (Source IEC/TC 57)

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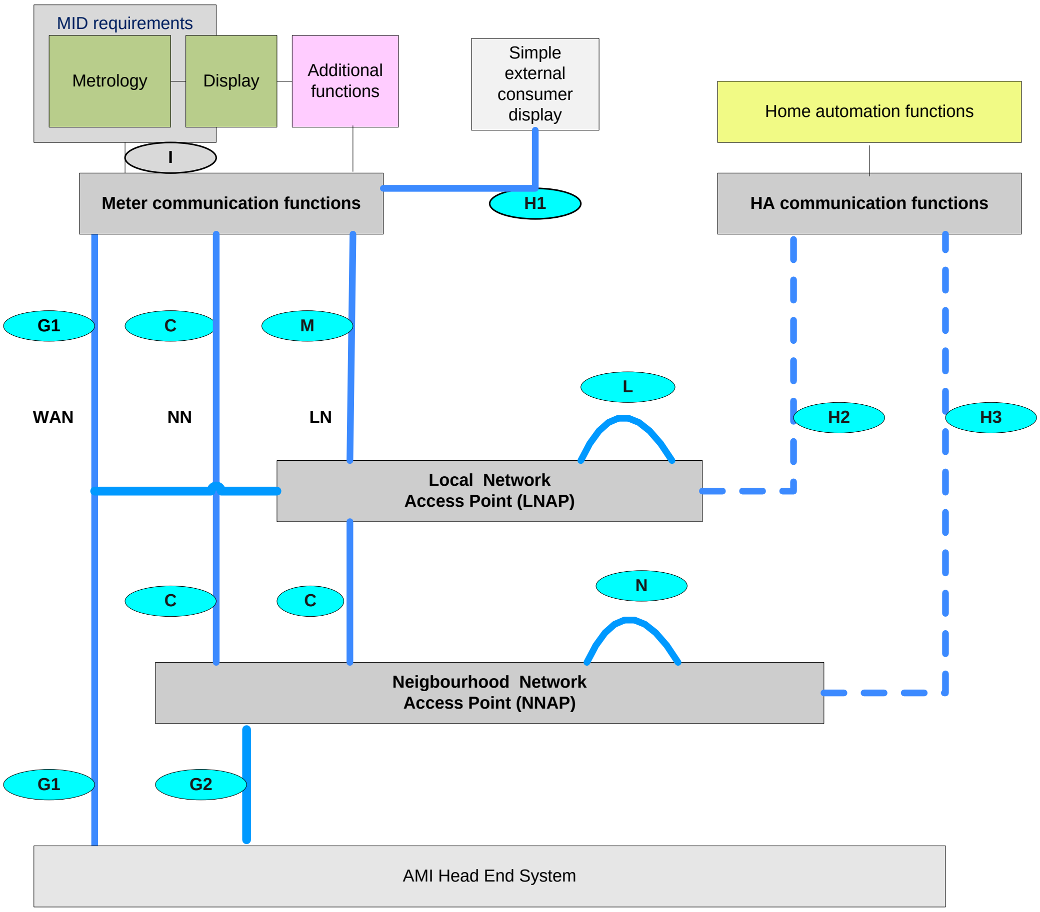
2 The IEC Mapping Tool should be available in Q1 2011 at http://www.iec.ch/smartgrid/

- The M/441 Smart Metering Coordination Group (SMCG) has developed a Functional Architecture of Smart Metering. Smart metering is an example of an application, i.e. a distributed service provided to end-users using functions provided by one or several subsystem(s).
  The functional architecture for smart metering is a subset of the smart grid functional architecture. This architecture addresses a specific application and only a part of the smart grids sub-systems and interfaces using a different methodology (e.g. different interface naming).
  A part of the SMCG architecture is shown in Figure 5. The SMCG diagram in Figure 5 below is for descriptive purposes, particularly as it is meant to evolve over time.



Source: [19]

Figure 5 – Reference architecture diagram for smart metering communications

It is important to remember that some specific applications or applications subsets – for example, smart metering – can be addressed by specific teams and may lead to additional (or alternative) interface specifications: this may be a challenge to the global coherence of the Reference Architecture.

Therefore, the availability of a Smart Grid Reference Architecture requires addressing several challenges:

- Selection of a representation methodology (e.g. IEC TC57, SMCG) to represent the architecture;
- Development of the Reference Architecture in a way that makes it altogether modular and coherent, in order to be worked on in parallel by several Work Groups;

- Harmonization of the subsets of the Reference Architecture, in particular the Smart Metering Reference Architecture, with coherent naming schemes, sub-systems and interfaces.

Recommendation

Ref-2: Functional Architecture
Develop, possibly based on the IEC/TC57 model, a Functional Architecture that takes into account all the generic, global aspects of smart grids as well as all the European specificities, in particular those outlined in the Conceptual Model. This model must accommodate the harmonization of potentially different architectures produced during the definition of several smart grid applications[3)].

5.1.2.1.3 Communication Architecture

The role – and impact – of ICT in smart grids is a key element in the way a smart grid architecture will be defined. In particular, a variety of communication technologies may potentially shape a very different role for the communication networks.

The functional architecture above considers communication through specific subsystems such as the communications infrastructure subsystem (encompassing public and private networks) or the internet.

However, it is important to note that:

- There are several communication networks involved: Home Area Networks (HAN), Enterprise LAN, Neighbourhood Area Networks (NAN), Powerline Communication Networks, Wireline Access Networks, Wireless Access Networks, Core Network. .The SMCG also uses Neighbourhood Networks (NN) and Local Network (LN).
- There are a variety of underlying communication technologies: powerline, cellular wireless, mesh wireless, etc.
- There are many possible connectivity scenarios between functional subsystems, generally involving only a subset of the communication networks.
- Various communication technologies can be used at the different layers of the communication stack. The choice will depend on the specific requirements and business models.

A more specific Communication Architecture can help understanding the impact of the communication standards on the organization of the subsystems. The definition of a generic model may help the coherent definition of specific sub-models.

Recommendation

Ref-3: Communication Architecture
Develop a Communication Architecture to take into account the large variety of network and connectivity scenarios involving communications interfaces.

5.1.2.1.4 Information Security Architecture

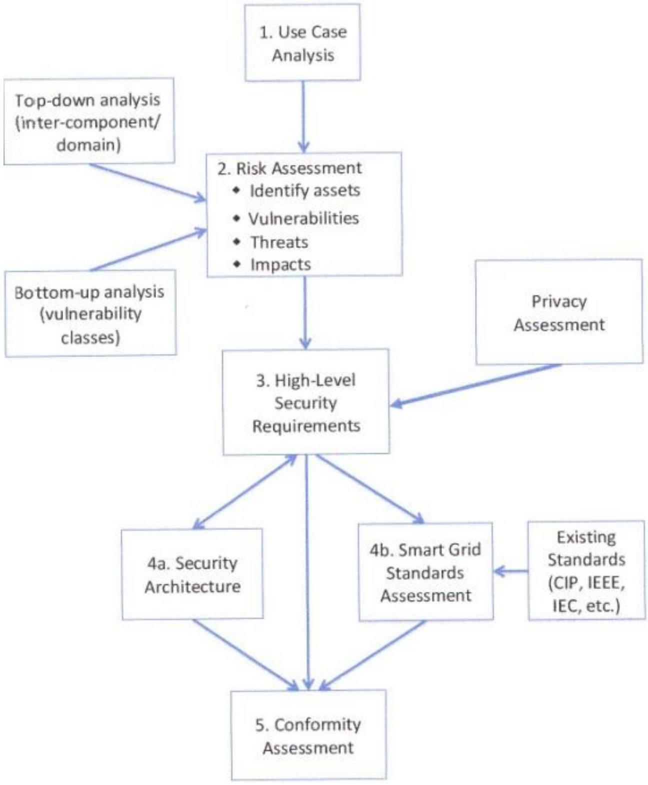
From the very beginning, NIST has adopted a comprehensive approach towards the Cyber Security Architecture. It has resulted in a set of documents (NIST IR 7628) [20] that addresses in particular:

- Strategy, Architecture and High-Level Requirements;

3) This model should be fed back to organizations developing global standards.

- Privacy.

The approach taken is summarized in Figure 6:



Source: [14]

Figure 6 – NIST approach to Security

Based on the NIST Computational Model, the Smart Grid Cyber Security Working Group (SGCSWG) has, in particular, developed a Security Architecture whose main characteristics are:

- Categories of Logical Interfaces. The set of interfaces derived from the Computational Model have been grouped in 22 categories (in fact, Security Classes), based on the specific security conditions across these interfaces;
- Security Requirements. Each requirement falls into one of three categories:
    - *Governance, risk and compliance* (GRC): applicable to all smart grid information systems within an organization and are typically implemented at the organization level and augmented, as required, for specific smart grid information systems.
    - *Common technical*: applicable to all smart grid information systems within an organization.
    - *Unique technical*: allocated to one or more of the logical interface categories defined in the logical reference model included in Section 2.

Based on this Security Architecture, NIST has also

- analyzed the existing Standards and considered the gaps;
- developed a Conformance Analysis program.

Realizing the crucial nature of security (cybersecurity as well as privacy), the Smart Grids Task Force Expert Group 2 (EG2) [18] has also developed a set of recommendations on data security that should be the basis for shaping the European view of the Security Architecture. In particular, a certain emphasis is put on privacy (of user data in particular) that may have a profound impact on the functional and communication architectures.

In particular, a holistic approach for achieving globally secure systems is proposed. The corresponding information security architecture not only proposes standards (existing or to be developed) but it also addresses the methodology and conformity assessment techniques required.

As an illustration, the information security architecture (section 5.1.5 below) introduces a model for the definition of implementation requirements. Other sources of work can be found at NIST, ISO/IEC JTC1/SC27 and IEC TC 57.

Recommendation

Ref-4: **Security Architecture**
Expand the work done in the European Commission Smart Grids Task Force, in particular the EG2 Report, to create a security architecture also taking into account a conformity assessment approach whenever applicable.

5.1.2.1.5 Information Architecture

The representation of the entities that interact within or between subsystems is mandatory for ensuring a required level of interoperability. The role of information models is to ensure this.

Several data models for the smart grid have been and are being defined, among which there are:

- General-purpose models such as the IEC 61970 Common Information Model (CIM) shown in the diagram below;
- Specific models addressing a particular application domain such as:
    - ANSI C12, IEC 61850 (partly), IEC 62056-XX (DLMS/COSEM), … for smart metering
    - SAE J1772, ISO/IEC 15118 for electrical vehicles
    - ZigBee Smart Energy Profile 2.0
    - …

A critical issue is the coherence of data models and the risk of excessively specific models leading to siloed applications. The diagram in Figure 8 shows the challenge of a coherent set of Information Model specifications. It is even more complicated when different organizations have defined similar models for the same range of applications in parallel. In addition, it should be noted that this diagram has a strong focus on system control and that other areas like metering still have to be included.

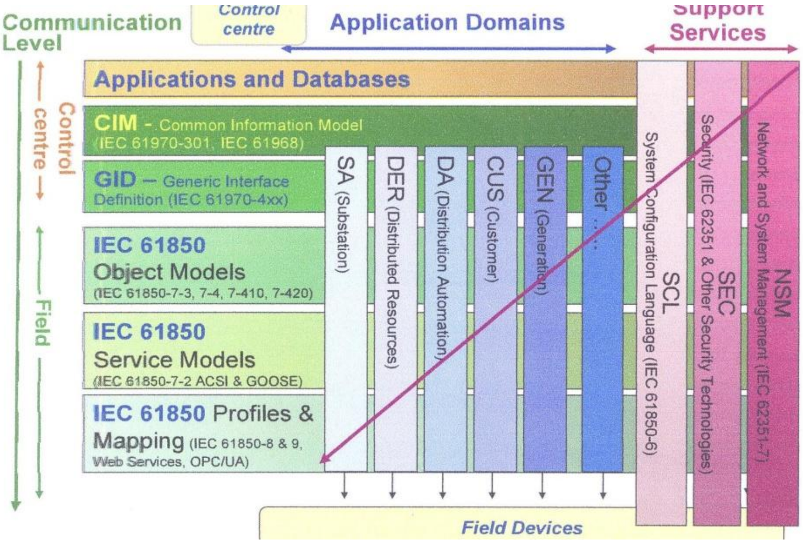


Figure 7 – IEC/TC57 Information architecture

Recommendation

Ref-5: **Consistent Information Model**
Ensure that the Information Architecture is both relying on precisely identified standards and also that the consistency of the Information Model is guaranteed by an appropriate mechanism for re-aligning separately developed (and possibly diverging) models.

5.1.2.1.6 Service-Oriented Architecture

A modern network control system provides a service-oriented architecture with standardized process. Interface and communication specifications such as the one in IEC 61968 and IEC 61970 provide a basis for modernizing the network control systems with state-of-the-art IT technologies. The services of a control system comprise:

- Data services with which, for example, the databases of the core applications can be accessed, e.g. readout of the operational equipment affected by a fault incident in the power supply system.
- Functional logic services, e.g. for starting a computing program for calculating the load flow in the power supply system.
- Business logic services that coordinate the business logic for specific energy management work processes of the participating systems, e.g. fault management in the network control system within the customer information system at the power supply company.

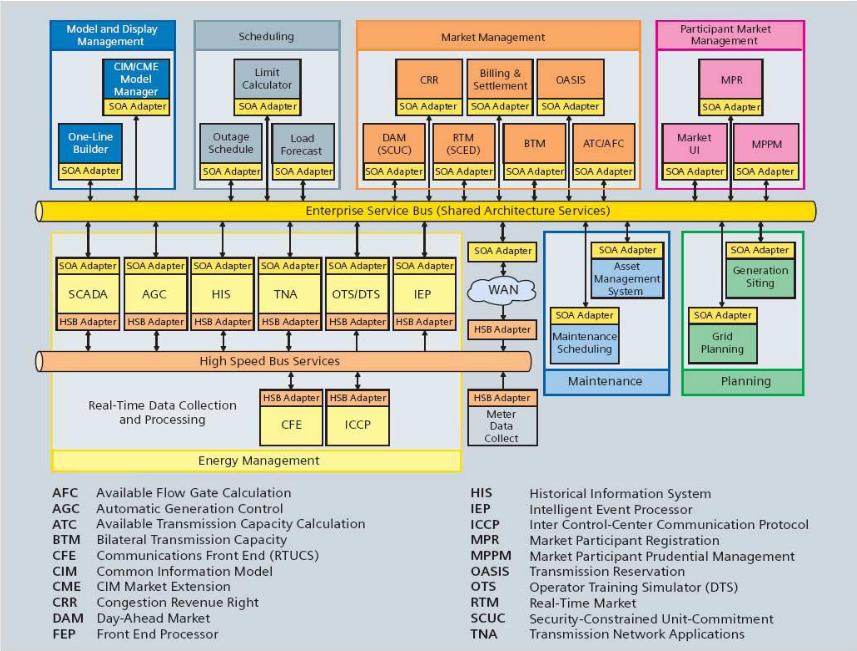


Figure 8 – IEC/TC 57 Service-oriented architecture

It should be noted that this architecture focuses on internal (utility) systems and not external systems and networks.

Such a model is descriptive, not prescriptive. The IEC/TC57 model is presented here (Figure 9) as an illustration of how a modern Service-Oriented Architecture can orient the structure of software in a smart grid system.

5.1.2.2 Recommendations

The Reference Architecture is a work in progress. It is expected to be delivered in a first iteration with the first version of this report. However, every element of the Reference Architecture may have to evolve and it is important that

- the evolution of each model of the Reference Architecture takes place in a comprehensive way, and
- the global coherence of these models be ensured by a coordinated approach.

Ref-1: **Conceptual Model**
Continue work on a Conceptual Model which describes the major stakeholders and their interactions taking into account the work of the Smart Grids Task Force

Ref-2: **Functional Architecture**
Develop, possibly based on the IEC.TC57 model, a Functional Architecture that takes into account all the generic, global aspects of smart grids as well as all the European specificities, in particular those outlined in the Conceptual Model. This model must accommodate the harmonization of potentially different architectures produced during the definition of several smart grid applications[4].

Ref-3: Communication Architecture
Develop a Communication Architecture to take into account the large variety of network and connectivity scenarios involving communications interfaces.

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4) This model should be fed back to organizations developing global standards.

Ref-4: **Security Architecture**
Expand the work done in the European Commission Smart Grids Task Force, in particular the EG2 Report, to create a security architecture also taking into account a conformity assessment approach whenever applicable.

Ref-5: **Consistent Information Model**
Ensure that the Information Architecture is both relying on precisely identified standards and also that the consistency of Information Model is guaranteed by an appropriate mechanism for re-aligning separately developed (and possibly diverging) models.

General Recommendation:

Ref-6: Create a Reference Architecture team within the Smart Grid Joint Working Group. The role of this team would be to set up the scope and work methods for the work associated with the Reference Architecture, and make sure that at least some of the major views (Conceptual Model, Functional, Communication and Security Architecture) are in line with the deadlines of the Standardization Mandate.

5.1.3 Addressing system aspects

5.1.3.1 Top-down approach and standardization process

As stated in the EG1 report, Smart Grid is a means to support a set of applications, and standards are there to enable applications to be deployed. This means that the standardization process is to consider a formal path between the application as "requested" by Smart Grid and the standards themselves, i.e. a "top-down" process, which is not there yet, or where such processes are already in place their scope often does not consider all the possible relevant standards impacted by this approach.

However, going down that path raises many questions:

- Which are the real functional requirements at application level?
- How mature are these requirements?
- How to manage requirement evolutions, backward compatibility and migration paths?
- Which entity within the CEN, or CENELEC, or ETSI body can hold and transform these high level requirements into consistent and comprehensive interface definition down to the technical bodies (could be CEN or CENELEC or ETSI) in charge of making the appropriate standard? In many cases, many entities will each hold a part of the answer.
- How to ensure that the finally delivered set of standards produced by the ESOs concerned are interoperable and match the high-level system requirement?

A top-down approach leads to two types of technical activities and associated processes:

- The formalization of functional requirements at application levels, in a way which is independent from the ESO in charge of defining a standard for the application concerned, and which will ensure consistency within the smart grid system, i.e. :
    - A single repository, where such definitions of functional requirements are hosted
    - A single glossary
    - A single list of actors and roles
    - A single method
- The management of the system enabler, i.e. the techniques and principles which are mostly application-independent but a prerequisite for an efficient deployment of the smart grid:
    - Data modelling -> common semantic definition and data presentation of information exchanged between all actors

  - System management and security -> processes and techniques provided to manage the smart grid system (start-up , connection of devices, disconnection, Role Based Access Control, maintenance of devices, system activity log, hot restart, …) and the expected level of security of the smart grid

This list of the main areas for a top-level systemic approach is not exhaustive, and can be further extended depending on market needs.

Gap

In general, ESOs do not have the adequate bodies and processes to address the above questions, and some changes are requested to handle them at the proper level:

- To cope with the transverse aspect of the market requests raised. This means building up sets of consistent use cases as the expression of European smart grid functional requirements. These sets of use cases have to be shared by all the relevant TCs in charge of producing standards contributing to these use cases.
- To manage the increasing maturity of the functional request, and then implement an incremental way of proceeding. This means having the right processes ready for managing new use cases, or use case modifications, with the ability to identify their impacts on the existing sets of standards.
- To ensure that all the TCs concerned at the relevant ESOs have the exact same understanding of the functionality to be implemented (i.e. are considering the set of use cases, described above, as the main functional requirement to be taken into account for specifying a standard), and are then producing consistent, interoperable, and efficient answers.

Recommendation

Sys-1: Adapt ESOs to handle top-down system approaches
Set up adequate bodies and sustainable processes to manage smart grid top-down system approaches and the relationship with the existing TCs in charge of developing standards. These processes should cover the overall life cycle of standards from upstream requirement definitions down to interoperability testing. Provide an incremental way of proceeding and maximum flexibility for addressing unknown future usages.
Establish the conditions for managing European smart grid use cases in a consistent way: shared rules, shared template, shared list of actors, …while keeping alignment with the IEC SG3 Smart Grid use cases initiative.
As soon as possible, feed the TC 8X with these top-down smart grid use cases, to be taken into account by ad hoc standardization bodies. Ask the European projects to feed the standardization process with European smart grid use cases and elaborate the set of European smart grid use cases.

The purpose of the next sections is to address these specific issues in more detail, and to identify associated standardization recommendations.

5.1.3.2 Handling transverse technical activities

5.1.3.2.1 Data modelling and description language

Description

Data modelling and description language are typical “system enablers” and should be considered with priority in a top-down approach. It may conflict with the traditional bottom-up approaches.

However, there are many benefits of proceeding top-down :

- Avoiding useless translators, which increase the complexity of the deployment of smart grids, increase its costs, reduce its reliability, reduce flexibility in the future and finally slow down the overall market acceptance.

- Avoiding misunderstanding between domains, and increasing the global reliability of the system.
- Increasing the flexibility of the system.
- Increasing the speed of spreading the smart grid, by reducing the amount of engineering time per additional point of connection.

Providing a harmonized data model and description language leads to ”transverse” thinking in order to be efficient, with the constraint to define not only an “ultimate” target but also the migration path from the existing situation.

Gaps

Harmonized electronic data model and description language are missing.

Recommendation

Sys-2: Initiate “Smart Grid Data model” activity
Initiate activity on a “Smart Grid Data model” within a group reporting to JWG.

5.1.3.2.2 System management and security

Description

As detailed in section 5.1.5 and also highlighted in the EG2 recommendations, which are a de facto reference for this work, system management and security will very soon become the cornerstone of any smart grid installation. However such an aspect of smart grids must be handled at system level first.

Gaps

Single and consistent smart grid system management rules and security policy and associated techniques definitions are missing.

Recommendation

Sys-3: Initiate “Smart Grid System Management and security” activity
Initiate “Smart Grid System Management and security” activity within a group reporting to the JWG.

NOTE Information security aspects are dealt with in 5.1.5.

5.1.3.2.3 Interoperability handling

Description

A smart grid consists of numerous components provided by different actors, working together to provide a smart power system. For such a system to operate and the desired services and functionalities to be provided in a sustainable way, interoperability of components and attached processes to demonstrate such interoperability become of major importance.

Interoperability means (derived from GWAC[5)] work):

- exchange of meaningful information between two or more components of the system,
- a shared understanding of the exchanged information,
- a consistent behaviour of components within the system, complying with system rules, and

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5) GWAC = GridWise Architecture Council

- a requisite quality of service: reliability, time performance, privacy, and security.

Many levels of interoperability can be considered, but in all cases smart grids require interoperability at the highest level, i.e. at information semantic level.

Defining standard interfaces is a path towards interoperability but is not a full guarantee.

Gaps

There is a gap in existing standards relevant to smart grids, which may not

- cover an accurate definition of the semantics, with no risk of ambiguity,
- define the behaviour of the object which implements the standard (state machine), consistently with the system behaviour,
- include a conformance statement, to check the implementation of the standard against the standard specification, or
- offer conformance verification procedures.

Currently, system interoperability is not achieved, since the following steps are not systematically covered:

- Select sets of use cases at system level, together with system architectures, with the target of testing interoperability of applications. Define expected results/performance approbation rules.
- Potentially define standard profiles (optional sub-set of standards, or standard package may become mandatory).
- Define a functional testing procedure.
- Execute test and evaluate the results.

Particularly in case of information technology related standards, it is also mandatory to consider the whole life cycle of standards, taking into account their increasing complexity, and also the need for fixing potential errors and the need for evolutions. This is not systematically addressed today.

Recommendations

Sys-4 Check comprehensiveness of standards towards interoperability
Check the coverage of selected standards against semantic, behaviour, conformance testing and fill gaps when needed.

Sys-5: Systematically address system interoperability
Pave the way for implementing step-wise approach to interoperability.

Sys-6: Create quality process for smart grid standards
Define open and transparent quality processes attached to identified smart grid standards covering their whole life cycle, including answers on how to collect issues, to treat/fix issues, to take into account new market needs and then to validate and test, including the compatibility with former releases.

5.1.3.3 Overview of system aspects recommendations

Sys-1: Adapt ESOs to handle top-down system approaches
Set up adequate bodies and sustainable processes to manage smart grid top-down system approaches, and the relationship with the existing TCs in charge of developing standards. These processes should cover the overall life cycle of standards from upstream requirement definitions down to interoperability testing. Provide an incremental way of proceeding and maximum flexibility for addressing unknown future usages.
Establish the conditions for managing European smart grid use cases in a consistent way: shared rules, shared template, shared list of actors, …while keeping alignment with the IEC SG3 Smart Grid use cases initiative.

As soon as possible, feed the TC 8X with these top-down smart grid use cases, to be taken into account by ad hoc standardization bodies. Ask the European projects to feed the standardization process with European smart grid use cases and elaborate the set of European smart grid use cases.

Sys-2: Initiate "Smart Grid Data model" activity
Initiate activity on a "Smart Grid Data model" within a group reporting to JWG.

Sys-3: Initiate "Smart Grid System Management and security" activity
Initiate "Smart Grid System Management and security" activity within a group reporting to the JWG.

NOTE Information security aspects are dealt with in 5.1.5.

Sys-4 Check comprehensiveness of standards towards interoperability
Check the coverage of selected standards against semantic, behaviour, conformance testing and fill gaps when needed.

Sys-5: Systematically address system interoperability
Pave the way for implementing step-wise approach to interoperability.

Sys-6: Create quality process for smart grid standards
Define open and transparent quality processes attached to identified smart grid standards covering their whole life cycle, including answers on how to collect issues, to treat/fix issues, to take into account new market needs and then to validate and test, including the compatibility with former releases.

5.1.4 Data communication interfaces

5.1.4.1 General description

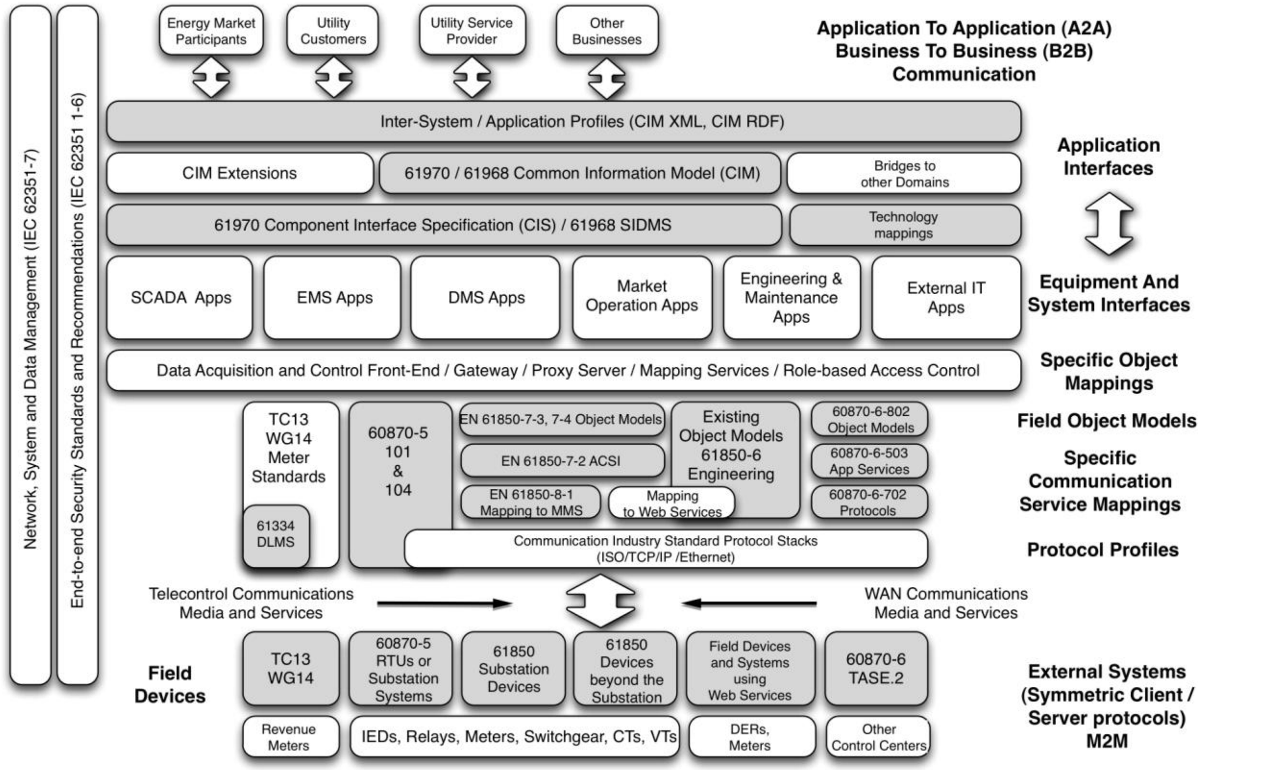
This section focuses on interoperability standards defined by IEC and CEN/CENELEC/ ETSI.

In order to be able to identify gaps in the available standards, technical (such as availability, performance, security) and functional requirements have to be defined. It is recommended that this work is performed at a later stage under the new Smart Grid Mandate. These requirements will depend on the domain and on the use cases within that domain.

The contents of this section are closely linked with section 5.1.2 which identifies the functional (sub)systems in a smart grid and the interfaces between these systems. Only a short overview of standards is given; a broader overview of available standards per interface is included in Annex 6.

The diagram in Figure 10 was designed by IEC TC 57 and gives an overview of their focused and maintained communication and data model standards as well as the applications using these standards.

Please note that this is not a complete overview of all relevant smart grid standards since standards such as those for non-electricity metering, home/building automation and EV are not included yet. Since TC13 maintains the IEC 62056 standard, based on DLMS/COSEM, this standard should also be included in the TC57 diagram below (see gaps).



Overview on IEC/TR 62357 Seamless Integration Architecture - CENELEC CLC/TC 57 adopted Standards in light grey

Figure 9 – IEC TC 57 Seamless Integration Reference Architecture – IEC TR 62357

5.1.4.2 Intra-domain standards

In terms of intra-domain standards, this chapter of the document refers to domains identified by other standardization bodies and smart grid roadmaps. An intra-domain standard is used for information exchange between domains as opposed to the domain-specific standards that are handled in the relevant sections of this document. The following sections provide examples of the standards available for data communication interfaces between the subsystems (domains) depicted in the functional architecture drawing in section 5.1.2.

5.1.4.2.1 WAN interface to Operations Subsystem

IEC 60870-5 and IEC 60870-6 standards are mainly being used for this interface. While the newer IEC 60870-6 standard has been developed for application in Wide Area Networks (Control Centre to Control Centre), the older IEC 60870-5 was originally designed for telecontrol (substations, RTUs). The 60870-5-104 version operates over TCP/IP networks. In favour of IEC 61850, IEC 60870-5 has not been selected by NIST and IEC to be one of the core standards of the future smart grid.

5.1.4.2.2 AMI interface to Home Automation

Display and home automation may be used to provide the following customer functionalities identified in the M/441 mandate:

- Provide accurate information on consumption in order to increase customer awareness.
- Provide additional functionalities enabling the customer to interact with the user's environment.

The first is possible through relatively simple displays linked to the metering system or other medium (e.g. via the internet). However, a decentralized HBES system can be used to provide a wide range of functionalities and a high level of customer interaction. This interface connects the MID part of the meter with an external consumer display.

Furthermore, this interface covers the connection of a Local or Neighbourhood Network Access Point with a home automation or display functionality. Based on the same interoperability model, options may be provided for communication over HBES standardized protocol on several media, or connection on IP LAN, or serial communication.

The Smart Meter Coordination Group (SM-CG) has not (yet) specified further interfaces from the AMI subsystem to other Smart Grid application areas, such as Electrical Vehicles charging and DER metering. Further work on Use Cases and standards regarding these interfaces should be aligned under the new Smart Grid Mandate, in cooperation with the SM-CG. See recommendation Com-3.

For further information refer to 5.2.4, Smart metering.

5.1.4.2.3 WAN interface to Distribution Automation

One of the most acknowledged standards in smart grid roadmaps around the globe is the Common Information Model CIM (IEC 61970 and IEC 61968) which has a part dedicated to Distribution Management Models and Automation. This part consists of several sub-standards related to the general CIM, which deal with the automation of distribution systems with special regard to the exchange of grid topology data, GIS based data, ERP, CIS and billing based data and asset management.

Since the IEC 61968 and IEC 61970 suites cover several domains of the smart grid landscape, such as Distribution, Transmission, Generation and Metering, they are included in the cross domain part of this report (5.1.4.3.). The CIM layer builds the upper part providing data model and system interfaces for secondary IT in terms of distribution management. Downstream, the IEC 61850 family focuses on the communication within the distribution equipment with the focus on substations.

In the field of distribution automation, the IEC 61850 communication standard also offers functionality for the distribution automation domain. Since also this standard covers multiple domains, it is included in 5.1.4.3. of this report.

5.1.4.2.4 WAN interface to Substation Automation

IEC 60870-5 and IEC 61850 have been the most prominent and growing standards in this technical area. IEC 61850 is mainly used for configuration and communication within substation and between substation equipment whereas IEC 60870-5 focuses on the communication between EMS and substation.

Since IEC 61850 covers various domains of the smart grid landscape, it is included in the section about cross domain standards (5.1.4.3).

5.1.4.2.5 WAN interface to Distributed Energy Resources

The most prominent standard in this scope is from the IEC. It is derived from the substation communications standards IEC 61850 and is being standardized as IEC 61850-7-420: Communication networks and systems for power utility automation. The standard currently exists as Edition 1 and has become the fastest growing standard for communications with distributed energy resources like CHPs, PV, fuel cells and BUGS (Back-Up Generating Systems).

5.1.4.2.6 WAN interface to AMI subsystem & Head-End

This interface is used to connect the meter, a Local Network Access Point, or a Neighbourhood Network Access Point to a Central Data Collection system. Typical interface platforms for these interfaces are PSTN networks, public G2 (GPRS) and G3 (UMTS) networks, DSL or broadband TV communication lines, power line communications (PLC), either in narrowband or broadband.

The Head-End systems are the central Data Collection Systems for the Advanced Metering Subsystem. Head-end systems are typically part of an AMR (automatic meter reading) or AMM (automatic meter management) solution. The interface towards the gateways and data concentrators (Network Access Points) is being standardized with Mandate M/441 whilst the interface from head-end systems towards central ERP and meter data management systems is covered by other IEC TCs, e.g. IEC TC 57 (61968-9). More information about standards covered by M/441 can be found in 5.2.4.

5.1.4.2.7 LAN/WAN interface to Generation Resources

External access to Generation Resources can be provided at different levels: generation devices, generation operation controllers and generation management applications. These access points can be supported over LAN (inside a plant or a central office) or WAN (between plant and office or between offices).

The prominent communication standards are described in Annex 6.

5.1.4.3 Cross domain standards

The Technical Committee 57 of IEC has developed a series of protocol suites that cover various sections of the smart grid landscape: IEC 61970, IEC 61968 and IEC 61850. These standards span the areas of Generation (including DER), Transmission, Distribution and Metering.

These standards are further explained alongside their architecture in Annex 6.

The ETSI M2M committee is working on Machine-to-Machine data communication standards (ETSI TS 102 690). These standards permit service creation and optimized application development and deployment. M2M Service Capabilities permit local/remote and flexible handling of application information. The M2M architecture intends to offer a framework for smart grid applications.

5.1.4.4 Gaps

Power/Distribution Line communication

Under the ruling of EN 50065-1 many technologies are available and under development. The IEEE P1901.2 Working Group formed in May 2010 gathered the main industry stakeholders and consortia (e.g. PRIME, G3 and others) to define a narrowband standard. On PLC communications only the band from 3 kHz to 148,5 kHz is currently specified in the standards.

During some narrowband PLC deployments for AMI purposes, cases of interference between domestic appliances and narrowband PLC equipment have been observed, the main reason for those interferences is that applicable EMC guidelines start at 150KHz. A report on these phenomena is being prepared in CENELEC SC205a.

Broadband PLC (BPL) is defined in IEEE 1901. This standard introduces “In home” and “Access” devices and a coexistence mechanism between those devices: ISP. The ISP mechanism can also be used for any other devices operating in the frequency range from 1,6 to 30 MHz, and also provides coexistence with “Low Rate Wide Band Services”. As coexistence is guaranteed between devices using the ISP mechanism, there is no need for frequency regulation for those devices.

Data transport technologies

The ETSI TC M2M Service Capabilities can broadly be grouped into the following categories:

- Data mediation capabilities: Allows basic data collection, storage and subscription/notification on events pertaining to data availability. Additionally some more complex data functions such as data aggregation and analytics can be provided.

- Communications: Hides network transport options as well as communication protocols to applications. Communication functions include name to network address translation, network bearer selection (SMS, data bearers), protocol translation, etc.

- Management functions: Provides to applications: configuration management, fault and performance management (such as battery life) as well as firmware and application software upgrade. Management functions are an important aspect for M2M especially considering the relatively long lifetime of M2M Devices (e.g. more than 20 years for smart meters).

- Context: Provides access to other functions such as location, provisioning (device activation, security key bootstrapping, etc) as well as billing functions.

The following figure provides a listing of all the ETSI M2M Service Capabilities defined in ETSI TS 102 690. These are classified into optional and mandatory capabilities. While this figure lists the M2M Service Capabilities that are exposed to business application on the network side, these have peer capabilities running on the M2M Devices (not listed in the Figure).

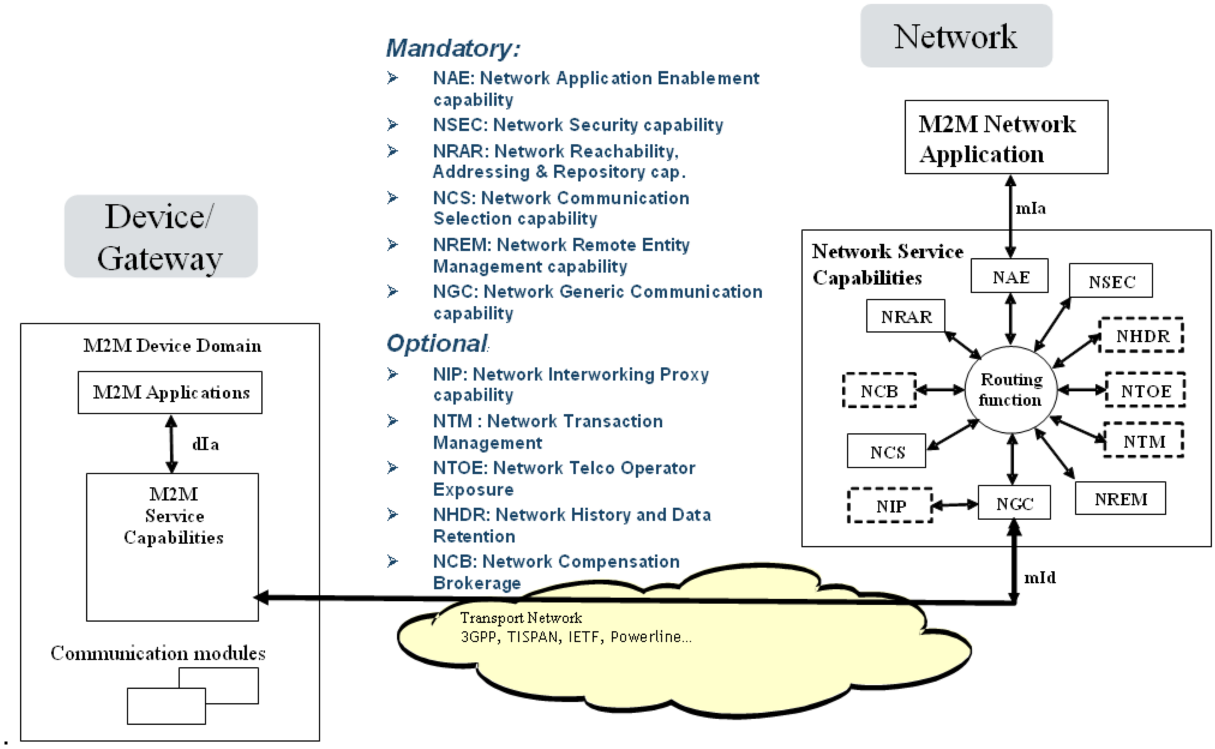


Figure 10 – M2M Service Capabilities (Source: ETSI M2M TC)

TC57 standards overview

This overview misses some specific metering-related standards such as IEC 62056.

5.1.4.5 Recommendations

Com-1: Further develop power/distribution line communication
Follow the recommendations of the SMCG Technical Report, which already contains a work plan for CEN TC13 to integrate different protocols with the existing standards.

Most EMC guidelines and standards start at frequencies above 150kHz, which could lead to interference between domestic appliances and PLC devices operating below this range. For frequencies lower than

150kHz the EMC guidelines/regulations should be developed. For PLC communication the use of the frequency range up to 540 kHz should be specified, subject to protecting existing users of these frequencies for radio communication and other purposes.

For broadband PLC we recommend that where applicable and no alternative standard inside ETSI/CEN/CENELEC can be found the IEEE P1901 should be taken into account.

Work with the ETSI PLT TC committee to evaluate the use of ITU-T PLC Narrow band OFDM G.9955.

Com-2: Harmonize activities on data transport technologies
Developments made by ETSI and the data communication related IEC and CEN/CENELEC activities within IEC and CEN/CENELEC should be mutually coordinated. The service capabilities defined by ETSI should be integrated with the smart grid related application protocols mentioned in 5.1.4.1.

Com-3: Align the work on intra-domain standards between the AMI and other Smart Grid subsystems
Further work on Use Cases and standards regarding the interfaces between the AMI and other Smart Grid applications (such as EV charging and DER metering) should be aligned under the new Smart Grid Mandate, in cooperation with the SM-CG.

5.1.5 Smart Grid Information Security (SGIS)

5.1.5.1 Description

This section describes the information security for the smart grid information system for all actors (system components and organizations) participating in the smart grid operation or its governance. This overall system view for information security is defined as the Smart Grid Information Security, abbreviated SGIS. This abbreviation is used in this document when addressing the Smart Grid Information Security. The elements contained in this section are results of a comprehensive analysis and bottom up summary, derived from inputs from many sources, namely the results of the European Commission Smart Grids Task Force Expert Group 2 (EG2)[6)] for data protection, the German standardization roadmap "E-Energy / Smart Grid" research demonstration projects for E-Energy (some of them have very detailed studies of smart grid-specific use case scenarios and their information security threats), as well as the research demonstration projects for integration of electric vehicles into the smart electricity grid. Furthermore, various national and international standards and reports related to information security in smart grids were reviewed and impacted the conclusions derived (e.g. IEC 62351, ISO/IEC 27000 family of standards, NIST IR 7628 and related documents i.e. from US-NERC, DE-BDEW White Paper on procurement requirements for distribution net equipment, just to name a few).

5.1.5.2 Gaps and required focus areas

For more details and examples about the conclusions and recommendations described in this section, please refer to the separate document ***"Smart Grid Information Security (SGIS)** - the way forward, ensuring client values and client acceptance",* published by the JWG on standards for smart grids. This document also contains detailed recommendations for implementing SGIS in a sustainable way.

Threats and vulnerabilities (common with ICT sector – but also specific to the energy sector) exist. Risks arise from those which may have a negative impact on the "smart grid information security" and subsequently on data protection/privacy such that operations potentially become unlawful.

1. There is lack of sector-specific information security essential requirements for the smart grid, which needs to be tackled.
   Those essential requirements for SGIS must consider the following:
   a. Essential requirements common with the ICT sector

6) Expert Group 2 "Regulatory recommendations for data safety, data handling and data protection"

Essential requirements: Confidentiality and privacy, integrity, authenticity of data and access, legitimacy, validity, legal certainty & tamper proofness in data processing, transition, storage and disposal, guarantees for non-repudiation /fraud detection, audit proofness, availability of services but also availability of data, data security & protection (i.e. usage boundaries for certain data protection classes).

Those are derived from and support relevant legal requirements i.e. DPP, MID (Measurement Instrument Directive) as well as from regulation and normative requirements for proper business operation.

b. Essential requirements specific to the energy sector and the future smart grid

   i. for the energy supply chain through all "sphere of action" domains until its final distribution in/from connecting objects, connecting object sub-cells and associated consuming or feeding devices.

   Essential requirements: Time synchronicity (required only in specific processes), robustness and resilience in situations of crisis, support of emergency situations, resiliency in/after blackout situations to ensure "energy supply", resiliency to interdependence, graceful degradation, availability of data required for the availability of energy supply, interoperation with legacy equipment (not smart grid enabled), especially for information security.

   The term "sphere of action" domain is used to highlight distinct boundaries and limitations in respect to freedom of action from an Information system ownership and information security point of view. It exists, due to legal limitations or defined responsibilities and accountabilities in respect to the smart grid information system and SGIS, within the distribution and the transmission networks, but also within connecting objects, e.g. in residential or commercial buildings. As example: the building owner or its building administration does not have the rights to define actions that affect the prosumers' rights as they are the sole owners of the specific connecting object sub-cell (e.g. household) and the information system inside their sub-cell, which is part of the smart grid information system and takes part in SGIS.

   The following Figure 11 illustrates the boundaries of the "sphere of action" domains for the various utilities.

   Figure 12 is provided as reference to the domains specified in US / IEC – without specifically highlighting the boundaries in respect to SGIS.

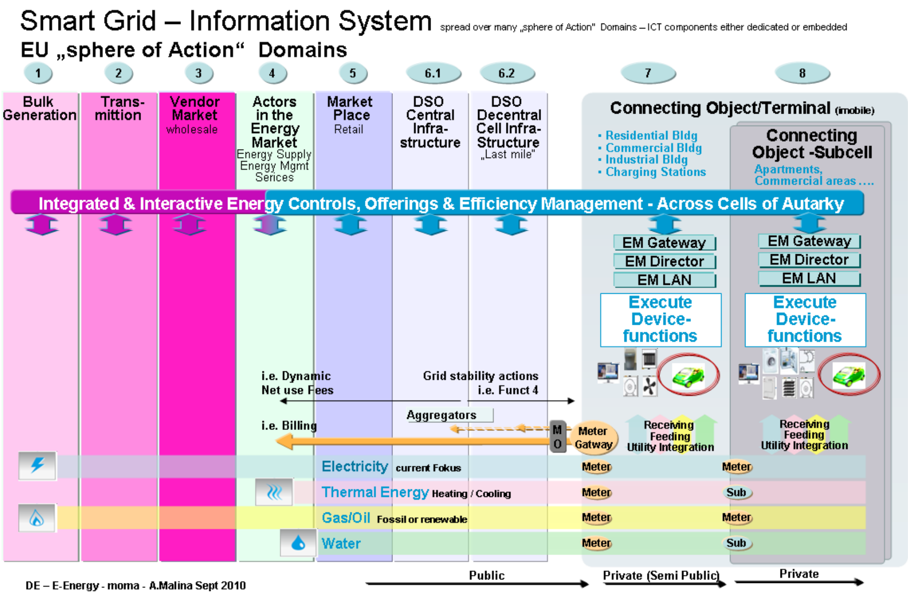


Figure 11 – The 8 "sphere of action" domains impacting SGIS

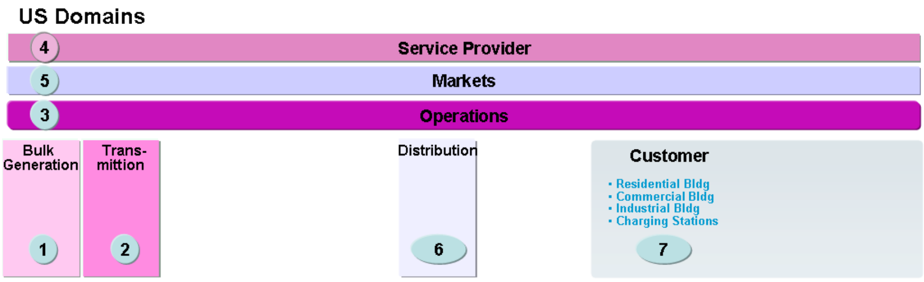


Figure 12 – Domains defined in US (without SGIS Focus)

ii. for energy management services from energy service providers (ESP) through the "sphere of action domains" market places, distribution (central, distributed) into/from connecting objects and connecting object sub-cells to influence prosumer behaviour or associated consuming or feeding sensors/actors.

Essential requirements: Time synchronicity (required only in specific processes), robustness and resilience in situations of crisis, support of emergency situations, automated restart of energy management services after/in blackout situations, resiliency to interdependence, graceful degradation and availability of all data required for the availability and operation of energy management services.

The total of SGIS essential requirements represents the sum of all the above mentioned elements (a, b.i and b.ii). This is different from the current situation, where the "only" Energy Information System is centralized (predominantly in the transmission and bulk generation domains), and therefore currently supports more or less the energy supply only.

In the course of transformation from the current situation to the smart grid, the information system will become highly distributed and will often be embedded in system components of the smart grid. A focus will be placed on the introduction of new energy management services including for example dynamic offerings to consuming or feeding devices or cells in the energy distribution net and within connecting objects – including appropriate billing.

The smart grid information system needs to provide process support to manage the steep increase in volatile energy sources – in all "spheres of action" domains of the smart grid – and at the same time it will experience a strong growth and dynamism of new energy management services due to innovation dynamics in future. Furthermore the components of information system components will be more often attached to the network and be embedded in decentralized system components that are critical for energy supply in the electricity distribution network, interacting with current information systems. The smart grid information system consists of dedicated ICT products (some are common ICT products) or ICT is embedded in products supporting smart grid operations for energy supply and energy management services.

The SGIS risk assessment needs to differentiate between infrastructures critical to energy supply and for those infrastructures supporting smart grid energy management services. Even though it is expected that those infrastructures will be separated, there will be an impact from one to the other. This may not be through an interface between the separated areas – but due to indirect and "soft" influences between them. One foreseeable indirect impact may be triggered by actions from many prosumers changing their energy consumption or feeding at the same time with a regional or country-wide scope. This may take place in the form of an unintended response by prosumers to offers provided through the information system for energy services, leading to an unexpectedly broad participation in changing behaviour (swarm effect). The "unexpected" change may indirectly cause threats to the energy supply, because it may lead to overload situations. This threat is caused by the information system for energy management services – the information system infrastructure for ensuring the energy supply will need to react to the unexpected changes in consumption of feed-in. This is not channelled through a communication line, yet this swarm impact needs to be addressed to the SGIS for both information systems and will probably need to be addressed to the governance system recommended later in this section. Protection needs to be implemented to recognize and counteract these changes in behaviour before energy supply is endangered. The following figure visualizes the above; it therefore does not draw a hard line between the information system security related to the energy supply and for the information system security supporting the energy management services – even though the information systems are considered to be separated.

	Current Energy Supply Information & Communication Systems	Smart Grid Information & Communication Systems
Critical to	to availability of energy supply	to energy management services
Dedicated	indispensable	Temporary expendable
Embedded	indispensable	Temporary expendable

Figure 13 – ICT systems of various types and impact areas

2. There are gaps and a lack of a “set of agreed and harmonized system level requirements” (technical and organizational) for SGIS, that are applicable to all actors in all “sphere of action” domains.

   For those system level SGIS requirements, the following has to be considered:

   a. The data models handled in smart grids need protection at appropriate information security levels. The protection needs to be based on all relevant legal aspects and all the essential requirements described above - compliance with these needs to be achieved at all times. No comprehensive definitions exist today for data that need protection. Great attention is paid to data that may compromise privacy and needs to be classified as personal data. The “data protection class” for personal data needs a high level of protection throughout all “sphere of action” domains. However, there are other relevant legal requirements, which demand protection of data handled in the smart grid information system. SGIS needs to address those requirements and other non-regulated data protection classes in a seamless way for all data that need protection. It is agreed that different types of data classes need protection at different information security levels. The classification for each data model used in the smart grid information system is called Smart Grid Data Protection Classes. Those classes will be abbreviated as SG-DPC, and this abbreviation will be used in this document for any of the recommended smart grid data protection classes (currently 12 classes are recommended).

   b. As described above there are data within the smart grid information system, where SGIS needs to provide protection at varying protection levels. This report recommends 5 different levels of protection for SGIS ranging from “highest to low”. The “Smart Grid Information Security – Security Level” is abbreviated as SGIS-SL – this abbreviation will be used in the document when addressing the different information security protection requirements. For each SG-DPC the appropriate SGIS-SL needs to be defined to ensure the appropriate protection measures. For more details and examples about the conclusions and recommendations described in this section, please refer to the separate document “Smart Grid Information Security (SGIS) - the way forward, ensuring client values and client acceptance”, published by the JWG on Smart Grid. This document also contains detailed recommendations for implementing SGIS in a sustainable way.

   c. As described in another section of this report, it is intended to provide complete use case descriptions, covering ALL data exchanges. Therefore the use cases will describe normal and intended usage for each single data model. Any data usage outside the defined scope of the use cases may cause SGIS to be vulnerable and may be a considered as attack on the SGIS and DPP.

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3. SGIS needs to consider all of the requirements and boundary conditions stated above to provide a horizontal solution approach applicable to all use cases in the scope. As of today, existing standards for system components of infrastructures for energy supply and for new system components in the energy management infrastructures (products/solution/services) or the related organizations may not sufficiently support those requirements.

   This is a horizontal cross cutting issue. As many of the smart grid functionalities and services are not yet defined and implemented, system components taking part in the Smart Grid Information System will evolve and SGIS requirements need to be included in product standards in a way which ensures that the product fulfils the essential requirements for SGIS in a compliant way. The analysis of the documents referenced in paragraph 5.1.5.1 indicate certain weak spots that need improvements in order to ensure SGIS at state of the art.

4. The SGIS is fundamental to legal compliance, interoperability and interchangeability. SGIS needs to be kept at acknowledged “state of the art”, in order to protect the smart grid information system. This will ensure protective measures are in place that support compliance for ALL legal requirements i.e. Data Protection and Privacy (the abbreviation DPP – will be used for data protection/data security and privacy in this document), Measuring Instruments Directive (MID), proper e-business operations and more in all spheres of action domains (i.e. Electricity Distribution Nets, Connecting Objects and its substructures) at all times.

5. Top down “system level” technical and organizational requirements for the SGIS need to be defined by regulatory authorities or a strategic guidance/reference group.

6. Subsequently, the top down “system level” requirements provided to ESOs need to be included in the standards for all actors participating in the smart grid – i.e. standards for products / solutions / services and the standards for organizations in their specific market roles.

7. There will be an evolution of functions, use cases and data models over time. Therefore an operational model is required for SGIS that copes with the essential requirements even if new data packages or new data fields are defined or its usage changes. At the same time findings will be available that indicate insufficient SGIS system level requirements or new requirements that need to be introduced. Therefore the SGIS model needs to consider both evolutions and in spite of this ensure the essential requirements are protected at all times as the evolution takes place in:

   a. the smart grid operational and business models, its functions and use cases, market roles and legal requirements.

      Various actors (manufacturers, installers and installers and users of system components) as well as the identified market roles should be participating in the definition of the above.

   b. The changes to the SGIS essential requirements or “system level” (SG-DPC, SGIS-SL for technical and organizational) requirements.

      The above mentioned actors and experts / authorities on information security need to provide guidance for the definition of SGIS.

   The challenge is to keep all actors participating in the smart grid (technical or organizational) updated at “state of the art” and synchronized in accordance with the evolution and innovation dynamics of both areas for new products put onto the market and for actors operating previously installed system components.

8. As SGIS needs to stay at state of the art at all times and in all respects, SGIS needs to include a governance model. This needs to be able to identify and handle fraud / incidents with immediate and medium / long term actions, i.e. to enable fast “credential management” at the point of attack. Furthermore the governance model needs to identify new/updated/insufficient essential or SGIS system level requirements. It also needs to define the obligations for actors participating in the Smart Grid information system – in support of this governance model.

9. Lack of tools to model SGIS / DPP operations and its interaction between the smart grid operations and business models, functions and use cases.

The above items describe the gaps and focal areas to be addressed in order to develop a standards framework for sustainable, “state of the art” SGIS and DPP.

ESOs should provide standards for all actors in all domains of the smart grid – standards defining requirements for system components (i.e. products with hardware and software, solutions, services) and standards for organizations in their role and responsibility as defined by EU Taskforces 1 and 3. Those standards need to include the requirements that will be outlined by the SGIS-SL depending on the functionality/use cases supported and the data models / SG-DPC handled within those use cases.

This is required to ensure SGIS and DPP operations are sustainable, compliant or compatible with all legal requirements and inherently secure by design and default, as well as to ensure interchangeability of the actors and interoperability of smart grid processes and interactions between those actors.

To achieve this in a harmonized way, ESOs require input on "top down" system level SGIS requirements describing protective measures (SGIS-SL, SG-DPC) to be included in both areas – technical and organizational.

5.1.5.3 Recommendations

"State of the art" SGIS has a direct impact on the availability of the client values - energy supply and the availability of energy management services. As discussed earlier there are different protection level requirements (SGIS-SL) applying to certain system components of the smart grid information system due to its functionalities and usage of certain data models (classified by SG-DPC).

SGIS has impact on client values and on client acceptance. The SGIS must have the ability to ensure compliance with all relevant legal requirements, i.e. those derived from DPP and from others. Furthermore it has a direct impact on interoperability and interchangeability. Therefore SGIS is top priority and critical in achieving and sustaining customer acceptance and for the availability of the client values, namely energy supply and energy management services. The following figure illustrates those interdependencies. The colour code indicates the differences between indispensable and expendable system components.

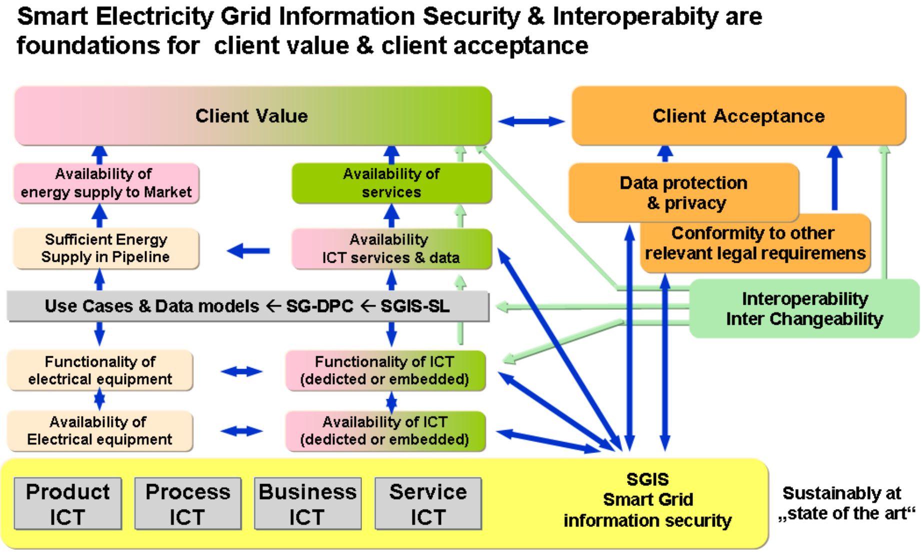

Figure 14 – SGIS chains of impact on client value and client acceptance

The smart grid operational and business models are not clearly defined and will keep evolving for a long time with ever changing impacts on the smart grid information systems supporting the availability of sufficient energy supply and the availability of today's and future energy services. As a result, the information system and the requirements for information security and data protection / privacy will also keep evolving.

It is undisputed that client acceptance is strongly and directly impacted by the client perception of the system-immanent concepts for data protection, data security and privacy on the one hand and by high interoperability and interchangeability of system components and participating organizations on the other hand. Both are assured by keeping SGIS "state of the art" - this includes the SGIS concept - and governance models to keep this status at all times.

The EU TF EG2 provided recommendations that are utilized in this report and section. The alignment between the TF EG2 and the JWG was discussed in the October 2010 meeting. At that meeting it was decided to feed the content of the JWG reports into the EG2 as there are parallel processes in place that need to be supported and synchronized as well as possible.

Recommendations from the EG2 focused on data handling, data security and consumer protection, laying out the foundation for a structured EU approach, and their fundamental conclusion at that time was: Smart Grid / Smart Meter must comply with privacy and data protection legislation.

This report supports the TF EG2 recommendation R1 to establish an EU Workgroup on End2End Data Protection & privacy in Smart Grid.

SGIS is fundamental to this – the recommendations of the JWG report focus greatly on information security aspects with a system approach. Smart Grid Information Security needs to ensure all essential requirements derived from ALL regulations that are relevant to the smart grid information system and its processes. The following regulations are examples of relevant legislation:

The harmonized, “new approach” Measuring Instrument Directive (MID) defines the requirements for putting measuring products onto the market. It is not “designed” in a way that considers smart grid meter requirements derived from, for instance, SGIS-SL 3 – that includes e.g. the requirement to ensure End2End integrity. Furthermore it does not cover regulations that are relevant to smart meters – e.g. regulation of proper e-business operations (including specific signature requirements) and consumer protection and more. This section provides the smart grid system view on SGIS.

SGIS has the scope to provide support for compliance with all regulations relevant to smart grids and provides indications of gaps, overlaps and potential conflicting goals of regulation. These are addressed to EG2 as well.

Furthermore this report supports TF EG2 recommendation R2 that ESOs should be mandated to incorporate the technical and organizational requirements of the system into standards for products and organizations. In addition it supports TF EG2 recommendation R3 that ESOs should be mandated to provide standards covering the security aspects of smart grid logical system components and its interfaces based on their specific “operation model” (use case & data models) as well as on data protection classes and their respective required information system security levels, as well as the EG2 recommendation R4, that ESOs should be mandated to establish a process for a sustainable “state of the art” definition of smart grid information system security levels. It furthermore supports EG2 recommendation R5, which states that ESOs should be mandated to identify and maintain smart grid / smart meter data protection class definitions and their respective required information system security levels.

The above items are covered in the Smart Grid Mandate. EG2 is currently performing an analysis of relevant regulatory requirements for SGIS based on the relevant regulatory framework and challenges in its application to SGIS.

Interoperability/interchangeability is not addressed in this section – in any case a harmonization of “system level” requirements for SGIS / DPP is a prerequisite for interoperability and interchangeability goals, for putting products / solutions / services onto the market and updating the assets in the market / field in a synchronized way.

It is obvious that the immature smart grid operational model and the immature and non-harmonized SGIS essential requirements and system level requirements lead to product standards that allow a wide variety of technological implementation in products/solutions/services or organizations that are participating or plan to participate as actors in the smart grid either as a market role or provider of system components. This may also lead to interoperability and interchangeability problems between different vendors’ products.

Variations in products, solutions and services provided and variations in processes / interactions of the participating organizations may result in a risk of failure to fulfil coherently all legal requirements for the information system and its information security, data-protection/privacy or interoperability and interchangeability in a sustainable manner.

Hence it must be **top priority** to provide concepts on how overall information security “system requirements” will be developed and stay at “state of the art” level while requirements for data protection increase, and the penetration of smart grid and the associated threat levels increase over time.

The definition of an agreed set of harmonized system level requirements (technical and organizational) for SGIS and DPP is critical to its sustainability, interoperability and interchangeability of system components and energy service providers in the various “sphere of action” domains. “Sphere of action” domains should cover e.g. bulk generation, transmission and distribution networks and their central, regional and local substructures or connecting objects (residential, commercial, industrial buildings, charging stations and the wide variety of their internal substructures through energy management LANs to the final nodes – the smart grid ready sensors, actors, equipment and appliances).

In some member states some of the anticipated SGIS/DPP system level requirements are defined by governmental bodies. It is a fact that a very high diversity of technology implementations exists or is planned for in many countries in Europe and globally.

Therefore, it is necessary to have “top down guidance” on the EU level to achieve the definition of a set of agreed, harmonized system level requirements (technical and organizational) for SGIS and DPP in the appropriate timeframe to support standardization work for smart grids.

This JWG report provides concepts and proposals on how to derive those technical and organizational requirements for the SGIS-SL (suggested levels 1 low to 5 highest) which are needed to protect the SG-DPC at their appropriate level and in their intended usage. Figure 15 illustrates how legal and normative requirements for system components (being developed, manufactured and put onto the market and into service) are then operated, maintained, repaired or updated. Finally they may be uninstalled and reused in additional usage cycles or even disposed of. Legal and normative requirements are different for those phases. Furthermore, those legal requirements may include essential requirements for SGIS.

Depending on

a. the Smart Grid operational and business models, its market roles complying to legal and system component functions and use cases with the included definition of the data models (and SG-DPC) used,

b. the SGIS sector-specific essential requirements (common essential requirements also applying to the smart grid – and essential requirements specific to the electricity grid), and

c. the common and sector-specific vulnerabilities and threats and their impacts on smart grid essential requirements, defining the required SGIS-SL system level requirements and its protection measures,

the protective measures can be identified for the SGIS-SL (suggested levels 1 low - 5 highest). Additionally, the monitoring and governance model to support the state of the art demand for SGIS can be identified. It is expected that this needs to be addressed to a specific SGIS and DPP guidance group, bound to the European Commission with participants from legal authorities, industry, standardization and others sending experts in smart grid operations and information security.

Based on this, the ESOs will define standards – including SGIS-SL 1-5 requirements for “sphere of action” domain specific organizational (market roles) and system component (products, solutions, services) requirements. The standards developed may even provide the presumption of conformity for putting products onto the market (as outlined in NLF decision 768:2008). The application of the EU decision on the New Legislation Framework in the smart grid legislation is to be discussed, as much of current and future legislation will be according to the NLF definitions. For products put onto the market, horizontal product legislation applies and may create conflicting goals.

There is no harmonized set of SGIS system level requirements for products. Those may apply in future to other sectors as well - e.g. to the internet of energy and the internet of things. This is also discussed in the separate document ***“Smart Grid Information Security (SGIS)** - the way forward, ensuring client values and client acceptance”,* published by the JWG on Smart Grid.

Due to this “gap” – there are certain legal initiatives in the member states, (i.e. in the Netherlands and in Germany) – essential requirements need to be identified, and consideration devoted to where the EU harmonized essential requirements and SGIS-SL (suggested levels 1 low - 5 highest) system level requirements differ. This is important to indicate to ESOs that there might be the need to provide standards with national deviations.

In addition, the fraud and incident responses need definition and monitoring. This will lead to conclusions about reporting requirements for all participating actors and change requirements for state of the art SGIS and credentials.

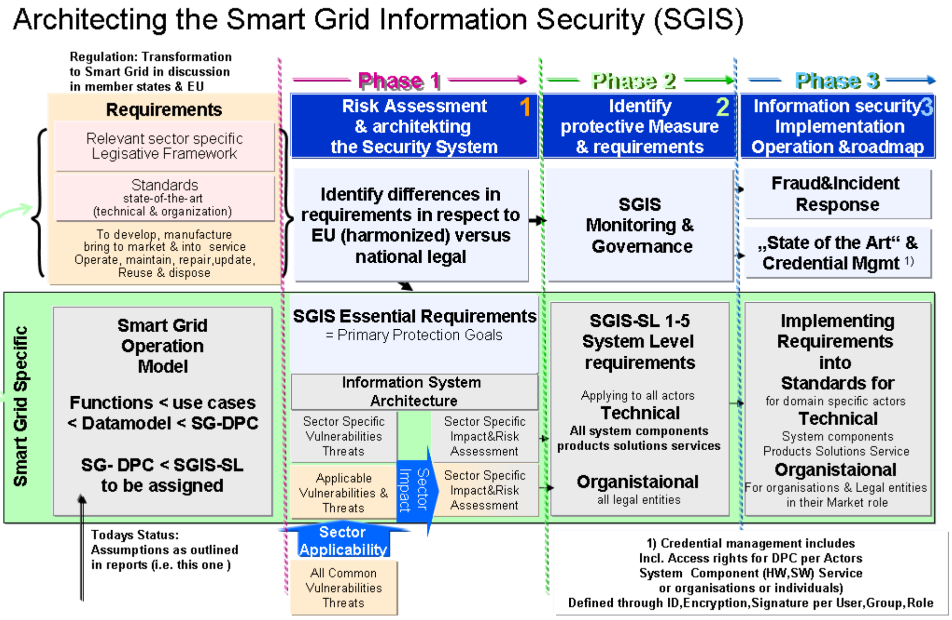

Figure 15 – Modelling smart grid information security implementing requirements

The following recommendations to the EU summarize the JWG expectations.

General recommendation 1 to EU
(Smart Grids Task Force EG2 or the recommended EU strategic guidance group for SGIS and DPP)
Define SGIS-SL requirements on “system-level”

EU needs to provide to ESOs a detailed set of harmonized system requirements (technical and organizational) for SGIS and DPP that should cover multiple smart grid information security levels SGIS-SL (suggested levels are 1=low, 2=medium, 3=high, 4=very high and 5=highest), as needed for specific legal requirements.

The JWG is prepared to send representatives to the group, in order to participate in outlining the SGIS-SL system level requirements.

The ESO TCs will ensure that standards provided for ALL actors interacting in smart grids – i.e. all system components (products, solutions, services) and standards for organizations participating in their respective smart grid role – will define system level requirements for SGIS and DPP. When implemented and appropriately addressed in a sustainable way, these requirements should ensure “state of the art” operation of SGIS and DPP and continued coverage of

- evolution of SGIS (SGIS-SL 1-5, SG-SPC) system level (technical and organizational) requirements and DPP,
- compliance with all legal requirements relevant to smart grids,
- interoperability and interchangeability of system components, services and organizations,

and needs to be synchronized in the market at all times along the journey of implementing smart grids and SGIS.

Milestones to achieve this are

a. EU should identify overall ownership for the integrated and interactive energy and energy efficiency management and its SGIS and DPP operations.
b. EU should establish a SGIS and DPP guidance group or enlarge the scope of the Smart Grids Task Force EG2 to address overall and system level SGIS and DPP with appropriate SGIS-SL levels by analyzing EU documents.
c. Analysis of global requirements to enhance exportability of smart grid solutions developed in Europe outside the EU; international harmonized standards would be the ultimate goal – at that stage this is a challenge. To provide a maximum of international commonality or compatibility a thorough analysis of NIST IR 7628 (especially the 189 recommendations (technical and organizational)) and other international documents should be used for identification of recommendations that may be used as and applied in the EU model SGIS and DPP; the analysis may also be used to highlight differences in legal and systematic methodologies and architectures.
d. EU to detail data protection classes and their required security levels for a sustainable and “state of the art” information security model of a multi utility smart grid that address technical system requirements for products / solutions and services – as well as system requirements for organizations’ and legal entities’ participation as “system/market roles”.
e. EG2 should identify the different national requirements in member states, e.g. for Germany qualified signature requirements for e-business-Jan 2010, or propose EU requirements for sustainable state of the art cryptographic principles (transforming over time) covering the various national layouts.

General recommendation 2 to EU
Guidance on information security and data protection / privacy governance

EU should provide guidance on the governance model (incident /fraud responses) and credential (ID/encryption key) management options for all actors in all sphere of action domains.

Recommendations to ESOs

ISec-1 Ensure system level information security requirements are covered in all relevant standards
Fast incorporation of system level information security requirements (for all data protection classes and information security levels) into

I. product, solution and service standards of all “sphere of action” domains;
II. “sphere of action” domain-specific “organizational standards” for market roles participating in smart grids, according to their responsibilities, and functions provided.

Ensure consistency between those and sustain “state of the art” SGIS DPP by synchronizing all standards with changing guidance on system level requirements for SGIS and DPP.

ISec-2 Smart grid functions and use cases require binding to SGIS and DPP requirements
For several data protection classes (SG-DPC) legal requirements exist and require the appropriation of the SG-DPC, i.e. personal data, control data, logging. Therefore, the concept of SGIS is to provide the enablement for bonds between

- the use cases which describe the intended utilization of data as well as

- the usage rights based on obligations and limits of its usage and its required specific information security level (who, when, why, what data is generated, processed, stored, transmitted, erased) and on justification derived from contractual/regulatory frameworks).

This will need a definition for all specific SG-DPCs and SGIS-SLs. The concept is to obligate the use case writing experts to identify ALL data models used in the function or use case (these describe the data usage and justification of the specific usage). The data model repository will need to include the specific data protection classes (SG-DPCs) for every single UML data model. The information security experts will need to specify the appropriate information security level requirement (SGIS-SL) for each single SG-DPC.

It is recommended that ESOs provide interlinked repositories to achieve the required bonds.

Figure 16 illustrates the above mentioned interlinked processes and interconnection of repositories for use cases, UML data models, SG-DPC and SGIS-SL.

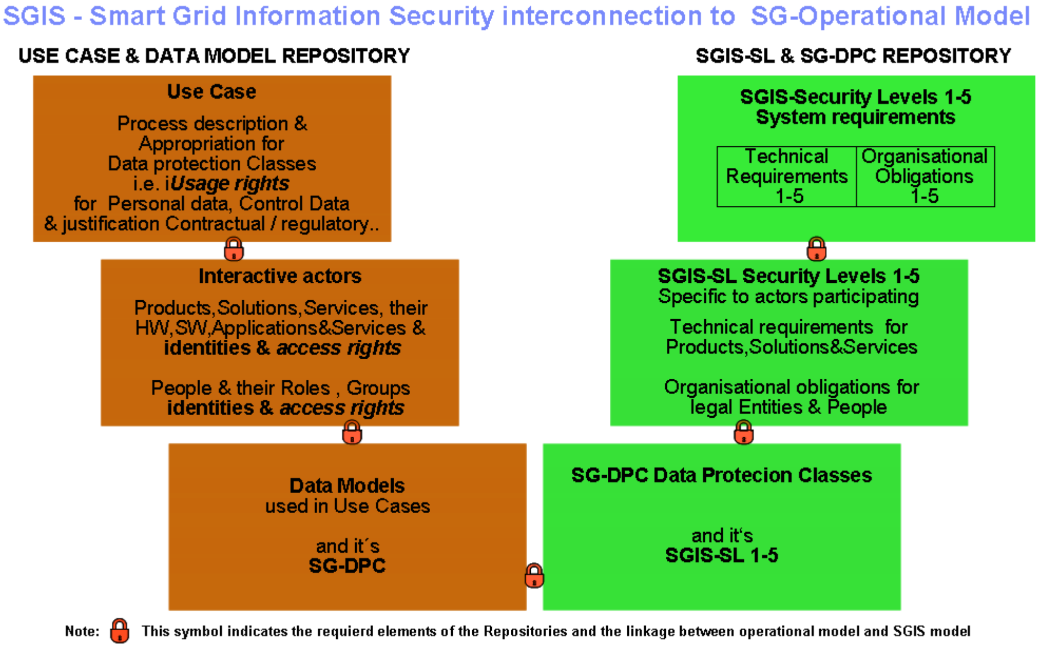

Figure 16 – Binding use cases and data models to SG-DPC and SGIS-SL

Experiences in smart grid operation and application will drive changes in

I. the Smart Grid Operational Model – actors, functions, use cases and data models used will experience high innovation dynamics in the open smart grid market

II. the guidance on SGIS system level requirements for SGIS-SL 1-5 technical requirements and SGIS-SL 1-5 organizational obligations
This area will evolve due to current and future legislative projects, e.g. on data protection and privacy, but also due to increasing knowledge on information security and privacy obtained from the SGIS and DPP governance model on fraud and incidents.

The SGIS model of interlinked operational and SGIS requirement repositories, both with required content, provides the concepts to keep the SG operation and the SG information security interlinked at all times, ensuring compliance with SGIS essential requirements by a “state of the art” SGIS for all actors and use cases they support - at all times even if the areas are evolving at different speeds

ISec-3 SGIS-SL and SG-DPP upgrade and synchronization requirements

There are 2 distinct independent areas with changing dynamics along the pathway to implementation of smart grids

- Innovation dynamics in smart grid function and use case definitions – describing the changing “Operational Model” of smart grids and the data models used

- and in dynamics in SGIS and DPP evolving the harmonized set of “system level” SGIS and DPP impacting the evolution of the SGIS-SLs and SG-DPCs.

The ESOs need to provide a sustainable mechanism to update and synchronize the bonds of data models used by functions and use cases to the SG-DPCs and their SGIS-SL requirements. This is required to link and synchronize use case and data model repositories as well as derived standards for smart grid system components (products, solutions, services) and organizational standards which need to be in sync with changing system requirements for the “smart grid information security” (SGIS) and data protection/privacy (DPP).

Figure 17 illustrates this process.

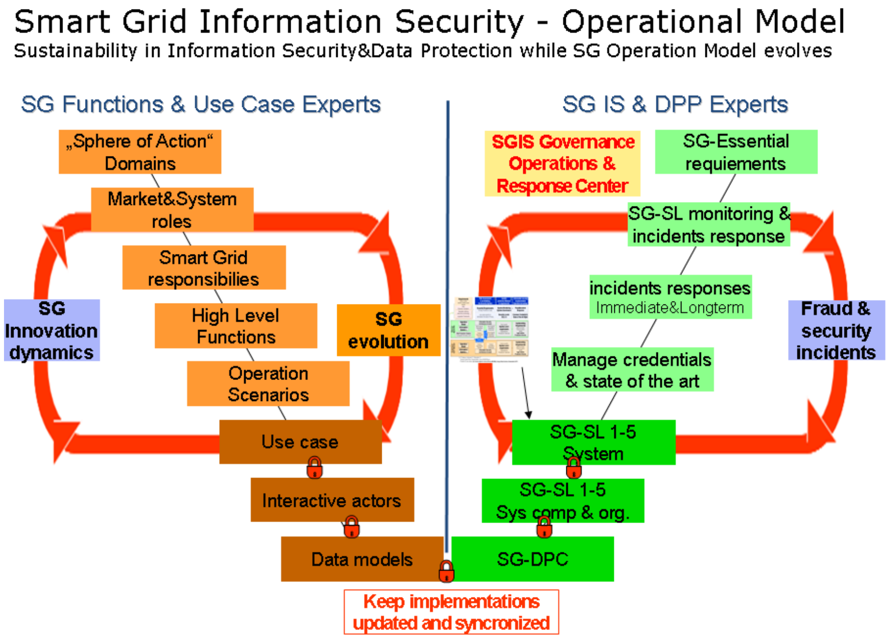

Figure 17 – Overall smart grid security operational model

ISec-4 ESO to provide IT Tools to support SGIS and DPP modelling and repositories for SGIS-SL/SG-DPC

As mentioned above (ISec-3) there are two distinct evolutionary areas – the Smart Grid operation model and the SGIS model, with different “innovation dynamics” - both areas need to be supported by tools that allow experts in both areas to define the content and models, and that interlink, each with the capability to inherit changes from the other area. The set of tools and repositories are unique to the area. Therefore the tools for modelling SGIS are different. The need for tools and repositories required in the area of the smart grid operation model – to capture functions, use case scenarios and use cases and all data models with their specific classifications are described in another section of this report.

The ESOs should also provide tools specifically for the area of SGIS, DPP and the repositories for SGIS-SL and SG-DPC to experts and communities in the area of information security to assist them in modelling SGIS and DPP and maintaining and upgrading repositories for the 5 information security levels (SGIS-SL), and the repositories for smart grid data protection classes (SG-DPC). The tools provided to model SGIS, DPP system level and the actor level (products, solutions, services and people, roles or organizations) and the repositories for SGIS-SL and SG-DPC need to be interlinked.

As mentioned above (ISec-3) there is the need to keep the two areas synchronized at all times. Therefore, the tools to be provided for both areas also need to permit synchronizing and binding, i.e. the repositories containing all SG-DPCs and their specific required/linked SGIS-SLs to the repositories containing the functions/use cases and their specific data models (to allow binding to the SG-DPC specified for the single data model).

5.1.6 Other cross cutting issues

EMC is a prerequisite for products and systems. Dependability and functional safety methodologies may be applicable to smart grids.

5.1.6.1 Dependability and functional safety

Dependability

Compared to today's grid, the smart grid is a more complex electricity network plus an ICT network. Nevertheless, the smart grid has to be as dependable as existing networks.

Dependability covers availability performance and its influencing factors: reliability performance, maintainability performance and maintenance support performance (including management of obsolescence). The standards prepared by IEC TC 56 (CENELEC SR 56) provide systematic methods and tools for the dependability assessment and management of equipment, services and systems throughout their life cycles.

Functional safety

As systems rely more and more on sophisticated hardware and software, safety is increasingly dependent on the relationship between products/systems and their responses to inputs. Functional safety depends on equipment or a system operating correctly in response to its inputs. Neither overall product safety nor functional safety can be determined without carefully evaluating systems as a whole and assessing the environment with which they interact.

A functional safety evaluation includes:

- Software
- Hardware
- Environmental factors, such as EMC
- Safety lifecycle management processes from specification to decommissioning

The IEC 61508 series (Functional safety of electrical/electronic/programmable electronic safety related systems), prepared by IEC SC 65A (CENELEC SR 65A) is a recognized tool.

5.1.6.1.1 Recommendations

Dep-1 Check relevance of existing methodologies to smart grids
Ask TCs (56 and 65A) whether their methodologies (with regard to Dependability and Functional safety) are well-suited/applicable to smart grids.

5.1.6.2 EMC and power quality

General

Electromagnetic compatibility is a prerequisite for all applications, products and systems and is therefore not limited and not unique to smart grids. It is governed by Directive 2004/108/EC of the European Parliament and of the Council of 15 December 2004 on the approximation of the laws of the Member States relating to electromagnetic compatibility.

For the smart grid to function properly and coexist with other electrical and electronic systems, it must be designed with due consideration for electromagnetic emissions and for immunity to various electromagnetic phenomena. EMC must be addressed effectively if the smart grid is to achieve its potential and provide its benefits when deployed.

For a number of “smart” applications (e.g. Electric Vehicle or PLC in the metering domain) EMC will be a major issue. This will then include the IEC 61000 and CISPR series, besides specific product standards.

If no product standard comprising EMC part(s) is relevant, the requirements of the generic EMC standards apply according to the application.

Electromagnetic compatibility (EMC)
EMC is the ability of an equipment or system to function satisfactorily in its electromagnetic environment without introducing intolerable electromagnetic disturbances to anything in that environment.

Power quality (PQ)
Power quality is a characteristic of the electric current, voltage and frequencies at a given point in an electric power system, evaluated against a set of reference technical parameters.

NOTE These parameters might, in some cases, relate to the compatibility between electricity supplied in an electric power system and the loads connected to that electric power system.

Standards exist for the characteristics of electricity supplied to customers or power quality (at the entry point of the user’s installation), up to 150 kV, and are used for contractual relationships and for regulation. The specified levels are generally close to the compatibility levels given in EMC standards, used as a reference for product EMC requirements (emission limits and immunity levels).

The smart grid is expected to be flexible, and consequently power quality and EMC standards should also address, in an appropriate way, distributed generation, islands or micro-grids and alternative grid conditions (self healing systems…).

5.1.6.2.1 Gaps

EMC standardization has some gaps for:

- immunity and emission in the frequency range from 2 kHz to 150 kHz, in order to ensure proper functioning of electronic equipment and protection of power line telecommunication (PLT) services (PLT emission levels are covered by IEC 61000-3-8 and IEC 61334-3-1);
- Power Quality in a smart grid context;
- Immunity and emission requirements applicable to Distributed Energy Resources.

5.1.6.2.2 Recommendations

The thorough change in the use of electricity, especially by the introduction of modern electronic equipment which has taken place during the last decades and, therefore, the increasing occurrence of voltage components above the frequency range of harmonics, up to 150 kHz, urges the consideration of this frequency range for ensuring EMC. It appears to be advisable to urge EMC Committees (CENELEC TC 210, IEC SC 77A and other EMC Committees where appropriate), as well as those Product Committees defining EMC requirements in their product standards (TC 22, TC 13, TC 57 …), to review the existing standards (see Annex 7) with a view to covering the above-mentioned gaps in EMC standardization.

EMC-1 Review existing standards
CENELEC TC 210 and Product Committees to review existing standards concerning an appropriate modification for closing gaps in order to also ensure EMC in the frequency ranges from 2 kHz to 150 kHz (in practice 2-9 kHz and 9-150 kHz).

NOTE Technical input in this domain can be found in several reports/publications, such as the CENELEC SC 205A Study report on electromagnetic interference between electrical equipment/systems in the frequency range below 150 kHz, (SC205A/Sec0260/R, April 2010). Nevertheless, further studies are probably necessary before a complete set of standards can be available.

Furthermore, the following actions of the standardization communities are suggested to support low frequency EMC/power quality in the context of smart grids.

EMC-2 Review EMC and Power Quality levels
Review electromagnetic compatibility levels and/or characteristics of voltage at interfaces for all standard voltage levels of public electrical power networks, and define the associated operating conditions in the context of the smart grids.

EMC-3 Consider distorting current emissions from DER equipment
Standardize how to give a limitation to the distorting current emission by DER equipment and to fairly allocate the ability of networks to absorb distorting current emissions among present and possibly forthcoming connected equipment, including Distributed Generation at sites in networks. Connected equipment may well be other networks. The work is recommended to originate from documents IEC TR 61000-3-6, IEC TR 61000-3-7, IEC TR 61000-3-13 and future IEC TR 61000-3-14.

5.2 Domain specific topics

5.2.1 Generation

5.2.1.1 Description

Power generation was initially mostly focused on transmission grid applications, but has been progressively expanded towards distribution as well as distributed generation and demand side portfolio management while deregulation required consideration of interactions with the grid and market systems.

Large scale power storage systems may also be considered in the future.

Considering the new European challenges supported by smart grids [7)], power generation will have to lead the way in many transformations

- in the way units are operated, especially in their interactions with the overall smart grids system,
- in welcoming a dramatically increased number of operators with probably a decreasing level of knowledge,
- in enabling possibly some areas to run as a microgrid, i.e as a local electric low-voltage installation, with local generation, energy storage and consumers able to operate when connected to the public network, but also when disconnected from the public network for a period of time.

Flexibility of control, life cycle management of power generation assets as well as real-time interoperability with other actors in the energy chain (grid dispatcher, trade down to end users selecting their energy in the longer term, Virtual Power Plants) are a critical capability to develop as part of Power Plant Control and Management Solutions.

Up to now, real-time performance imperatives and limited industry standardization for data exchanges with the energy ecosystem outside the power plant naturally led the industry towards highly customized solutions built upon proprietary system platforms.

Furthermore, fleet and power scheduling will provide generation asset owners with decision support tools which will optimize the production schedule of assets, at the fleet level and at the individual asset level. Those applications will rely on existing CIM standards to ensure interoperability through the different control solutions.

7) Namely the series of demanding climate and energy targets to be met by 2020, set by the EU Heads of State and Government. A reduction in EU greenhouse gas emissions of at least 20% below 1990 levels – 20% of EU energy consumption to come from renewable resources – A 20% reduction in primary energy use compared with projected levels.

5.2.1.2 The high level services and use cases

Setting up a smarter grid in Europe, matching the requested high-level services as defined in Annex 9, leads to a consideration of four main use cases with, for each, two aspects to consider: interfaces with the grid and interfaces to the energy market (details are provided in Annex 9):

Table 2 – Use cases – Generation

Use cases	Interface to the Grid (and Grid operation)	Interface to the market
Connect the power generator to the Grid	Electrical interface	
Make the power generator monitorable	Enable the network operator to monitor the electrical point of connection of the generator	
Make the power generator dispatchable	Enable the network operator to send control to the generator	Enable the generator to participate in the energy market, including ancillary services
Make the Virtual Power Plant dispatchable	Enable the network operator to send control to generators organized in clusters (VPPs)	Enable the cluster of generators (VPP) to participate in the energy market including ancillary services

5.2.1.3 Existing standards and gaps

When approaching a detailed analysis of existing standards to face the above challenge (ref Annex 9), some gaps appear. Ranking them between highest and lower priority leads to consideration of the following list.

- (Ref Annex 9 – Gap 1): Harmonized glossary, semantic & modelling between back-office applications (CIM[8)]) and field applications (IEC 61850[9)])
  Glossaries & data modelling between the control centres (CIM-based) and the field application (IEC 61850) are not aligned, and this gap is leading to additional complexity, and reduces reliability and upgradeability of concerned systems. This issue is to be addressed by CENELEC TC 57 with a full alignment of other worldwide initiatives in this same domain. Europe should support the first step which is to obtain a UML modelling of IEC 61850.
  A clear message to the market is expected from the corresponding roadmap to get the first fixes.

- (Ref Annex 9 – Gap 7): Harmonization between IEC 62056-XX (DLMS/COSEM) data model and IEC 61850/CIM
  There is currently no common data modelling and description language between generation and metering. Considering that many actors of the grid will become both generators and consumers, a common data modelling shared by these two areas is needed. This harmonization should also be considered between field devices and remote centers (as explained above).
  Europe should take the lead on the IEC 62056-XX (DLMS/COSEM) data model harmonization with CIM/IEC 61850, within the IEC body (through CENELEC TC 57 and TC 13)

- (Ref Annex 9 – Gap 8, 9, 11) : Extended field data modelling standard (part of IEC 61850) to support demand response schema

8) IEC 61968 and IEC 61970 standards provide models of transmission, distribution systems and energy markets, as well as partial models of power generation, models known as the CIM (Common Information Model), structure and semantics for integrating a variety of back-office applications.

9) IEC 61850 standard provides a model for substation automation system and renewable energy resources (PV, hydro & wind and other), a basis for field equipment communications, including semantics, and encompasses real-time operations as well as non-operational data, such as condition monitoring.

Extended field data modelling standard (part of IEC 61850) to enable DER (and VPPs) to contribute to network ancillary service
Extended CIM to model more accurately Generation Fleet Management Applications in the case of Bulk Generation, and to integrate DER and VPPs
Standard data modelling is missing in three main areas which are key for smart grids as far as generation or storage are concerned :

- Supply side management, including generation fleet management,
- Network ancillary services (such as voltage control, reactive power management, frequency control, power reserve management),

In order to fill this gap, the European Standardization Organizations should clearly express and formalize to CENELEC TC 8X the selected use cases the smart grid system has to support.

Then IEC TC 57/WG 17 body (through CENELEC TC 57) should provide expected answers by proposing IEC 61850 data modelling extensions. The European Standardization Organization should also support TC57 initiatives to define use cases and modelling (such as “CIM Extension for Generation” NWIP).

- (Ref Annex 9 – Gap 6, 10): Standard for electrical connection and installation rules to ensure energy availability and security, in the presence of a high ratio of DER.
  Standard to allow all connected generators associated in VPPs to participate in new ways of operating the grid
  Unified standards for electrical connection and installation rules of generators (including DER) to ensure energy availability and security, in the presence of a high ratio of DER, are missing. Europe is to define and promote harmonized electrical connection and installation rules, whatever the levels of connection of DER.
  In addition, some new ways of operating the grid, such as microgrid, may appear to achieve maximum benefits from the newly installed distributed energy resources. However standards are missing to allow such new ways of operating grids. Thus CENELEC is to adapt installation rules in order to make such grid operation possible.

5.2.1.4 Recommendations

Gen-1 Harmonized glossary, semantic & modelling between back-office applications (CIM[10)]) and field applications (IEC 61850[11)])
Provide experts to IEC TC 57 body to boost CIM/IEC 61850 harmonization planning, fix this issue ASAP and establish clear messages to the market. Support electronic form of IEC 61850 data model at IEC level based on UML language.

Gen-2 Harmonization between IEC 62056-XX (DLMS/COSEM) data model and IEC 61850/CIM
Take the lead on this IEC 62056-XX (DLMS/COSEM) data model harmonization with CIM/IEC 61850, within the IEC body (through CENELEC TC 57 and CENELEC TC 13)

Gen-3 Extended field data modelling standard (part of IEC 61850) to support demand response, DER and VPP & Extended CIM to model more accurately Generation Fleet Management Applications in the case of Bulk Generation, and to integrate DER and VPPs
Clearly express and formalize to CENELEC TC 8X the selected use cases which the European smart grids have to support and ensure IEC TC 57/WG 17 body (through CENELEC TC 57) will provide expected answers in IEC 61850 data modelling regarding: Demand response for generators, for ancillary services,

10) IEC 61968 and IEC 61970 standards provide models of transmission, distribution systems and energy markets, as well as partial models of power generation, models known as the CIM (Common Information Model), structure and semantics for integrating a variety of back-office applications.

11) IEC 61850 standard provides a model for substation automation system and renewable energy resources (PV, hydro & wind and other), a basis for field equipment communications, including semantics, and encompasses real-time operations as well as non-operational data, such as condition monitoring.

including VPPs and aggregators. Support TC 57/WG 13 initiatives to define use cases and modelling (such as AI715)

Gen-4 Standard for electrical connection and installation rules to ensure energy availability and security, in the presence of a high ratio of DER
Harmonize electrical connection and installation rules within Europe, down to all levels of connection of DER

Gen-5 Standard to allow all connected generators associated in VPPs to participate to new ways of operating grid
Adapt installation rules of DER to allow new ways of operating grid such as microgrid (TC 64 and TC 8X)
More specifically, TC64 should develop new requirements and adapt existing installation rules within the HD 60364 to cover DER needs.

5.2.2 Transmission

5.2.2.1 Description of scenario

The evolution of the electricity market in Europe emphasizes the need to enlarge the European transmission grid by merging power systems through interconnections, creating strong electrical networks all over Europe. A strong interconnected power system provides several advantages as mutual supports, to accommodate disturbances of the generation and load balance and reduce costs of mitigation measures and also reduce synchronous peak loads below the sum of individual ones, hence requiring less generation equipment.

The transmission grid is a key facilitator for the European low-carbon energy future. Its reinforcement is a precondition but is, indeed, not sufficient.

With the 20-20-20 goals defined by the European Union, transmission must face new challenges, especially by the implementation of Renewable Energy Sources, which present new characteristics compared with the traditional generation facilities already connected to the grid.

Renewable electricity may often be produced at times and in places where there are no local needs to be met. It must be transported over long distances and redistributed where consumption needs arise or where large-scale storages facilities are located.

The integration of Renewable Energy Sources induces the implementation of new transmission components, such as for example solutions for off-shore wind power plants, long connections, etc. But interoperability with the present grid is also required.

The solutions expected are not limited to the installation of new transmission system components and functionalities. Also the optimization of the use of the present assets by a better knowledge of their load capacity should prolong their life, in order to avoid reinforcement, and should minimize the cost impact.

In addition to increased transmission needs, distributed renewable energy sources by their nature call for service providers to aggregate the plurality of the generation facilities. The transmission system operators are facing needs for coordination with aggregators or even devolution of the subsystem balance responsibility to a service provider. Such a challenge implies a multilevel control and monitoring communication infrastructure. Based on the fact that several renewable energy sources are predictable to some extent, coordination with flexible loads is foreseen to be an essential function for stability in the future electrical network.

Therefore, the ”smart grids” concept must provide solutions for the new integration and also provide new facilities to enhance grid flexibility, active demand and new usage of electricity in line with the European and national energy policies.

All choices must be consistent to ensure a global security of supply, quality of electricity, minimal cost for society and limitation of impact on the environment.

5.2.2.2 The high level use cases/services

The report of the Smart Grids Task Force Expert Group 1 [4] suggests 6 high level services for smart distribution grids. As a strong coordination between transmission and distribution will be needed for issues concerning demand, operation and distributed energy sources, in order to ensure the suitable contribution of local resources to the global system security, it can be assumed that all of these high level services should be valid for smart transmission grids, with a slight adaptation in order to fit properly with transmission issues.

The high level use cases/services taken into account are:

a) Enabling the network to integrate grid users with new requirements **(grid connection)**.

b) Enhancing the observability and the monitoring of the transmission grid **(grid observability)**.

c) Ensuring network security of supply in a more complex and optimized grid **(grid security of supply and optimization)**.

d) Planning of the future network **(grid planning of the future network)**.

e) Improving market functioning and customer service **(grid market)**.

f) Enabling and encouraging direct involvement of consumers in the energy usage **(prosumers)**.

Details and explanations on high level services and the associated functional requirements are provided in Annex 10.

5.2.2.3 Existing standards

a) Grid connection

Existing standards relevant for grid connection are listed in Annex 8. For wind energy, IEC 61400 *Communication for monitoring and control of wind power plants,* based on IEC 61850, is worthy of especial mention.

b) Grid observability

The relevant communication and equipment standards are listed in Annex 11.

In Annex 12, Figure A12.1, extracted from IEC 62357, gives an overview of the reference architecture (present and future) addressing the communication requirements of the applications in the power utility domain.

c) Grid security of supply and optimization

Complementing the standards already mentioned for grid observability, the relevant standards for the capacity of transmission assets are in Annex 11.

d) Grid planning of the future network

The standards already existing and covering new technologies as well as interoperability and secure information are indicated in Annex 11.

e) Grid market

The relevant standards are in Annex 11.

f) Prosumers

The relevant standards are in Annex 11.

5.2.2.4 Gaps

a) Grid connection

The potential need for the development of new standards or revision of existing standards with relevance to grid connection should be assessed once the new legal framework has become effective, or at least developed to a mature stage.

Nevertheless, with the development of renewable energy sources, an important part of generation is moved from conventional power plants in the proximity of loads to new power plants far away. This is particularly the case with off-shore wind plants.
DC technology offers an efficient solution, compared to AC technology, for bulk power long distance transmission capabilities, with low transmission losses and precise power flow control.
The development of off-shore wind plants will soon induce the need for an off-shore transmission grid, as a small number of bulk power systems will be more efficient than many small scale systems.
Furthermore, the reduction in the number of DC/AC converters, in order to contribute to lower transmission losses, will push in the direction of a DC grid.

All the requirements for DC grid still lack:

- Grid codes, i.e. common rules and guidelines, voltage level
- Clear interfaces between grid users
- Competitive supply chains for all equipment
- International technical standards

A project for a new CENELEC WG for this issue is in progress. This initiative should be encouraged to start the development of standards and technical guidelines for DC grids as soon as possible. These tasks should be performed by TC 22/SC 22F (converters), TC 13 (metering), TC 17/SC 17A (high-voltage switchgear), TC 38 (current & voltage measurement), TC 99 (general installation), TC 8/TC 115 (grid design), TC 11 (conversion from AC to DC for OHL), TC 20 (underground cables), TC 33 (capacitors), TC 115 & TC 8X (coordination) and TC 95 (protection relay). It is noted that there is not yet a European Group for TC 95.

In addition to DC issues, it must be noted that there is a lack of standards regarding interface issues for AC equipment in the intermittent generation domain (wind, tidal and photovoltaic generation).

b) Grid observability

Data models, classes and functionalities may be required for advanced state estimation, which includes phasor information. This must be specified as a data model in the IEC 61850 and IEC 61970 series.

Now, the main issue is to bring into interoperability the new SCADA concept (generally represented by IEC 61970/68) and the data transmission protocols of IEC 61850 and IEC 62056.

In the existing standard architecture, no uniform specifications are described that might limit the extent and depth of a complex dispatching system in bulk electricity power systems.

In order to realize VPP decentralized energy management, communication facilities are needed that have standardized interfaces and protocols.

Among all the issues to be faced by standards, interoperability is a very important one. A lot of standards are already available, but coherence and interoperability should be improved, at least for the CIM model.

In both Editions 1 and 2 of IEC 61850, interchangeability is out of the focus. All solutions are based on the product related naming approach on the station bus, described in Part 6 “Configuration description language for communication in electrical substations related to IEDs”. But in future the same naming will be required for the same function on the station bus, independently of the IEDs.

Condition monitoring of components of substations or of lines provides technical information useful for the optimized use of the assets. Particularly, it could provide relevant data in order to optimize the loading capabilities. It should also improve the knowledge of the behaviour of the assets in order to assess the lifetime of the transmission assets with more accurate models.
Therefore, there is a need for standards on condition monitoring including prediction models and applicable to all assets, even to the assets already in operation for years.
Nevertheless, the standard should be focused only on the relevant data, instead of monitoring excessive and useless parameters. The standard should help users to identify the value of condition monitoring and how it can be used in operation for decision making.

IEC 61850 is the reference standard for communication in substations. It enables the integration of all protection, control, measurement and monitoring functions within a substation. Nevertheless this standard does not cover the issue inside the assets themselves, i.e. the communication between sensors of assets and the upper level. The work of IEC 61850-90-3, presently in progress, is devoted to this issue. The TCs involved are TC 14 (transformers), TC 17 (switchgear), TC 38 (transformer measurement), TC 11 (OHL), TC 7 (conductors), TC 20 (underground cable), TC 57 (data & communication), TC 13 (metering) and protection relays (TC 95).

c) Grid security of supply and optimization

The present standards for load capacity generally concern equipment manufactured after the implementation of the standard.

For assets older than the standards, which represent the main part of the transmission assets, the load capacity is not well known. Therefore it would be relevant to know in which conditions the present load standards are also applicable to old assets.

d) Grid planning of the future network

The existing product standards describe the general requirements of the equipment itself. However, there is a need for the integration of all these standards in a smart grid perspective.

Even if the submarine connections have been present for a long time, the off-shore substation on a platform is a new issue for the transmission grid. Due to the fast development of off-shore wind plants, the requirements and specifications used for the engineering of off-shore substations had to adapt the present standards. Nevertheless it should be relevant to check if the present standards for transmission equipment properly cover the specific requirements of the off-shore environment.

With regard to the DC issue, the gaps concern equipment standards (AC/DC converters, DC/DC converters, circuit-breakers, protection, ….) as well as grid topology standards (grid design, voltage level, grid code, ,,,).

5.2.2.5 Recommendations

T1 – HV-DC grid architecture
With the development of off-shore grids, there is a need for coordination, coherence and interoperability for equipment (converters, circuit-breakers, protection,….) as well as for grid topology (grid design, voltage level, grid code,…) in the High Voltage DC domain. The ESO standardization should take into account the work done in the German committee context.

T2 – Smart assets
The ongoing IEC 61850-90-3 work, devoted to condition monitoring in the power energy domain, should be encouraged. The present standard and protocol for communication in substations should involve communication and relevant data models, whereas the relevant products Technical Committees have to standardize the methods and the devices needed for on-line monitoring.
Therefore, it is recommended that the ongoing IEC standard involves on the one hand the experts on equipment to monitor for the technical aspects and on the other hand representatives of users in order to assess the condition values.

T3 – Offshore equipment
A review of the existing standards for transmission equipment is required in order to check that the special requirements for off-shore installations are properly covered. Otherwise, standards should be adapted. These tasks should be notably performed by TC 14 (transformers), TC 17 (switchgear), TC 38 (instrument measurement) and TC 20 (underground cable).

5.2.3 Distribution

5.2.3.1 Description of scenario

In order to achieve the European and national energy policy objectives, a new global approach in the generation, transmission, distribution, metering and consumption of electricity is necessary, as well as for electricity markets. Massive integration of renewables and energy storage technologies will have to be deployed. Energy efficiency will have to be a general driving factor, demand will become an active player within the electrical system and the increasing electrification of transport will be a challenge. These latter drivers will require far-reaching changes in the area of distribution networks and will determine modifications in system operation, with consequent impact on design, planning and operation of transmission networks.

In the promotion of energy efficiency, distribution system operators (DSOs) will need to actively participate as major enablers for services and integration. Not only the transmission grid, but also the distribution grid is a key facilitator for the European low-carbon energy future.

Smart grids must play a key role in the process to transform the functionality of the present electricity transmission and distribution grids so that they are able to provide a user-oriented service, enabling the achievement of the 20/20/20 targets and guaranteeing, in an electricity market environment, high security, quality and economic efficiency of electricity supply. Their development will be facilitated by the wide-scale deployment of smart metering, as envisaged in the Third Energy Package, Directive 2009/72/EC.

Though elements of smartness also exist in many parts of existing grids, the difference between today’s grid and a smart grid of the future is, from a simple point of view, the grid’s capability to handle more complexity than today in an efficient and effective way, while developing a customer-centric approach. A smart grid employs innovative products and services together with intelligent monitoring, control, communication, and self-healing technologies in order to:

- better facilitate the connection and operation of generators of all sizes and technologies,
- allow consumers to play a part in optimizing the operation of the system,
- provide consumers with greater information on consumption/generation and adequate support for choice of supply,
- significantly reduce the environmental impact of the whole electricity supply system,
- improve the existing services while promoting end-user energy efficiency,
- maintain and improve the existing services efficiently, and
- foster market integration towards an integrated European market.

As already defined in the introduction, a smart grid is an electricity network that can cost-efficiently integrate the behaviour and actions of all users connected to it – generators, consumers and those that do both – in order to ensure an economically efficient, sustainable power system with low losses and high levels of quality and security of supply and safety, as well as a framework for innovative services.

The implementation of this concept will be made possible by the participation of all smart grids actors, according to their specific roles and responsibilities which are described in greater detail in the report of the Expert Group 3. Accordingly, smart grids participants are categorized in this report as follows:

- Grid providers: transmission and distribution system/network operators (DSOs/DNOs).
- Grid users: generators, consumers (included mobile consumers), storage owners.
- Other actors: suppliers, metering operators, ESCOs, aggregators, ICT hub providers, power exchange platform operators.

Conceptually, some smart grid actors are to provide services, based on elementary functionalities, to other smart grid participants.

A smart grid service identifies the outcome a user needs/will need from the electricity grid in a fully developed liberalized market; it is associated to one provider and to one or more primary beneficiaries, recognizing that the benefits will ultimately be reflected in consumer societal and environmental terms.

The achievement of service outcomes is possible only through smart grids functionalities that represent elementary building blocks through which services can be implemented and delivered to beneficiaries.

5.2.3.2 High level use cases/services – Functional requirements

The detailed services to be provided in smart grid solutions will have to be agreed in discussion between the relevant parties. However, extracted from the EG1 report, the following represents a list of the broad services envisaged, showing the provider of the service and the primary beneficiaries.

a) Enabling the network to integrate grid users with new requirements, EV charging and demand side management = **Grid access of distributed energy resources**

b) Enhancing the efficiency in day-to-day grid operation = **MV and LV Grid automation**

c) Ensuring network security, system control and quality of supply = **Grid security and quality of supply**

d) Planning of the future network = MV and LV Grid planning (distributed generation, flexible loads)

e) Improving market and customer service = Grid market (Aggregators, EV recharging, support for Intelligent Homes)

f) Enabling and encouraging direct involvement of consumers in distributed energy and storage = **Prosumers (metering data and remote management)**

Details and explanations on high level services and the associated functional requirements are provided in Annex 13.

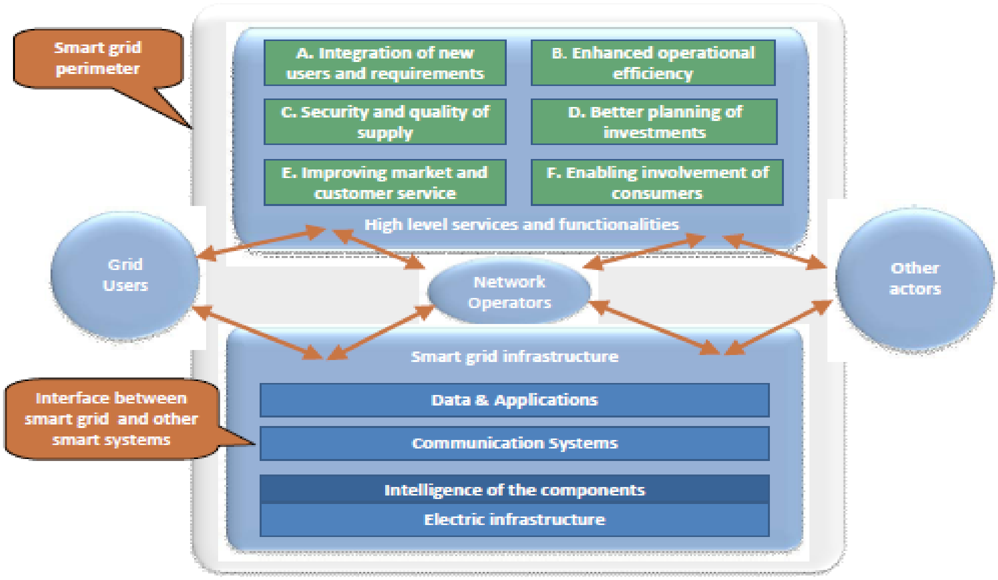

Figure 18 – Functionalities of smart grids

Different functionalities of smart grids as extracted from the EG1 Report and how they fit into the vision of the future network are shown in Figure 18.

5.2.3.3 Existing standards

Product standards

IEC 61850, *Communication networks and systems in substations*

IEC 60870, *Telecontrol equipment and systems*

All the standards are described in IEC proposal (IEC Smart Grid Standardization Roadmap), pages 48-136.

IEC 61869, *Instrument transformers*

IEC 62351, *Power systems management and associated information exchange – Data and communications security*

NERC CIP002-009, *Implementation Plan for Cybersecurity Standards*

NIST IR 7628 vol. 1, 2, 3, *Cybersecurity guidelines*

IEC 61400 series, *Wind turbines*

IEC 61085, *General considerations for telecommunication services for electric power systems*

EN 61727, *Photovoltaic (PV) systems – Characteristics of the utility interface*

IEC 61334, *Distribution Automation Using Distribution Line Carrier Systems*

EN 62056, *Electricity Metering – Data Exchange for meter readings, tariff and load control*

EN 13757, *Communication systems for meters and remote reading of meters*

Interoperability standards

IEC 61968 series, *Distribution Management System – CIM and CIS definitions*

IEC 61970, *Energy management system application program interface (EMS-API)*

IEC 62357, *Reference Architecture – SOA EMS DMS*

5.2.3.4 Gaps

There is a strong need for better harmonization between CIM and IEC 61850 because all modelling work in different areas should be consistent and possible to reutilize.

5.2.3.5 Recommendations

Dis-1 Feeder and Advanced Distribution Automation
Develop a standard that supports feeder automation (at CEN/CENELEC), and Advanced Distribution Automation.

Dis-2: Use CIM (see also Gen-1)
Give high priority to the works needed in the area of harmonization of CIM /IEC 61850.

Dis-3: Seamless communication between control centre and substation
Support international work in order to provide seamless communication between control centres and sub-stations based on 61850.

Dis-4: Develop cybersecurity around IEC 62351
Work on a standard for cybersecurity as long as intensive public communication services (from Telecom Operators) will be used in distribution, enhance IEC 62351 in this area.

Dis-5: Auxiliary power systems standardization
Develop standardization for auxiliary power systems (low voltage DC networks): AC/DC converters, DC management systems, DC protection.

Dis-6: Integrate condition monitoring capabilities
Condition monitoring of components of substations or of lines provides technical information useful for optimized loading and helps to increase the lifetime of the distribution assets. IEC 61850, the present standard and protocol for communication in substations, should involve communication as far as the sensors needed for on-line monitoring. Ongoing work in TC 57: IEC 61850-90-3 (TR)

Dis-7 Standards for Medium Voltage (MV) lines
Develop a set of standards covering V and I sensors, switching equipment (definition, and modelling) and fault detectors (definition, and modelling) for Medium Voltage lines (overhead and underground)

5.2.4 Smart metering

5.2.4.1 Description

Introduction

Smart electricity meters, which are distinguished from conventional meters by having one or more additional functionalities including bi-directional communication, allow the meter to collect usage data and transmit this data back to the designated market organization(s) via an advanced metering infrastructure, to control supply, tariffs, loads and distributed generation and to inform customers. They are thus an important enabler for smart grids.

The essential (metrological) requirements of meters are covered by the Measuring Instruments Directive, unlike other sensors or actuators.

Standardization mandate M/441

Smart metering has been the subject of standardization mandate M/441, which is directed at meeting the needs of the residential (household) and small commercial (SME) sectors. This corresponds to the focus of the M/441 mandate and the need to improve consumers' awareness not just of their electricity consumption but also of their gas, heat and water usage.

The work undertaken in response to Mandate M/441 considers the high-level smart metering functionalities which are additional to the traditional metrological requirements applying to electricity and other meters and recognizes that many smart meters have been or are currently being installed in the EU. In the next phase the M/441 infrastructure will need to be developed with particular reference to the interfaces with smart grid applications such as DER and EV metering and control.

Legislative background

In the case of electricity, the Energy Services Directive (2006/32/EC) and the recently adopted Electricity Directive (2009/72/EC) are important elements in the background to the mandate. The latter requires the implementation of *'intelligent metering systems that shall assist the active participation of consumers in the … market'.* Such systems must be in place in 80% of electricity customers by the end of 2020 (unless an economic assessment shows that a lower figure is appropriate).

Additional functionalities

M/441 standardization has identified six broad areas of additional functionality or service. These are being used to guide detailed consideration of the standards to be developed under the mandate and will support/complement future standardization in the area of smart grids.

Note that the six additional functionalities identified under M/441 should not be seen as a minimum list of smart metering functionalities to be implemented in Europe, since not all functionalities will necessarily feature in all applications or in all Member States and Member States may also define functions outside this list.

Particularly in the context of smart grids however, two-way communications envisaged in M/441 will be of special importance.

Linkage with smart grids

The major focus of the mandated work under M/441 is the provision of improved information and services to customers and enabling customers to better manage their consumption. However, in addition, particularly in relation to electricity metering, there is the important additional objective of facilitating smart grid applications, notably through the incorporation of distributed generation. Smart metering is an important aspect within a smart grid system.

In smart grids, the meter acts as a remote sensor and actuator, enabling information flows between the customer and the customer's metering point, grid operators and other market participants. Other data used by grid management and control systems will also be available – the meter is only one of the sensors or actuators in a smart grid.

The additional functionalities envisaged for smart metering already take into account the services needed to support smart electricity grids in homes and buildings (see 5.2.4 below) although not all the interfaces are fully covered by the M/441 mandate. Recommendations to address this are included in 5.2.4.3.

5.2.4.2 Use cases

The additional functionalities identified to support smart metering standardization can be considered in greater detail through use cases. These can be defined at differing levels, depending on their purpose, but include the kind of functionalities typically considered as aspects of a smart grid system including

- uploading of data and information to permit, for example. monitoring of supply quality and electricity outages,
- receiving messages from designated market organization(s), both standard and ad hoc (e.g. on planned interruptions, messages on price changes) and other information,
- communications used by the customer or other party to support remote load management applications by means of a local energy management system or home/building control system and – where appropriate – direct control of individual devices within a home/building, and
- interfacing with home communications systems / home area networks, enabling the meter to export metrological and other information for display and potential analysis, and interfacing with potential home and building control applications and sophisticated energy management systems.

Smart metering use cases have been developed to support M/441 standardization, and these will be further developed to assist the detailed work by the Technical Committees concerned. Attention will be given to ensure that the detailed SMCG use cases meet the requirements envisaged for smart grids.

Smart grid interfaces

The M/441 standardization work makes specific provision for communications interfaces with smart electricity grids.

While the smart metering functionalities necessary to support smart grids are already envisaged, the final design of smart grids has not yet been defined and standardization is not at a similar level as in smart metering. Thus the detail of the interface cannot be fully defined at this time, although it should cover the introduction of metrologically relevant measurements within a smart grids environment. Similar considerations apply in the case of e-Mobility (see below).

Communications requirements

As the management structure of a smart grid technology mainly focuses on online balancing of the physical grid and quality of service, the metering and power quality data collected will be used for forecasting grid status and the load balance required prior to delivery.

By contrast, the management structure of a smart metering infrastructure mainly focuses on the collection and processing of data, such as measurement results, tariffs and consumption data post delivery.

A distinction can therefore be made between smart metering and smart grids in terms of the accuracy, data volume and data acquisition speeds required. Smart metering calls for a large volume of highly accurate individual data but with a relatively limited need for high speed access; smart grids may require smaller volumes of less accurate data, but this typically needs fast, quasi real-time access.

Smart grids and smart metering have different objectives and different construction priorities. The overlapping functionality can be seen as the common usage of metrological measurement information where appropriate such that the interface can be seen as an “online-link” for metrological values from a smart meter network into a smart grid network.

E-Mobility

A separate interface is foreseen as a possible link for metrologically relevant measurements in e-Mobility environments. As the charging of electrical cars is an event under metrological control, the same basic interfaces and same kind of metering services will apply for mobile measurements as for non-mobile measurements.

It is not yet defined where measurements for e-Mobility will be performed (in the charger, in the car, in both) but the metering part of this application has to follow the same principles as for all other metrological measurements.

5.2.4.3 Recommendations

SM 1: Currently various standards or extensions of existing standards are being developed to cover the exchange of metering data. Examples are:
- EN 62056 Electricity metering – Data exchange for meter reading, tariff and load control
- EN 13757-1:2002: Communication systems for meters and remote reading of meters
- IEC 61968-9: System Interfaces for Distribution Management – Part 9: Interface Standard for Meter Reading and Control

While harmonization of EN 62056 and EN 13757 is already being undertaken, some standardization initiatives go beyond the scope of M/441. A harmonization of standards more generally in this area is necessary to prevent further development of different (and competing) standards for the same purpose.

SM 2: Smart metering, building/home automation and electric vehicles are envisaged as elements in smart electricity grids. It is recommended that CEN/CENELEC/ETSI consider the use cases involving these elements and take care in their standardization work in these areas to ensure the needs and applications of smart grids are addressed in a harmonized fashion.

SM 3: Specifically to assist the development of proposals for possible link technologies in relation to smart grids and e-Mobility, it is recommended that CEN/CENELEC/ETSI should jointly undertake an investigation of the interfaces required insofar as they are not currently being addressed within the M/441 mandate. The ESOs should propose where standardization in these areas is necessary, taking care to ensure harmonization with existing metering models and other relevant standardization initiatives.

5.2.5 Industry

5.2.5.1 Description of scenario

In Europe, the share of electricity demand for industry is around 40% of the total electricity demand [12)]. 70% of this electricity consumption is related to motors, 9% for electrolysis, 4% for lighting and 17 % for various other uses. Now, if we look at the breakdown of motor consumption, 30% is for compression, 20% for pumps, 13% for ventilation and 37 for various other uses.

Considering now the objectives of smart grid in Europe, which are:

- Objective 1: The average level of energy consumption shall be reduced as much as possible in order to reduce CO_2 emission, carbon footprint.
- Objective 2: The energy consumption should be smoothed as much as possible in order to use the power generation at its optimum level.
- Objective 3: Peaks of energy demand shall be reduced as much as possible.
- Objective 4: Any distributed energy sources should be integrated as active sources without affecting the power quality of the network.

This part summarizes the major scenarios that should be considered for industrial installations and how European standardization can contribute to reaching the objectives, identifying the gaps to be filled in different domains.

Every industrial application can be split into three major parts:

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12) Source: Eurelectric 2005 – Primes baseline.

- The industrial process (motors, electrolysis…)
- The electrical components linked to the process (the electrical distribution from the main supply connection (possibly high or medium voltage, possibly single or multiple connection point) down to the loads, including the switchgear and cabling system, lighting, heating, ventilation, air conditioning, Information Technology…). Many industrial sites may also have their own on-site generation facilities, combined with the process or not.
- The auxiliary equipment supply (gas, compressed air…)

Energy management

The first and most important step for industry is to understand where and how energy is being consumed or exchanged. Daily and seasonal variations have to be considered.

It is more and more common to have on site an energy management system which ensures the availability of electricity and provides a first level of understanding of how the electrical network is loaded (monitoring load consumption, switchboard load and spare capacities), which is the current power quality (monitoring harmonics, sags, …), which source is currently active, and possibly offers remote manual and/or automatic means to control the network and then increase the field staff efficiency, while improving the electricity availability.

This energy management system can be stand-alone or can be part of the process automation system. This applies to industrial processes, electrical components linked to the processes and auxiliary equipment. In many cases, the same technology is used on the power utility supply side (substation automation technology) and demand side.

In order to facilitate energy management, all the equipment related to the process, to the electrical installation and to the auxiliary services should be able to communicate together. Because of many existing industrial processes, an important consideration is the ability to upgrade on-site energy systems to enable integration with smart grid signals such as dynamic pricing and curtailment demand response.

Industrial micro grids

Industrial facilities are often built in areas conducive to the installation of renewable power generation such as wind, solar, geothermal or biofuels. Many of them currently operate gas-fired or coal-fired co-generation.

This new application of industrial micro grids will require advanced automation systems.

At some time, the development of bulk generation based on renewable resources may be considered. Solar energy during the day can be balanced with wind energy at night and storage energy providing energy when needed. This can be considered as a virtual power plant operated as a single generator.

5.2.5.2 Use cases

Table 4 – Use cases - Industry

Related objective	Use case	System(s)	Main Interfaces
1	I want to know how much electricity I am using per usage (industrial process, lighting, HVAC …) in order to make me aware of the energy consumption and CO_2 emission.	• Energy management system • Internal electrical installation/ installation for gas/installation for compressed air…	Electronic equipment able to measure electricity parameters (can be combined with functions), communication systems for aggregations.

Related objective	Use case	System(s)	Main Interfaces
1	I want to know the cost of electricity per usage (manufactured product, industrial process, lighting, HVAC …).	Energy management system	Electronic equipment able to evaluate the cost of consumed electricity (time-of-use measurement capabilities), as close as possible to the load, communication systems for aggregations. Tariff event channel down to the load.
2 – 3	I want to be informed about the change of tariff, peak period… to make decisions on load management.	• Energy management system • Internal electrical installation process automation system	Tariff information channel, accessible to the energy management system (or process automation system).
4	I want to participate in grid ancillary services and get the best value from the reactive energy I can provide.	• Energy management system • Internal electrical installation / distributed network operator	Demand response information channelled down to the energy management system.
2	In case of a power cut, I want my on site generator(s) to be able to supply the loads and/or to charge possible batteries.	Energy management system, on site generator(s)	Energy management system
4	By aggregation of several generators, I would be able to build a micro grid in order to increase power availability and contribute to reducing power variation in the grid.	Micro grid installation / utility network	Energy management system

5.2.5.3 Existing standards

Relevant standards for communication in industrial electrical installations:

EN 61850, *Communication Networks And Systems For Power Utility Automation*

EN 61158, *Industrial communication networks (including Profibus, Modbus TCP, and many others, ..)*

EN 62056, *Data exchange for meter reading, tariff and load control*

EN 13757, *Communication systems for meters and remote reading of meters*

EN ISO 16484-5 *Building automation and control systems* – Part 5: Protocol (BACNET) (ISO/TC 205, CEN/TC 247)

5.2.5.4 Recommendations

Going into detail to fulfil the requirements of the above use cases, the following gaps appear and related recommendations are proposed:

Ind-1: Tariff information
On-site energy management systems should be able to spread tariff information down to the load. We recommend extending the IEC 61850 model (the most common backbone system for EMS) to support tariff-related information.

Ind-2: DR information
The demand response mechanism is not considered yet to support network ancillary services. We recommend extending the IEC 61850 model (DER) and other DR information channels to support ancillary services participation.

Ind-3: Smart Meter and building system interface
In their work on data exchange between the smart meter and the building management system, the European Standardization Organizations should ensure coordination between CEN TC 247 and TC 13.

Ind-4: Harmonized data model for industry and power grid
Too many data models already exist without mapping between them. We recommend harmonizing the data model related to energy management between Industry and Electricity (EN 61158, EN 61850).This work should be coordinated between CLC/TC 205, TC 65 and TC 57.

Ind-5: Electrical installation allowing for DER integration
The usage of distributed energy resources as part of electrical installations and part of micro grids for industry raises new safety and protection issues. The multi-sources aspect is not covered by current installation rules. We recommend TC 64 to work on new installation rules for safety aspects and TC 8 or TC 99X to work on common rules for grid protection. TC64 should develop a dedicated part within the HD 60364 to cover this need, keeping in mind that all national wiring rules through European countries are based on the HD 60364.

5.2.6 Home and building

5.2.6.1 Description of scenario

The domain *Home and building* covers on the one hand residential buildings (family houses, apartment blocks etc.) and on the other side non residential buildings (offices, education buildings, hospitals, hotels, restaurants, wholesale, industrial buildings etc.). [13)].

This part describes the scenarios from this domain that require information to be shared between the other domains of the smart grid.

The ideas described in the following are independent from the technology which is used for the implementation and provide a technology-neutral description of energy management functions in homes and buildings.

Energy management in home and building applications should consider visualization of energy consumption, load management and also local generation and possible storage. It might be necessary to consider various possible interlinks between multi-energy sources like e.g. electricity, heat, gas, solar and their interdependencies. Some energy management related functions within a building are already available, and new functions might be developed. But now the new challenge will especially be the link between the grid and the building which will need new functionalities to be defined.

Some resulting scenarios are described with use cases referring to the following objectives:

Main objectives

- The average level of primary energy consumption is to be reduced as much as possible in order to save money and to reduce CO_2 emissions (carbon footprint).
- Power generation will change to CO_2-free generation in the long term with a high share of renewables and with distributed energy resources (DER).

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13) For further definitions of Home Automation refer to the respective documents of CLC/TC 205 and of Building Automation to the respective documents of CEN/TC 247

Conclusions:

- A new balance of supply and consumption has to be established. The energy consumption domains should receive enough information to be able to organize the use of power in relation to generation. Peaks of energy supply are to be reduced by management of energy consumption accordingly.
- Energy consumption as well as power generation from in-house facilities (e.g. PV, CHP or other distributed energy resources) should be managed and controlled in such a way that
    - the consumption is minimized, and
    - the load and the internal generation will be balanced inside and/or in relation to the needs of the electricity grid.

5.2.6.2 Use cases

The following four major use cases for home and building applications arise from these considerations.

These use cases expand the work done in the EG1Task Force.

1) Visualization of energy consumption (see EG1 Report page 11)
The user should be aware of the consumption: water, gas, electricity, heat. For electricity, it is fundamental to inform the consumer of energy consumption per usage (heating, cooling, lighting, ventilation, …) This provides the opportunity to empower people to manage better the utilization of their energy based on this transparency. For that purpose, clear, consumer friendly information is necessary. In order to visualize meter data, some form of communication between energy management and metering is necessary. This use case also leads to a request for sub-metering within homes and buildings of the important resources as well as important consumers.

2) Efficient control of homes and buildings (see EG1 Report page 11)
A variable, digitally transmitted electricity tariff enables smart appliances, automation and management systems or intelligent devices to optimize their respective processes regarding smart grid aspects like the optimized use of renewable energy. In a next step, variable price signals might also be investigated for water, heat or gas supply.

3) Increasing use from in-house generation as a result of an optimized synchronization of appliances or by means of additional stationary storage systems. Therefore the inclusion of distributed energy resources in homes and buildings (e.g. photovoltaics on the low voltage level, local storage facilities, micro-CHPs) as a part of the Home and Building domain is seen as an advantage. This allows a first balancing within each home or building.

4) Extension of the use cases by further classical home automation, health care and service information issues, to secure the financing of infrastructure inside the home and buildings, which is necessary to reach the main objectives.
If the infrastructure is available, various other use cases, applications or services might be developed. The ideas of these use cases already partly exist, but as stand alone solutions they are often not economical. Experience from telecommunications also shows that completely new ideas will arise as soon as an open infrastructure is available and widespread. If the aim is to develop attractive business models and to provide an attractive system for the customer, a segmentation of various automation tasks within a future smart home might be counterproductive. Therefore standards have to be designed in such a way that they enable further integration of use cases coming from different domains like classical home automation, energy management, health care, ambient assisted living and service information issues. Such an approach might go hand in hand with the world of home and building automation/appliances as well as home entertainment and the telecom industry.

5.2.6.3 Recommendations

For realization of these use cases, there are the following recommendations, which are subdivided into a number of statements in general and two concrete recommendations for standardization.

- In order to reach a widespread use of new energy management functions very rapidly, it is seen as fundamental to limit effort and costs for new installations and new wiring. Therefore it should be considered to use and improve wireless solutions such as radio frequencies (RF) or communications using the existing wiring for electrical power (Mains Signalling, PLC Power Line Carrier). For new buildings, special communications wiring such as a TP system can additionally be used for communication.
- In future smart homes and buildings the energy management systems should be part of the infrastructure. Considering that the owner of smart appliances might move several times in his lifetime he will expect that his smart appliances will work in the new surroundings again – together with new suppliers of energy and their new price signals / tariffs. It is advisable from the customer acceptance point of view that the smart grid functions of devices and appliances be available even after a removal. Therefore standardization is of the greatest interest if customer acceptance is to be achieved.
- One important requirement for such a kind of infrastructure must be minimum power consumption. Otherwise, the standby power consumption of the new devices will eat up the efficiency advantage realized on grid level or inside the house. (e.g. primarily specializing in the optimum between necessary data rate and power consumption or realized as “add on” to other services).
- Energy management in the area of private households should work by means of incentive systems. According to market research, many customers will not accept external control of their equipment, but indirect control by means of incentives with a final decision by the customer will be accepted. This means that the final control of applications by the customer is necessary (charging of electric vehicles, washing machine, lighting, HVAC, shutters, alarms, intrusion and safety, etc...).
  For this reason energy management is to be part of the “home and building” domain, not part of the “grid” domain.
  Also in case of commercial buildings, standardization concepts are to be given freedom in achieving the main objectives by managing the resources, renewable infrastructure and comfort/process requirements within the domain.
  Especially for customers with a higher amount of consumption (cf. “Industry” section of this report) external energy services might be offered, including controlling and managing the devices. This kind of control only works with agreed preconditions and contractual agreements.
- The standardization needs to ensure that incentives for efficient power usage may be provided by the utility itself or a third party service provider. Also the optimized use of in-house generation (e.g. photovoltaic) might be an incentive for energy management.
- Consumer privacy and security are to be maintained; therefore, issues of IT security and data privacy must be considered very seriously. It is not necessary for any device inside the home/building to be visible and addressable directly from the grid/net. Security strategies have to be worked out over all domains. A cross domain security strategy is needed to identify and cover gaps in the existing standards (cf. “Information Security” section of this report).

Recommendations for standardization

HB-1: Separate realization from standards description
The use cases described above interface with the field of smart metering, but have to be logically separated. In standardization, there are arguments for distinguishing meter gateways from energy management gateways, considering both applications as two logical blocks, since both fields are driven by different kinds of interests and innovation speeds. Competition is likely to result in different devices and technologies combining logical applications defined by standardization. In order to be open for such market development and for innovation, standardization should not define the device but the logical functions, data and interfaces in case these are needed for communication between different market roles or devices.

HB-2: Unified language for tariff information
A unified language (a kind of common semantic layer above the existing technologies) has to be defined to communicate demand response related elements (e.g. an incentive like a new price / tariff). A Europe-wide or even worldwide unified data model for these aspects would be favourable considering the global market for smart appliances, devices and automation systems. For that purpose, data models/profiles have to be developed from the use cases. A multi-stakeholder committee considering the different domains and ESOs

involved should be assigned this task of considering ongoing initiatives (from research, industry and standardization).
This approach can succeed only by broad introduction including existing standard technologies. Therefore, the unified language must be mapped onto the communication standards lying below. These "lower standards" should support this mapping mechanism which is not the case today.

The diagram shown in Figure 15 is suggested as reference architecture for the home/building, pointing out the different logical blocks, and can be easily integrated in the whole system architecture (e.g. smart metering or service provider architecture; the relationship with Smart Metering Mandate M/441 is therefore given). Please note that the figure is not related to a specific hardware design, but merely shows a logical separation of functions without predefining where and how those functions are implemented.

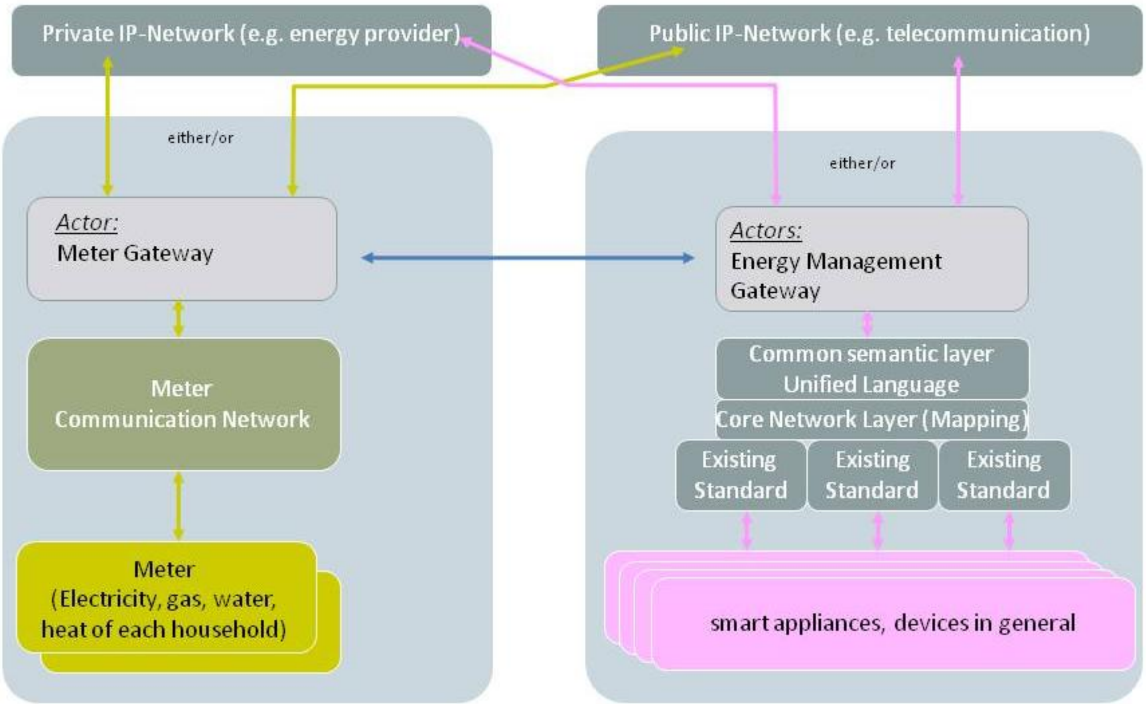

Figure 15 – Logical separation of metering and energy management

5.2.7 Demand response applications

5.2.7.1 Description

Demand response includes the mechanisms and incentives needed for utilities, power generators, power storage, energy market, energy retailers, industrial, building and residential customers, electricity installers/contractor to contribute to **grid level optimization.**

This includes (but is not limited to)

- shaping energy load profiles over time by requesting changes in current use,
- shaping the generation (bulk and DER) profiles depending on selected criteria (production constraints, emission regulation, energy price, ..), or

- performing power network ancillary services when energy quality (voltage, frequency, ..) criteria may not be reached or power reliability is at risk.

Demand response is necessary for optimizing the balance of power supply and demand and the balance of reactive power supply and demand, and appears as one cornerstone of smart grid deployment, as shown in Annex 5. Demand response standards are to support market concepts and models for demand response services (real time market, price signals, schedule exchange formats…).

Demand response appears de facto as one of the largest and most complex smart grid applications to set up.

Demand response technologies have evolved over the years; non-automated mechanisms (currently in use) include phone calls, pagers, and other messaging to plant managers. Current mechanisms support varying levels of automation.

However, the deployment of a high ratio of intermittent sources in a smart grid seriously increases the need for demand response:

One of the characteristics of these types of energy sources is the unpredictable energy production. Successful integration of these sources is supported by improved methods of forecasting distributed demand and supply as well as novel mechanisms for leveraging flexibilities in distributed demand and supply, e.g. reducing peak load or matching production profiles from renewable energy sources through scheduling of the production or consumption.

The integration of renewable and other intermittent sources increases the need for balancing reserves and spinning reserves, but also offers new means of participation by ancillary services. It also increases the expected level of responsiveness of the system.

The context of demand response is new for the market, and will be based on business models which may need years to mature.

A key load shaping requirement will come from the deployment of the Electric Vehicle.

The integration of electrical vehicle related applications is one of the focal points of smart grids and the application which enables the efficient connection of the electrical vehicle must be seen from a system approach:

- From an electrical point of view -> considering that, more or less, an electric vehicle will need 1 kWh to travel 5 to 7 km, a quick calculation shows that unmanaged charging methods can create distribution network congestions in unexpected areas.
- From an energy management point of view, the global optimization of the charging of electric vehicles must support some mechanisms to avoid charging at times of peak load and make the most efficient use of sources of renewable energy. In that sense, the electric vehicle may potentially support quick charging mechanisms and operator based load levelling.
- In addition, the EV can become a storage device and then participate in ancillary services under certain conditions (which may appear by 2015).

5.2.7.2 Gaps

New standard energy supply products like pricing signals, DR signals and DR process interfaces as part of CIM, COSEM and IEC 61850 are missing.

It therefore appears relevant to consider only one body to address demand response applications including the integration of DER and the coming need for integration of EVs. However, the EV deployment has its specific set of constraints:

- The standardization environment is different, and involves other standardization bodies (today mostly the ISO/IEC JWG V2G in charge of defining the set of standards needed to define the communication interface between the vehicle and the grid). The joint WG ISO/IEC JWG V2G standardization is positioned between IEC (mostly TC 69) and ISO (mostly TC 22/SC 3/JWG 1).
  IEC TC13 and IEC TC69 have established a liaison to support EV metering requirements.
  IEC TC57 has already embarked on standardization work to support the connection of the charging station to the grid.
- The European Commission has already mandated (M/468) the European Standardization Organizations (CEN-CENELEC and ETSI) to work on electric vehicle charging systems.

5.2.7.3 Recommendations

DR-1 Create DR task force
Create a single DR task force at CEN/CENELEC/ETSI level encompassing the adaptation of DR signals to manage DER and electric vehicle charging issues. Consider other countries' experiences and standards (OpenADR, OASIS work in EMIX and Energy Interop committees, E-Energy…)
Close coordination with the IEC/ISO and ETSI ITS standardization bodies for communication exchange with the EV.
When coming to "How to proceed", some more detailed insights are given in Annex 5.

DR-2 Avoid European mandates overlapping
Define clear interface and responsibilities between the smart grids mandate, the smart metering mandate and the EV mandate and associated standardization bodies (part of smart grids mandate). Ensure interoperability between the different standards.

DR-3: Complement Data Model for DR signals
Include pricing signals, DR signals and DR process interfaces into CIM, COSEM and IEC 61850.

5.3 Market actors and roles

The concept of market actors and roles is crucial, e.g. for building a relevant set of use cases for smart grids. For each actor in the electricity supply chain and electricity market, its current role and responsibilities are summarized, followed by the recommendations on necessary changes (in terms of scope, actions and governance with particular focus on regulatory aspects) required for smart grids deployment. Special attention is paid to the issues of relevance for standardization, indicating where applicable relationships with the electricity and / or ICT standardization aspects.

5.3.1 Roles & responsibilities – Current status

Transmission System Operator (TSO) [14)]
is responsible for operation, maintenance and development of the transmission network in its own control area and at interconnections with other control areas, long-term power system ability to meet the demand, and grid connection of the transmission grid users, including the DSOs.

Distribution System Operator (DSO) [15)]
is responsible for operation, maintenance and development of its own distribution grid and where applicable at the connections with other grids, ensuring the long-term ability to meet the distribution demand, regional grid access and grid stability, integration of renewables at the distribution level and regional load balancing (if that is not done by the balance responsible party).

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14) Cf. Article 2.4 of the Electricity Directive 2009/72/EC

15) Cf. Article 2.6 of the Electricity Directive 2009/72/EC

Generator
is generating electricity, contributing to voltage and reactive power control and providing relevant data to the energy marketplace.

Electricity installer/contractor
Electrical contractors have an important role for smart grids deployment. They design, install and maintain intelligent systems for all kinds of industrial, commercial and domestic purposes. Alongside the well-known power and lighting applications, they also install ICT and telecommunications, public street lighting, high medium and low voltage lines, control and energy management systems, access, fire and security control equipment, lightning protection systems, advertising and identification signs, emergency power generating systems and renewable energy systems.

Customer/consumer
can, besides consuming electricity, be involved in contract based demand response. Depending on their characteristics, consumers are classified as industry, transportation, buildings and residential customers.

Supplier
is a grid user who has a grid connection and access contract with the TSO or DSO, supplies electricity to the customers and provides local aggregation of demand and supply.

Retailer
sells electricity directly to consumers and could also be a supplier.

Power Exchange
provides a market place for trading physical and financial (capacity/energy and derivates) contracts for capacity allocation within a country/control area, region or across the control area border.

Balance Responsible Party
ensures that the supply of electricity corresponds to the anticipated consumption during a given time period and financially settles imbalances that arise.

Clearing & Settlement Agent
assumes liability for clearing and/or settlement of contracts and provides contractual counterparty within a Power Exchange and for Over the Counter (OTC) contracts.

Trader
buys and sells energy in an organized electricity market (Power Exchange) or over the counter.

Aggregator
offers services to aggregate energy production from different sources and acts towards the grid (TSO and / or DSO) as one entity.

Technology, products and service providers
in addition to the actors above: electric power grid equipment vendors, ancillary services providers, metering point service providers & metering point service operators, information & communication technology (ICT) service providers, grid communications network providers, home appliances vendors, building automation / energy management providers, electric transportation / vehicle solutions providers.

Regulator
is an independent authority responsible for the definition of electricity market framework (market rules), for setting up of system charges (tariffs), monitoring of the functioning and performance of energy markets and undertaking any necessary measures to ensure effective and efficient markets, non-discriminative treatment of all actors and transparency and involvement of all affected stakeholders.

Standardization bodies
are responsible for standardization of all relevant elements and components within the electricity supply chain.

EU and national legislation authorities
are in charge of defining legislation and metrics for areas such as environmental policy, social policy, energy policy and economic policy. They are also responsible for the authorization needed to develop the electricity grid infrastructure.

Financial sector undertakings
provide capital to other actors or invest themselves into the projects within the electricity supply chain (grid, generation, etc.).

5.3.2 Roles and responsibilities – Recommendations to other actors

The recommendations on scope, policy and regulatory directions below address the necessary changes to the current roles and responsibilities of market actors, in the light of smart grids deployment and standardization.

TSOs and DSOs

It appears that the DSOs will have to face the greatest changes to make smart grids a reality. The reasons for that are the growing distributed character (resulting in growing bidirectional power flow at all voltage levels) and variability of generation, customer privacy issues, system security, data and information processing for new applications and concepts such as Virtual Power Plants, etc.

The TSOs will have to provide more support and communication of data to the DSOs, but will also require more specific information from the DSOs, especially with respect to the real-time aspects of distributed generation. In order to achieve this, both TSOs and DSOs need to ensure that the standards they implement for communication and data exchange are compatible.

Generation

The responsibility of distributed generation in contributing to grid stability and operational security will increase, hand in hand with the technological progress which will enable that in a cost effective manner.

Electricity installers/contractors

The role of electricity contractors in ensuring proper functioning of the future smart grids will increase in the future. Because of the large scale / number of respective installations and equipment used, standardization is an essential issue in order to ensure on the one hand effective and efficient fulfillment of their role and on the other hand to reduce costs.

Customers/consumers

Customers/consumers will become more engaged in Demand Side Response (DSR) and DSR will become increasingly important to enhance the overall system efficiency and effectiveness.

Moreover, based on the increased information on consumption, consumers will make more informed decisions on how and when they can save energy, either by changing their behaviour or by engaging with an energy efficiency service provider.

Suppliers and aggregators

Suppliers and aggregators will offer new energy efficiency services such as peak load management or energy efficiency enhancement services. The ultimate result will be more competitive and market driven products.

New market places

New market places will emerge, contributing to further power system optimization, but also requiring different rules than the ones of today. The structures in the markets will reflect the decentralized character of the power system and balancing, clearing and settlement will have to react to this development by opening up to smaller participants.

Traders

Trade will be characterized by increasing use of intraday trading platforms, relying further on more sophisticated, flow-based capacity allocation methods to cope with changes in the increasingly variable generation patterns. Beyond that, DSR will allow the best use of the most effective measures on the customers' side, also contributing to managing the variability of wind power.

Providers of technologies, products and services

Technology and solution providers will continue to improve the equipment supplied, integrating more and more 'smartness' into their products. An open, standards-based approach will be the key to market development with standards set at the European level, through a transparent process. New technologies will fulfil functionalities that had not been available in the past (e.g. relying on advanced power electronics).

The ability to better understand the customers' needs and behaviour will enable new innovative business models and service offerings to be delivered. These in turn will fuel further development in new technologies, products and services to capitalize on these new opportunities.

Examples of new services range from data mining systems for identification of new customer opportunities, infrastructure management products for distribution systems, home automation devices and home energy management devices and services, contract-based products to consumers based on their individual usage pattern of energy, etc.

Regulators

It is important that national regulatory authorities and European institutions (CEER, ERGEG and ACER in the future) ensure a long-term predictable and stable regulatory framework, including adequate incentives for investments, taking account of: 1) economic and technical efficiency, 2) quality of supply, 3) "smartness" of the electricity grids and 4) energy efficiency. The payment of costs must at any time – today and in the future – remain fair according to the actual originator of these costs, adhering to the principle of causality. It follows that a well balanced and sustainable approach is needed between the appropriate rate of return for the regulated grid operators and the respective requirements and benefits for the grid users.

EU and national legislation authorities

Policy makers should ensure active support for market and competitive business activities – including innovative approaches. At the same time, they should avoid interfering where this is not necessary to preserve a competitive environment, ensure non-discriminatory treatment and guarantee proper functioning of all markets in a sustainable way, for the benefit of all actors and society as a whole.

5.3.3 Recommendations to the ESOs

An open, standards-based approach is crucial for the deployment of smart grids. The recognized European Standardization Organizations (ESOs), CEN, CENELEC and ETSI are traditionally closely linked to regulation at the European level, providing the technical specifications that are needed to implement regulation. These links are explicit in the context of EU Directives including those for EMC (Electro-Magnetic Compatibility), low-voltage and (in relation to Smart Metering) measuring instruments. The ESOs maintain formal links with global standardization bodies ISO, IEC and ITU-T (and also with UN-ECE, which is relevant for electronic business process standards) and those links should be utilized to avoid duplication of activities and possibly conflicting standards at the European or a wider level. Whereas some issues can only be standardized at European level, in other cases the necessary standards should be provided globally but the ESOs should ensure these global standards meet European requirements. In the ICT standardization, there is a plethora of different industry consortia providing sometimes competing standards solutions, and care needs to be taken to avoid interoperability problems or issues related to intellectual property rights.

Mkt-1 Defined actors and roles as the basis of smart grid use cases

Standardization should also play a role in other areas where technical enforcement of market decisions by regulators or private sector actors is needed. Moreover, Standardization Organizations have to provide the needed flexibility to accommodate the increasing variety of business models. These needs must be based on an agreed set of use cases to be developed and maintained over time. All of those use cases should be based on the described actors and roles.

Mkt-2 Market communication

One of the particularly important areas of ICT standardization concerns market communication standards like EDIFACT, etc. and their capability to provide the services and functionalities. Besides being of general interest to standardization bodies and all other stakeholders, this issue is of utmost interest to all market players (suppliers, generators, traders, etc.) and also network operators, as it ensures a uniform and efficient exchange of data and information in the market. It is the standardization bodies for electricity and the ICT sector together who will need to review and identify all the required improvements and further developments in this area.

6. Further activities

6.1 Organizational activities and projects to be started

A number of recommendations are found to be fundamental in order to further improve the smart grid standardization landscape in Europe. These require immediate action by the JWG and therefore changes to the scope and organization of the JWG itself.

1) Prioritization of the identified gaps and recommendations
A prioritization of the identified gaps and recommendations needs to be performed. The importance of the identified standards will vary in their relation to smart grid applications. A number of standards will form a core set of standards, which will be valid or necessary for nearly all smart grid applications. These standards will be considered priority standards. Furthermore, a whole framework of standards and further actions needs to be defined in order to help the smart grid vision to become true. A number of criteria will be defined, in order to perform the desired prioritization. The prioritization needs to be checked against the requirements of an upcoming mandate.

2) European reference architecture
One of the major tasks found during the report was to develop a European reference architecture which is complete and flexible enough to incorporate current and future high level services and functionalities. The task of developing such a reference architecture should be performed by a subgroup of the JWG. Therefore a task force “Reference Architecture” will be formed by the JWG, starting operation from 01/2011.

3) European smart grid use cases
Based on the work on the reference architecture a single set of European smart grid use cases needs to be collected in order to start a systematic, top-down, continuous process of identifying gaps in standards. The necessary tools and processes must be developed by the ESOs. The design of these changes should be performed by a subgroup of JWG. Therefore a task force “Use Cases” will be formed by the JWG, starting operation from 01/2011. Close cooperation with the activities of IEC TC 8 and CENELEC TC 8X respectively is needed.

6.2 Mandate

A Standardization Mandate to European Standardization Organizations was developed to support European Smart Grid deployment. The scope of “Smart Grid” for the purpose of this mandate is as defined by the Task Force for the implementation of Smart Grids on the European internal market.
The objective of the mandate is to develop or update a set of consistent standards within a common European framework of communication and electrical architectures and associated processes that will enable or facilitate the implementation in Europe of the different high level smart grid services and functionalities as defined by the Smart Grid Task Force that will be flexible enough to accommodate future developments.The mandate will be issued to the ESOs in spring 2011. It will have four main deliverables:

- Technical Reference Architecture
- Sustainable processes
- First set of standards
- Further iteration

Efforts have been made to ensure that the findings of the report do not conflict with this future smart grid standardization mandate and that the identified actions from the report meet the process to execute the mandate.

6.3 Report 2.0

The report in its current status is seen as a basis for further work on the smart grid standardization in Europe. The current focus is on the overview of already usable European standards to support the basic functionalities set out by the Smart Grids Task Force. Some high level recommendations have been derived in the respective domains and the cross cutting issues. The report is the current working result of the joint working group. Other comments have not up to now been collected. The report will be circulated to technical committees of the ESOs and other interested parties.

Therefore, there are a number of reasons why this report needs continuous updating:

- Comments from a wider audience need to be incorporated (e.g. TCs / NSOs).
- The initial report was developed in a parallel work mode, which could not avoid some overlaps or even inconsistencies.
- The requirements of the current status of the European legislation laid down by the respective mandates must be considered.
- The ever changing environment in technical and regional aspects make it necessary to revise the report at periodic time intervals.

A revision of the report is to be planned and executed in 2011, mainly in order to accommodate the collected comments from outside the JWG.

Annexes

Annex 1 – Summary list of recommendations

(4.1 General recommendations)

G-1 Further development of the report
This report should be further developed with regard to the focal topics identified, in cooperation with the corresponding professional groups and stakeholders. Topics such as energy storage, security of supply and micro-grid may also be included.

G-2 International standards as a basis for promoting EU industry
Standardization of smart grids must be based on existing international work, to avoid reinventing the wheel, to accommodate solutions which are already standardized and applied for practical purposes and to secure the interests of European manufactures who are operating globally. This document recognizes that work and therefore builds upon the globally recognized smart grid standards as identified in Section 5.

G-3 Speed of implementation – reuse existing systems
There are already a number of quite advanced initiatives around the world which are described in section 2.4. In order to secure European interests in the implementation in Europe and around the world existing mature domain communication systems should be used. The ESOs should further standardize necessary interfaces and product requirements and must avoid standardizing applications and solutions. The focus must be on standard development according to the R&D and deployment priorities of the EU given in the Smart Grids Task Force reports, the ETP and the SDD.

G-4 Concentrate on future proof standardization
Smart grids is a highly dynamic technical field. Standards must therefore be generic and open to include future developments from R&D and pilot projects. It is therefore recommended to concentrate on generic standards which flexibly mirror market needs and technological development.

G-5 Build up a SINGLE repository for smart grid use cases
The descriptions of functionalities / use cases represent an important basis for the further work, including that on standardization. It is therefore recommended to collect use cases as a base to start detail work on standards. Supply this repository with at least

- the M/441 set of use cases,
- active liaisons with all European smart grid projects,
- the EG1 to EG3 reports of the Smart Grids Task Force of the European Commission, and
- experience from of the national committees.

Check if the re-use of use cases coming from other countries or regions may lead to single worldwide use-case definition.

Define the methodologies: templates, classification, organization, harmonization of use cases, publication, etc.

G-6 Adapt standardization processes
Define the processes needed to match the lack of maturity of many smart grid applications. As stated in the EG1 report, "smart grids deployment will be a continuous learning process" and standardization should propose a clear set of processes to cope with this learning process. For instance, use an electronic form of communicating standards in order to enable seamless integration of standard data models. Define open and transparent quality processes attached to smart grid standards, covering the whole life cycle of such standards, including how to collect issues, to treat/fix issues, and then to validate and test.

G-7 - Relationship between legislative requirements and standardization
A proven concept, described as New Approach and further developed as New Legislative Framework (NLF), has been the legislative definition of essential requirements. Related to the legislative document (e.g. directive or regulation), harmonized standards from the European Standardization Organizations (ESOs) describe further technical details. Following the harmonized standards it can be assumed that the essential requirements of the legislative document are fulfilled (presumption of conformity).
For the system approach of the Smart Grid no essential requirements from legislation are currently available. The relationship between the standards produced by the ESOs under the standardization mandate and future legislative initiatives at the European level needs further consideration in due course, once the latter are defined.

(4.2 European Standardization Organizations (ESOs))

O-1 Extend timeframe and scope of JWG Smart Grids
The JWG scope and duration should be adapted to the wider needs of further tasks, coordination of responses to an EC mandate and a further investigation of the ever changing environment in the smart grids area.

O-2 Marketing of ESOs work on Smart Grids
ESOs must highlight their work on the markets, and promote the work already done on international and various regional levels. This is necessary to maintain the high level of influence on international standardization and therefore on solutions. Funding of the external representation of the ESOs should be investigated as international activities indicate that the roles of the US and Asia are growing due to high public funding of the respective standardization organizations. Although this might conflict with the traditional role of European standardization the short time frame for action in order to participate within the ongoing debate at international level and the need to standardize in areas where R&D still is needed, public funding might be justified for some stakeholder groups like R&D institutes or SMEs. Any solution should be based on the co-operation with national standardization organizations and their experts and expertise.

O-3 Mandates in relation to Smart Grids
Concerning the different mandates that are or will be issued in the context of smart grids, consistency and coherence must be ensured by the Technical Boards of CEN and CENELEC and by the ETSI Board by taking account of and building on the results of the work carried out already as far as possible.

(5.1.1 Terminology, object identification and classification)

Term-1 : Harmonization of glossaries
Establish a process for harmonizing smart grid vocabulary over different domains.

PPC-1 Electronic Data models
Align glossaries as much as possible with Electronic Data Models (TC 57/SC 3D)

(5.1.2 Reference architecture)

Ref-1: **Conceptual Model**
Continue work on a Conceptual Model which describes the major stakeholders and their interactions taking into account the work of the Smart Grids Task Force

Ref-2: **Functional Architecture**
Develop, possibly based on the IEC/TC57 model, a Functional Architecture that takes into account all the generic, global aspects of smart grids as well as all the European specificities, in particular those outlined in

the Conceptual Model. This model must accommodate the harmonization of potentially different architectures produced during the definition of several smart grid applications[16)].

Ref-3: Communication Architecture
Develop a Communication Architecture to take into account the large variety of network and connectivity scenarios involving communications interface.

Ref-4: **Security Architecture**
Expand the work done in the European Commission Smart Grids Task Force, in particular the EG2 Report, to create a security architecture also taking into account a conformity assessment approach whenever applicable.

Ref-5: **Consistent Information Model**
Ensure that the Information Architecture is both relying on precisely identified standards and also that the consistency of Information Model is guaranteed by an appropriate mechanism for re-aligning separately developed (and possibly diverging) models.

Ref-6: Create a Reference Architecture team within the Smart Grid Joint Working Group. The role of this team would be to set up the scope and work methods for the work associated with the Reference Architecture, and make sure that at least some of the major views (Conceptual Model, Functional, Communication and Security Architecture) are in line with the deadlines of the Standardization Mandate.

(5.1.3 System aspects)

Sys-1: Adapt ESOs to handle top-down system approaches
Set up adequate bodies and sustainable processes to manage smart grid top-down system approaches and the relationship with the existing TCs in charge of developing standards. These processes should cover the overall life cycle of standards from upstream requirement definitions, down to interoperability testing. Provide an incremental way of proceeding and maximum flexibility for addressing unknown future usages.
Establish the conditions for managing European smart grid use cases in a consistent way: shared rules, shared template, shared list of actors, …while keeping alignment with the IEC SG3 Smart Grid use cases initiative.
As soon as possible, feed the TC 8X with these top-down smart grid use cases, to be taken into account by ad hoc standardization bodies. Ask the European projects to feed the standardization process with European smart grid use cases and elaborate the set of European smart grid use cases.

Sys-2: Initiate "Smart Grid Data model" activity
Initiate activity on a "Smart Grid Data model" within a group reporting to JWG.

Sys-3: Initiate "Smart Grid System Management and security" activity
Initiate "Smart Grid System Management and security" activity within a group reporting to the JWG.

NOTE Information security aspects are dealt with in 5.1.5.

Sys-4: Check comprehensiveness of standards towards interoperability
Check the coverage of selected standards against semantic, behaviour, conformance testing and fill gaps when needed.

Sys-5: Systematically address system interoperability
Pave the way for implementing step-wise approach to interoperability.

Sys-6: Create quality process for smart grid standards
Define open and transparent quality processes attached to identified smart grid standards covering their

16) This model should be fed back to global standards developing organizations.

whole life cycle, including answers on how to collect issues, to treat/fix issues, to take into account new market needs and then to validate and test, including the compatibility with former releases.

(5.1.4 Data communication interfaces)

Com-1: Further develop power/distribution line communication
Follow the recommendations of the SMCG Technical Report, which already contains a work plan for CEN TC13 to integrate different protocols with the existing standards.

Most EMC guidelines and standards start at frequencies above 150kHz, which could lead to interference between domestic appliances and PLC devices operating below this range. For frequencies lower than 150kHz the EMC guidelines/regulations should be developed. For PLC communication the use of the frequency range up to 540 kHz should be specified, subject to protecting existing users of these frequencies for radio communication and other purposes.

For broadband PLC we recommend that where applicable and no alternative standard inside ETSI/CEN/CENELEC can be found the IEEE P1901 should be taken into account.

Work with the ETSI PLT TC committee to evaluate the use of ITU-T PLC Narrow band OFDM G.9955.

Com-2: Harmonize activities on data transport technologies
Developments made by ETSI and the data communication related IEC and CEN/CENELEC activities within IEC and CEN/CENELEC should be mutually coordinated. The service capabilities defined by ETSI should be integrated with the smart grid related application protocols mentioned in 5.1.4.1.

Com-3: Align the work on intra-domain standards between the AMI and other Smart Grid subsystems
Further work on Use Cases and standards regarding the interfaces between the AMI and other Smart Grid applications (such as EV charging and DER metering) should be aligned under the new Smart Grid Mandate, in cooperation with the SM-CG.

(5.1.5 Smart grid information security)

ISec-1 Ensure system level information security requirements are covered in all relevant standards
Fast incorporation of system level information security requirements (for all data protection classes and information security levels) into

I. product, solution and service standards of all “sphere of action” domains;
II. “sphere of action” domain-specific “organizational standards” for market roles participating in smart grids, according to their responsibilities, and functions provided.

Ensure consistency between those and sustain “state of the art” SGIS DPP by synchronizing all standards with changing guidance on system level requirements for SGIS and DPP.

ISec-2 Smart grid functions and use cases require binding to SGIS and DPP requirements
For several data protection classes (SG-DPC) legal requirements exist and require the appropriation of the SG-DPC, i.e. personal data, control data, logging. Therefore, the concept of SGIS is to provide the enablement for bonds between

- the use cases which describe the intended utilization of data as well as
- the usage rights based on obligations and limits of its usage and its required specific information security level (who, when, why, what data is generated, processed, stored, transmitted, erased) and on justification derived from contractual/regulatory frameworks).

This will need a definition for all specific SG-DPCs and SGIS-SLs. The concept is to obligate the use case writing experts to identify ALL data models used in the function or use case (these describe the data usage and justification of the specific usage). The data model repository will need to include the specific data protection classes (SG-DPCs) for every single UML data model. The information security experts will need to specify the appropriate information security level requirement (SGIS-SL) for each single SG-DPC.

It is recommended that ESOs provide interlinked repositories to achieve the required bonds.

ISec-3 SGIS-SL and SG-DPP upgrade and synchronization requirements

There are 2 distinct independent areas with changing dynamics along the pathway to implementation of smart grids

- Innovation dynamics in smart grid function and use case definitions – describing the changing "Operational Model" of smart grids and the data models used
- and in dynamics in SGIS and DPP evolving the harmonized set of "system level" SGIS and DPP impacting the evolution of the SGIS-SLs and SG-DPCs.

The ESOs need to provide a sustainable mechanism to update and synchronize the bonds of data models used by functions and use cases to the SG-DPCs and their SG-ISL requirements. This is required to link and synchronize use case and data model repositories as well as derived standards for smart grid system components (products, solutions, services) and organizational standards which need to be in sync with changing system requirements for the "smart grid information security" (SGIS) and data protection/privacy (DPP).

ISec-4 ESO to provide IT Tools to support SGIS and DPP modelling and repositories for SG-ISL/SG-DPC

As mentioned above (ISec-3) there are two distinct evolutionary areas – the Smart Grid operation model and the SGIS model, with different "innovation dynamics" - both areas need to be supported by tools that allow experts in both areas to define the content and models and that interlink, each with the capability to inherit changes from the other area. The set of tools and repositories are unique to the area. Therefore the tools for modeling SGIS are different. The need for tools and repositories required in the area of the smart grid operation model – to capture functions, use case scenarios and use cases and all data models with their specific classifications are described in another section of this report.

The ESOs should also provide tools specifically for the area of SGIS, DPP and the repositories for SGIS-SL and SG-DPC to experts and communities in the area of information security to assist them in modelling SGIS and DPP and maintaining and upgrading repositories for the 5 information security levels (SGIS-SL), and the repositories for smart grid data protection classes (SG-DPC). The tools provided to model SGIS, DPP system level and on the actor level (products, solutions, services and people, roles or organizations) and the repositories for SGIS-SL and SG-DPC need to be interlinked.

As mentioned above (ISec-3) there is the need to keep the two areas synchronized at all times. Therefore, the tools to be provided for both areas also need to permit synchronizing and binding, i.e. the repositories containing all SG-DPCs and their specific required/linked SGIS-SLs to the repositories containing the functions/use cases and their specific data models (to allow binding to the SG-DPC specified for the single data model).

(5.1.6.1 Dependability and functional safety)

Dep-1 Check relevance of existing methodologies to smart grids

Ask TCs (56 and 65A) whether their methodologies (with regard to Dependability and Functional safety) are well-suited/applicable to smart grids.

(5.1.6.2 EMC and power quality)

EMC-1 Review existing standards

CENELEC TC 210 and Product Committees to review existing standards concerning an appropriate modification for closing gaps in order to also ensure EMC in the frequency ranges from 2 kHz to 150 kHz (in practice 2-9 kHz and 9-150 kHz).

NOTE Technical input in this domain can be found in several reports/publications, such as the CENELEC SC 205A Study report on electromagnetic interference between electrical equipment/systems in the frequency range below 150 kHz, (SC205A/Sec0260/R, April 2010). Nevertheless, further studies are probably necessary before a complete set of standards can be available.

Furthermore, the following actions of the standardization communities are suggested to support low frequency EMC/power quality in the context of smart grids.

EMC-2 Review EMC and Power Quality levels
Review electromagnetic compatibility levels and/or characteristics of voltage at interfaces for all standard voltage levels of public electrical power networks, and define the associated operating conditions in the context of the smart grids.

EMC-3 Consider distorting current emissions from DER equipment
Standardize how to give a limitation to the distorting current emission by DER equipment and to fairly allocate the ability of networks to absorb distorting current emissions among present and possibly forthcoming connected equipment, including Distributed Generation at sites in networks. Connected equipment may well be other networks. The work is recommended to originate from documents IEC TR 61000-3-6, IEC TR 61000-3-7, IEC TR 61000-3-13 and future IEC TR 61000-3-14.

(5.2.1 Generation)

Gen-1 Harmonized glossary, semantic & modelling between back-office applications (CIM[17)]) and field applications (IEC 61850[18)])
Provide experts to IEC TC 57 body to boost CIM/IEC 61850 harmonization planning, fix this issue ASAP and establish clear messages to the market. Support electronic form of IEC 61850 data model at IEC level based on UML language.

Gen-2 Harmonization between IEC 62056-XX (DLMS/COSEM) data model and IEC 61850/CIM
Take the lead on this IEC 62056-XX (DLMS/COSEM) data model harmonization with CIM/IEC 61850, within the IEC body (through CENELEC TC 57 and CENELEC TC 13).

Gen-3 Extended field data modelling standard (part of IEC 61850) to support demandresponse, DER and VPP & Extended CIM to model more accurately Generation Fleet Management Applications in the case of Bulk Generation, and to integrate DER and VPPs
Clearly express and formalize to CENELEC TC 8X the selected use cases which the European smart grids have to support and ensure IEC TC 57/WG 17 body (through CENELEC TC 57) will provide expected answers in IEC 61850 data modelling regarding: Demand response for generators, for ancillary services, including VPPs and aggregators. Support TC 57/WG 13 initiatives to define use cases and modelling (such as AI715)

Gen-4 Standard for electrical connection and installation rules to ensure energy availability and security, in the presence of a high ratio of DER
Harmonize electrical connection and installation rules within Europe, down to all levels of connection of DER

Gen-5 Standard to allow all connected generators associated in VPPs to participate to new ways of operating grid
Adapt installation rules of DER to allow new ways of operating grid such as microgrid (TC 64 and TC 8X). More specifically, TC64 should develop new requirements and adapt existing installation rules within the HD 60364 to cover DER needs.

(5.2.2 Transmission)

T1 – HV-DC grid architecture
With the development of off-shore grids, there is a need for coordination, coherence and interoperability for equipment (converters, circuit-breakers, protection,….) as well as for grid topology (grid design, voltage level,

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17) IEC 61968 and IEC 61970 standards provide models of transmission, distribution systems and energy markets, as well as partial models of power generation, models known as the CIM (Common Information Model), structure and semantics for integrating a variety of back-office applications.

18) IEC 61850 standard provides a model for substation automation system and renewable energy resources (PV, hydro & wind and other), a basis for field equipment communications, including semantics, and encompasses real-time operations as well as non-operational data, such as condition monitoring.

grid code,…) in the High Voltage DC domain. The ESO standardization should take into account the work done in the German committee context.

T2 – Smart assets
The ongoing IEC 61850-90-3 work, devoted to condition monitoring in the power energy domain, should be encouraged. The present standard and protocol for communication in substations should involve communication and relevant data models, whereas the relevant products Technical Committees have to standardize the methods and the devices needed for on-line monitoring.
Therefore, it is recommended that the ongoing IEC standard involves on the one hand the experts on equipment to monitor for the technical aspects and on the other hand representatives of users in order to assess the condition values.

T3 – Offshore equipment
A review of the existing standards for transmission equipment is required in order to check that the special requirements for off-shore installations are properly covered. Otherwise, standards should be adapted. These tasks should be notably performed by TC 14 (transformers), TC 17 (switchgear), TC 38 (instrument measurement) and TC 20 (underground cable).

(5.2.3 Distribution)

Dis-1 Feeder and Advanced Distribution Automation
Develop a standard that supports feeder automation (at CEN/CENELEC), and Advanced Distribution Automation.

Dis-2: Use CIM (see also Gen-1)
Give high priority to the works needed in the area of harmonization of CIM /IEC 61850.

Dis-3: Seamless communication between control centre and substation
Support international work in order to provide seamless communication between control centres and sub-stations based on 61850.

Dis-4: Develop cybersecurity around IEC 62351
Work on a standard for cybersecurity as long as intensive public communication services (from Telecom Operators) will be used in distribution, enhance IEC 62351 in this area.

Dis-5: Auxiliary power systems standardization
Develop standardization for auxiliary power systems (low voltage DC networks): AC/DC converters, DC management systems, DC protection.

Dis-6: Integrate condition monitoring capabilities
Condition monitoring of components of substations or of lines provides technical information useful for optimized loading and helps to increase the lifetime of the distribution assets. IEC 61850, the present standard and protocol for communication in substations, should involve communication as far as the sensors needed for on-line monitoring. Ongoing work in TC 57: IEC 61850-90-3 (TR)

Dis-7 Standards for Medium Voltage (MV) lines
Develop a set of standards covering V and I sensors, switching equipment (definition, and modelling) and fault detectors (definition, and modelling) for Medium Voltage lines (overhead and underground)

(5.2.4 Smart metering)

SM 1: Currently various standards or extensions of existing standards are being developed to cover the exchange of metering data. Examples are:
- EN 62056 Electricity metering – Data exchange for meter reading, tariff and load control
- EN 13757-1:2002: Communication systems for meters and remote reading of meters
- IEC 61968-9: System Interfaces for Distribution Management – Part 9: Interface Standard for Meter Reading and Control

While harmonization of EN 62056 and EN 13757 is already being undertaken, some standardization initiatives go beyond the scope of M/441. A harmonization of standards more generally in this area is necessary to prevent further development of different (and competing) standards for the same purpose.

SM 2: Smart metering, building/home automation and electric vehicles are envisaged as elements in smart electricity grids. It is recommended that CEN/CENELEC/ETSI consider the use cases involving these elements and take care in their standardization work in these areas to ensure the needs and applications of smart grids are addressed in a harmonized fashion.

SM 3: Specifically to assist the development of proposals for possible link technologies in relation to smart grids and e-Mobility, it is recommended that CEN/CENELEC/ETSI should jointly undertake an investigation of the interfaces required insofar as they are not currently being addressed within the M/441 mandate. The ESOs should propose where standardization in these areas is necessary, taking care to ensure harmonization with existing metering models and other relevant standardization initiatives.

(5.2.5 Industry)

Ind-1: Tariff information
On-site energy management systems should be able to spread tariff information down to the load. We recommend extending the IEC 61850 model (the most common backbone system for EMS) to support tariff-related information.

Ind-2: DR information
The demand response mechanism is not considered yet to support network ancillary services. We recommend extending the IEC 61850 model (DER) and other DR information channels to support ancillary services participation.

Ind-3: Smart Meter and building system interface
In their work on data exchange between the smart meter and the building management system, the European Standardization Organizations should ensure coordination between CEN TC 247 and TC 13.

Ind-4: Harmonized data model for industry and power grid
Too many data models already exist without mapping between them. We recommend harmonizing the data model related to energy management between Industry and Electricity (EN 61158, EN 61850).This work should be coordinated between CLC/TC 205, TC 65 and TC 57.

Ind-5: Electrical installation allowing for DER integration
The usage of distributed energy resources as part of electrical installations and part of micro grids for industry raises new safety and protection issues. The multi-sources aspect is not covered by current installation rules. We recommend TC 64 to work on new installation rules for safety aspects and TC 8 or TC 99X to work on common rules for grid protection. TC64 should develop a dedicated part within the HD 60364 to cover this need, keeping in mind that all national wiring rules through European countries are based on the HD 60364.

(5.2.6 Home and building)

HB-1: Separate realization from standards description
The use cases described above interface with the field of smart metering, but have to be logically separated. In standardization, there are arguments for distinguishing meter gateways from energy management gateways considering both applications as two logical blocks, since both fields are driven by different kinds of interests and innovation speeds. Competition is likely to result in different devices and technologies combining logical applications defined by standardization. In order to be open for such market development and for innovation, standardization should not define the device but the logical functions, data and interfaces in case these are needed for communication between different market roles or devices.

HB-2: Unified language for tariff information
A unified language (a kind of common semantic layer above the existing technologies) has to be defined to

communicate demand response related elements (e.g. an incentive like a new price / tariff). A Europe-wide or even worldwide unified data model for these aspects would be favourable considering the global market for smart appliances, devices and automation systems. For that purpose, data models/profiles have to be developed from the use cases. A multi-stakeholder committee considering the different domains and ESOs involved should be assigned this task of considering ongoing initiatives (from research, industry and standardization).
This approach can succeed only by broad introduction including existing standard technologies. Therefore, the unified language must be mapped onto the communication standards lying below. These “lower standards” should support this mapping mechanism which is not the case today.

(5.2.7 Demand response applications)

DR-1 Create DR task force
Create a single DR task force at CEN/CENELEC/ETSI level encompassing the adaptation of DR signals to manage DER and electric vehicle charging issues. Consider other countries’ experiences and standards (OpenADR, OASIS work in EMIX and Energy Interop committees, E-Energy…)
Close coordination with the IEC/ISO and ETSI ITS tandardization bodies for communication exchange with the EV.
When coming to “How to proceed”, some more detailed insights are given in Annex 5.

DR-2 Avoid European mandates overlapping
Define clear interface and responsibilities between the smart grids mandate, the smart metering mandate and the EV mandate and associated standardization bodies (part of smart grids mandate). Ensure interoperability between the different standards

DR-3: Complement Data Model for DR signals
Include pricing signals, DR signals and DR process interfaces into CIM, COSEM and IEC 61850

(5.3 Markets and actors)

Mkt-1 Defined actors and roles as the basis of smart grid use cases
Standardization should play a role also in other areas where technical enforcement of market decisions by regulators or private sector actors is needed. Moreover, Standardization Organizations have to provide the needed flexibility to accommodate the increasing variety of business models. These needs must be based on an agreed set of use cases to be developed and maintained over time. All of those use cases should be based on the described actors and roles.

Mkt-2 Market communication
One of the particularly important areas of ICT standardization concerns market communication standards like EDIFACT, etc. and their capability to provide the services and functionalities. Besides being of general interest to standardization bodies and all other stakeholders, this issue is of utmost interest to all market players (suppliers, generators, traders, etc.) and also network operators, as it ensures a uniform and efficient exchange of data and information in the market. It is the standardization bodies for electricity and the ICT sector together who will need to review and identify all the required improvements and further developments in this area.

Annex 2 – Abbreviations and acronyms

3GPP	third generation partnership project
AAL	ambient assisted living
AMI	advanced metering infrastructure
AMM	automatic meter management
AMR	automatic meter reading
ANSI	American National Standards Institute
API	application programming interface
BACS	building automation and control systems
BUGS	back-up generating system
CC	control centre
CCS	carbon capture and storage
CEN	European Committee for Standardization
CENELEC	European Committee for Electrotechnical Standardization
CHP	combined heat and power
CIM	common information model
CIP	critical infrastructure protection
CIS	component interface specification
CISPR	International Special Committee on Radio Interference (in IEC)
COSEM	companion specification for energy metering (See IEC 62056 - xx)
CD	committee draft
DER	distributed energy resources
DG	Directorate-General (European Commission)
DIN	Deutsches Institut für Normung
DKE	Deutsche Kommission Elektrotechnik Elektronik Informationstechnik im DIN und VDE
DLMS	distribution line message specification (used by IEC 61334)
DLMS	Device Language Message Specification (IEC 62056)
DLMS/COSEM	see IEC 62056 series
DMS	distribution management system
DON	distribution network operator
DR	demand response
DPP	data protection / privacy
DSL	digital subscriber line
DSO	distribution system operator
DSR	demand side response
EAI	enterprise application integration

EDGE	enhanced data for global evolution
EEGI	European electricity grid initiative
EG	expert group (of the European Commission Smart Grid Task Force)
EISA	Energy Independence and Security Act (in USA)
EMC	electromagnetic compatibility
EMS	energy management system
ERP	enterprise resource planning
ESO	European Standardization Organization (CEN, CENELEC and ETSI)
ETP	European Technology Platform
ETSI	European Telecommunications Standards Institute
EU	European Union
EV	electric vehicle
FACTS	flexible alternating current transmission system
GIS	geographic information system
GPRS	general packet radio service
GRC	governance, risk and compliance
HAN	home area network
HBES	home and building electronic system
HES	home electronic system
HV	high voltage
HVAC	heating, ventilating and air conditioning
HVDC	high voltage direct current
JWG	Joint Working Group (of CEN, CENELEC and ETSI on standards for smart grids)
ICT	information and communication technologies
IEC	International Electrotechnical Commision
IED	intelligent electronic device
IEEE	Institute of Electrical and Electronics Engineers
IEV	International Electrotechnical Vocabulary
IP	internet protocol
ISO	International Organization for Standardization
IT	information technology
ITU	International Telecommunication Union
ITU-T	ITU's Telecommunication standardization sector (ITU-T)
JISC	Japanese Industrial Standards Committee
JTC	Joint Technical Committee (ISO/IEC)
LAN	local area network
LV	high voltage
KATS	Korean Agency for Technology and Standards

M2M	machine-to-machine
M/441	standardization mandate on smart metering, issued by the European Commission
METI	Ministry of Economy, Trade and Industry (in Japan)
MID	Measuring Instruments Directive
MV	medium voltage
NAN	neighbourhood area network
NERC	North American Electric Reliability Corporation (USA)
NIST	National Institute of Standards and Technology (USA)
NISTIR	NIST interagency report
OTS	online training simulator
PAS	Publicly Available Specification (in IEC)
PLC	power line communications
PMU	phasor measurement unit
PPC	product properties and classification
PSTN	public switched telephone network
PV	photovoltaic
R&D	research & development
RDF	resource description framework
RES	renewable energy sources
SAE	Society of Automotive Engineers
SC	sub-committee
SCADA	supervisory control and data acquisition
SDD	strategic deployment document
SET	strategic energy technology
SG	strategic group (IEC)
SGCC	State Grid Corporation of China
SGIS	smart grid information security
SGCSWG	Smart Grid Cyber Security Working Group (in USA)
SIDM	system interfaces for distribution management
SIPS	system integrity protection scheme
SMB	Standardization Management Board (of IEC)
SMCG	Smart Metering Coordination Group (of CEN, CENELEC and ETSI)
SME	small and medium enterprises
SOA	service oriented architecture
TASE	telecontrol application service element
TC	Technical Committee (in CEN, CENELEC, ETSI, ISO or IEC)
TCP	transmission control protocol
TR	Technical Report (in CEN, CENELEC, ETSI or IEC)

TV	television
UML	unified modelling language
UMTS	universal mobile telecommunications system
V2G	vehicle to grid
VPP	virtual power plant
WAN	wide area network
XML	eXtensible markup language

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5.1.6 Other cross cutting issues

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Annex 5 – Demand response

Demand response is one of the cornerstones of smart grids that facilitates many of the expected smart grid top-level services.

Table A5.1 – Top level services – Demand response

Top-level services	**N°**	**Main SG applications**	**Typical demand response application**
Integrate users with new requirements	1	Facilitate connections at all voltages / locations for any kind of device	DR is needed to shape loads on users' side DR helps to achieve quality criteria, and balance reactive power
	2	Use of network control systems for network purposes	Automated DR contributes to increase the ratio of new users
Enhancing efficiency in day-to-day grid operation	3	Enhance monitoring and control of power flows and voltages	
	4	Enhance monitoring and observability of grids down to low voltage levels	
	5	Exchange of information on actual active/reactive generation / consumption	DR is needed to balance active power DR helps to achieve quality criteria, and balance reactive power
Ensuring network security, system control and quality of supply	6	Allow grid users and aggregators to participate in ancillary services market	DR helps to achieve quality criteria, and balance reactive power
	7	Operation schemes for voltage/current control	DR helps to achieve quality criteria, and balance reactive power
	8	Intermittent sources of generation to contribute to system security	DR helps to achieve quality criteria, and balance reactive power
	9	Allow demand response for system security purposes at sufficient speed	DR (high speed) contributes to network security
Improving market functioning and customer service	10	Participation of all connected generators in the electricity market	Automated DR contributes to increasing the ratio of DER
	11	Participation of VPPs and aggregators in the electricity market	DR, through VPPs, is needed to shape active power DR, through VPPs, helps to achieve quality criteria, and balance reactive power
More direct involvement of consumers in their energy usage	12	Availability of individual continuity of supply and voltage quality indicators	

A5.1 How to proceed to tackle DR standardization?

Against the background of the level of uncertainty attached to the setting up of DR mechanisms within the smart grid, here are some recommendations for going more in-depth, and this could be a roadmap for the proposed Task Force:

Main objective : Define consistent signals and processes for an efficient deployment of DR smart grid application:

Main system level use cases to be covered by DR:

- Balance active power supply (low speed)

- Balance reactive power supply and reach Energy quality criteria (low speed)
- Automatic DR (low speed)
- Contribute to network security (high speed)
- Manage the EV charging issues, including the constraint of having the electricity supply contract follow the charging location change due to the EV movement.

Proposed steps :

Today's DR specifications are still too broad, and too business model dependent. Standardization should focus in a first stage on sub-functions (as enablers of the top-level use cases listed above):

Role definitions :

DR Asset or Resource : An energy resource that is capable of delivering demand response services, such as shaping load in response to Demand Response Events, Electricity Price Indications or other system events (e.g. underfrequency detection).

DR Participant : An entity or role with the responsibility to coordinate Demand Assets or Resources to deliver demand response services.

DR Requester : An entity or role with the responsibility to specify and initiate DR events.

DR Event : A DR Event is defined by a set of data, and refers to the time periods, deadlines, and transitions during which Demand Asset or Resources are expected to perform.

Table A5.2 – Use cases – Demand response

Exchange Pricing indications	Communicate the energy and service price indications to the interested parties.
Manage DR contract	Handle the process which links a DR participant (or stakeholder) and a DR requester (Market or Grid operator) in implementing a DR service.
Notify DR event	Inform the DR Participants that a DR event is expected to be implemented by a DR requester.
Dispatch DR instruction	Instructs a DR Asset or Resource to offer the requested service (change its consumption level or produce a defined level of reactive power, …).
Verify DR implementation	Handle the needed process to verify that the DR Asset or Resource effectively reached the committed level of performance during the DR Event.

A5.2 One case: managing distributed demand and supply flexibility

Among many potential mechanisms to consider, explicitly offering and trading fine-grained flexibilities provides one alternative mechanism to influence distributed demand and supply behaviour as currently addressed by the European DG INFSO Miracle project.

Explicit knowledge of available flexibilities in distributed demand and supply in combination with forecasts of power from intermittent power sources and non-flexible load and generation allows more detailed scheduling.

In order to support such mechanisms, standardization effort should focus on enabling

- communication/sharing of available flexibility in both time and power of distributed supply and demand (between market roles),
- communication/sharing of conditions under which the flexibilities are provided (between market roles),
- negotiating the usage of flexibility provided, and
- communicating/sharing the desired behaviour within the flexibility provided, e.g. in terms of lowering, raising or shifting demand and/or supply.

Annex 6 – Interoperability standards

This annex lists currently available standards for the interfaces that are identified in the functional communication architecture of a smart grid shown in section 5.1.3 (note this list is not exhaustive).

A6.1 Intra-domain standards

A6.1.1 WAN interface to Operations Subsystem

Related to external WANs and LANs:

- IEC 60870-5, *Telecontrol equipment and systems*
- EN 60870-5-101, *Telecontrol equipment and systems – Part 5-101: Transmission protocols – Companion standard for basic telecontrol tasks*
- EN 60870-5-103, *Telecontrol equipment and systems – Part 5-103: Transmission protocols -Companion standard for the informative interface of protection equipment*
- EN 60870-5-104, *Telecontrol equipment and systems – Part 5-104: Transmission protocols Network access for IEC 60870-5-101 using standard transport profiles*
- Mapping of IEC 61850 Common Data Classes on IEC 60870-5-104 (IEC 61850-80-1 TS)
- IEC 60870-6, *Telecontrol equipment and systems – Part 6: Telecontrol protocols compatible with ISO standards and ITU-T recommendations*

Related to internal enterprise LANs:

- IEC 61968/61970 suites (see cross sectional standards)

A6.1.2 AMI interface to Home Automation

- EN 50090 series, *Home and Building Electronic Systems (HBES, KNX)*
- EN 50523-1, *Household appliances interworking – Functional specification*
- EN 14908 series, *Open data communication in building automation, controls and building management implementation guideline – Control network protocol – Implementation*
- EN ISO 16484 series, *Building Automation and Control Networks*
- ISO/IEC 14543-3 series, *Information technology – Home electronic system (HES) architecture*
- ISO 16484-5, *Building automation and control systems – Part 5: data communication protocol*
- EN 13321 series, *Open data communication in building automation, controls and building management – Home and building electronic systems*
- EN 50428, *Switches for household and similar fixed electrical installations*
- EN 50491 series, *General requirements for Home and Building Electronic Systems (HBES)*
- IEC 62056-31: *Electricity metering – Data exchange for meter reading, tariff and load control Part 31: Use of local area networks on twisted pair with carrier signalling (Under revision, see 13/1361/CDV)*
- ISO 16484-5/ ANSI-ASHRAE 135-2008, *BACnet, A Data Communication Protocol for Building Automation and Control Networks*
- ISO/IEC 15045, *Information technology – Home Electronic Systems (HES)*
- ISO/IEC 15067-3, *Model of an energy management system for the Home Electronic System*
- ISO/IEC 18012, *Guidelines for Product Interoperability*

A6.1.3 WAN interface to Substation Automation

For 60870, CENELEC has adopted the following parts:

- EN 60870-5-6:2009, *Telecontrol equipment and systems – Part 5-6: Guidelines for conformance testing for the EN 60870-5 companion standards*
- EN 60870-5-104:2006, *Telecontrol equipment and systems – Part 5-104: Transmission protocols – Network access for IEC 60870-5-101 using standard transport profiles*
- EN 60870-6-802:2002 + A1:2005, *Telecontrol equipment and systems – Part 6-802: Telecontrol protocols compatible with ISO standards and ITU-T recommendations – TASE.2 Object models*
- EN 60870-5-101:2003, *Telecontrol equipment and systems – Part 5-101: Transmission protocols – Companion standard for basic telecontrol tasks*
- EN 60870-5-103:1998, *Telecontrol equipment and systems – Part 5-103: Transmission protocols – Companion standard for the informative interface of protection equipment*
- EN 60870-2-2:1996, *Telecontrol equipment and systems – Part 2: Operating conditions – Section 2: Environmental conditions (climatic, mechanical and other non-electrical influences)*
- EN 60870-5-102:1996, Telecontrol equipment and systems – Part 5: Transmission protocols – Section 102: Companion standard for the transmission of integrated totals in electric power systems
- EN 60870-2-1:1996, *Telecontrol equipment and systems – Part 2: Operating conditions – Section 1: Power supply and electromagnetic compatibility*
- EN 60870-5-5:1995, *Telecontrol equipment and systems – Part 5: Transmission protocols – Section 5: Basic application functions*
- EN 60870-5-1:1993, *Telecontrol equipment and systems – Part 5: Transmission protocols – Section 1: Transmission frame formats*
- EN 60870-5-2:1993, *Telecontrol equipment and systems – Part 5: Transmission protocols – Section 2: Link transmission procedures*
- EN 60870-5-3:1992, *Telecontrol equipment and systems – Part 5: Transmission protocols – Section 3: General structure of application data*
- *A version of IEC 61850 is planned to be available for WAN communication among substations.*

A6.1.4 WAN interface to Distributed Energy Resources

- IEC 61850-7-410 Ed. 1.0, *Communication networks and systems for power utility automation – Part 7-410: Hydroelectric power plants – Communication for monitoring and control*
- IEC 61850-7-420, *Communication networks and systems for power utility automation – Part 7-420: Basic communication structure – Distributed energy resources logical nodes*
- EN 61400-25-1, *Communications for monitoring and control of wind power plants – Part 25-1: Overall description of principles and models*
- EN 61400-25-2, *Communications for monitoring and control of wind power plants – Part 25-2: Information models*
- EN 61400-25-3, *Communications for monitoring and control of wind power plants – Part 25-3: Information exchange models*
- EN 61400-25-4, *Communications for monitoring and control of wind power plants – Part 25-4: Mapping to communication profiles (Mapping to XML based communication profile)*
- EN 61400-25-5, *Communications for monitoring and control of wind power plants – Part 25-5 Conformance testing*

- EN 61400-25-6, *Communications for monitoring and control of wind power plants – Part 25-6 Communications for monitoring and control of wind power plants: Logical node classes and data classes for condition monitoring*

CENELEC has adopted the following parts so far:

- EN 61850-7-410:2007, *Communication networks and systems for power utility automation – Part 7-410: Hydroelectric power plants – Communication for monitoring and control*
- EN 61850-7-420:2007, *Communication networks and systems for power utility automation – Part 7-420: Basic communication structure – Distributed energy resources logical nodes*
- EN 61400-25-X *Logical Nodes for WPP*, from CENELEC TC 88

A6.1.5 WAN interface to AMI subsystem & Head-End

Metering protocols

- o EN 13757 series, *Communication systems for meters and remote reading of meters (M-bus)*
- o IEC 62056 series, *Electricity metering – Data exchange for meter reading, tariff and load control*, Parts 21, 31, 41, 42, 46, 47, 51, 52, 53, 61, 62

Power Line Communications (PLC)

- EN 50065-1:2001, *Specification for signalling on low-voltage electrical installations in the frequency range 3 kHz to 148,5 kHz – Part 1: General requirements, frequency bands and electromagnetic disturbances*
- IEC 61334, Distribution automation using distribution line carrier systems – Part 4 Sections 32, 511, 512, Part 5 Section 1

A6.1.6 LAN/WAN interface to Generation Resources

EN 60870-5 is commonly used to access Generation operation controllers :

- EN 60870-5-101 and EN 60870-5-104 for EMS/SCADA
- EN 60870-5-103 is used to access Generation operation protection devices for the electrical process part

IEC 61850 extension is in progress in order to be used in the following cases :

- IEC 61850-7-420 to access DER Generation devices and controllers
- IEC 61850-7-410 to access Hydro Generation devices and controllers
- EN 61400-25 to access Wind Generation devices and controllers
- 57/1079/DC to access large-scale power production units (e.g. Thermal devices and controllers)

Since IEC 61850 covers various domains of the smart grid landscape, it is included in the section on cross sectional standards (5.1.4.2).

CIM (IEC 61970, IEC 61968, IEC 62325) extension is in progress in order to be used in the following cases :

- Communication between Generation applications (e.g. Fleet Scheduling / Unit Operation or Performance Monitoring / Maintenance)
- Communication between Generation and Market applications (e.g. Fleet Scheduling / Energy Trading)

- Communication between Generation and External IT applications (e.g. for production reports, fuel planning, pollutant emission caps and prices etc…)

Since CIM (IEC 61970, IEC 61968, IEC 62325) covers various domains of the smart grid landscape, it is included in the section about cross sectional standards (5.1.4.2).

OPC UA (IEC 62541) is considered as a possible candidate to support the above CIM profiles.

A6.2 Cross domain standards

A6.2.1 IEC 61970

The Common Information Model being standardized as the IEC 61970 family provides a proper EMS-API for energy management systems which can be used to provide seamless integration based on a common data model for EMS. It is being standardized by the IEC and has the following sub-parts which are of relevance to the smart grid. It contains a data model (domain ontology), system interfaces, generic payload descriptions and generic interfaces for mass data processing. Therefore, it should also be considered a cross-sectional standard.

Figure 9 – IEC TC 57 Seamless Integration Reference Architecture – IEC TR 62357 provides an overview of the IEC TR 62357 Seamless Integration Architecture with a joint view of both IEC and CEN/CENLEC standards. The CIM family provides various inputs and interfaces for this layered communication architecture. For data communications, the CIM provides three main use cases:

Custom Interface Design based on common semantics: For custom EAI solutions within a utility, the CIM ontology /information model can be used to define custom payloads for message-based system integration based on standardized semantics. With the included profiles and XML naming and design rules, a canonical process and methodology for designing the XML schemas and payloads exists.

Data exchange of topological data: Apart from the XMl-based serialization for data exchange between EMS-related systems, topological information about the power grid can be serialized as RDF-triple graphs and be exchanged between GIS, SCADA and OTS systems. RDF being a graph based format, it is less fragile than XML based tree structures and reasoning capabilities to find inconsistencies in the modelling of the power grid can be applied.

Predefined interfaces for secondary IT: The IEC 61968 family provides the so called Interface Reference Model IRM which is used for providing interfaces for typical systems used in the distribution management. Alongside XML schemas, payloads and processes are defined in order to provide a good blueprint for a high level of standardization of the interfaces between those systems. Figure A2 provides an overview of the scope of those interfaces already being standardized and capable of functioning as Distribution Automation interfaces.

The following lists contain an overview of the standards for the IEC 61970 family with a focus on SCADA and EMS operations.

CENELEC adopted standards (non-adopted parts are depicted light grey in Figure 9 – IEC TC 57 Seamless Integration Reference Architecture – IEC TR 62357; the list is not exhaustive, parts to be replaced are left out):

- EN 61970-1:2006 Ed. 1, *Energy management system application program interface (EMS-API) – Part 1: Guidelines and general requirements*
- CENELEC TS 61970-2, *Energy management system application program interface (EMS-API) – Part 2: Glossary*
- EN 61970-301:2004, *Energy management system application program interface (EMS-API) – Part 301: Common information model (CIM) base*

- EN 61970-453:2008, *Energy management system application interface (EMS- API) – Part 453: CIM based graphics exchange*
- EN 61970-501:2006, *Energy management system application interface (EMS- API) – Part 501: Common information model resource description framework (CIM RDF) Schema*

IEC SG3 recommended standards for operations in smart grids:

- IEC 61970-1 Ed. 1, *Energy management system application program interface (EMS-API) – Part 1: Guidelines and general requirements*
- IEC 61970-2 Ed. 1.0, *Energy management system application program interface (EMS-API) – Part 2: Glossary*
- IEC 61970-301, *Energy management system application program interface (EMS-API) – Part 301: Common information model (CIM) base*
- IEC 61970-302 Ed. 1.0, *Energy management system application program interface (EMS-API) – Part 302: Common information model (CIM) financial, energy scheduling and reservations*
- IEC 61970-401 TS Ed.1, *Energy management system application program interface (EMS-API) – Part 401: Component interface specification (CIS) framework*
- IEC 61970-453 Ed. 1.0, *Energy management system application interface (EMS- API) – Part 453: CIM based graphics exchange*
- IEC 61970-501 Ed. 1, *Energy management system application interface (EMS- API) – Part 501: Common information model resource description framework (CIM RDF) Schema*

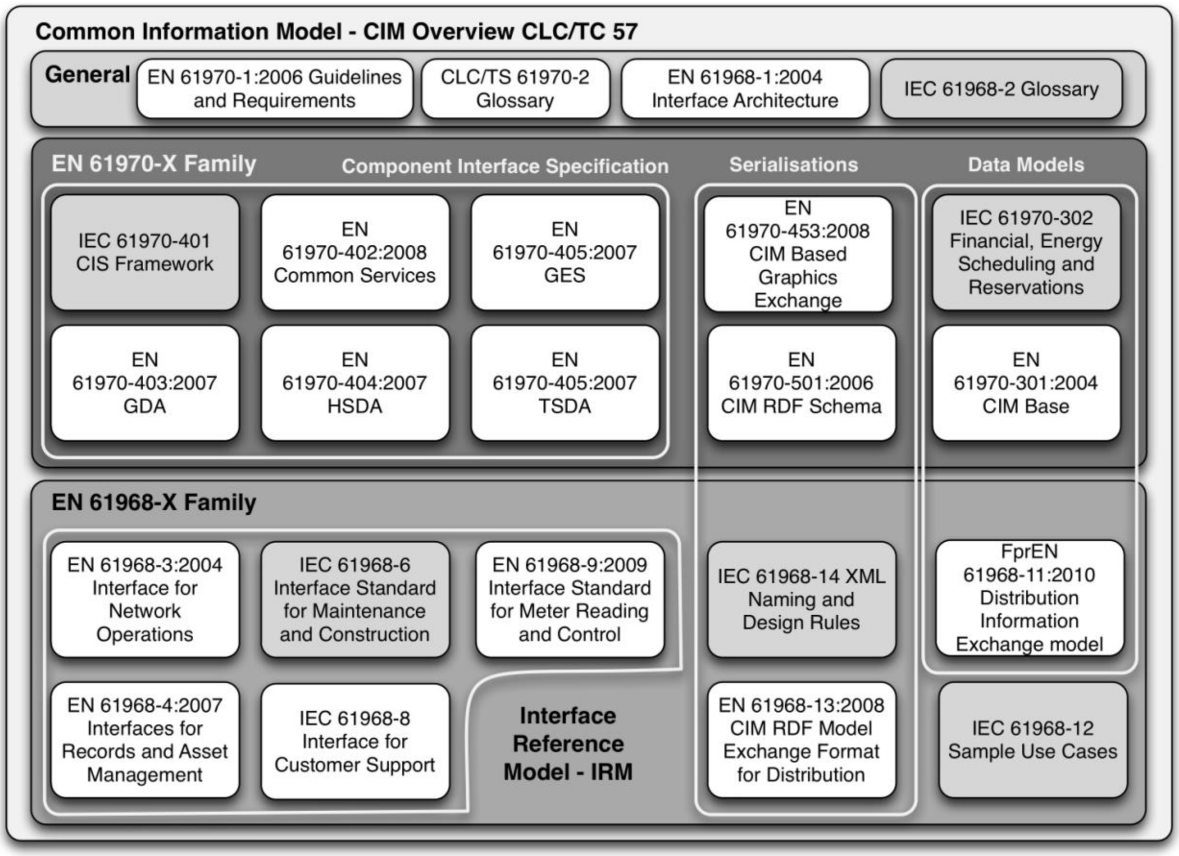

Figure A6.1 – Overview of the CIM family – both EN 61968 and 61970

Most of these standards have also been recommended by the IEC SG3 roadmap, US NIST Smart Grid Interoperability Framework, the German DKE e-Energy /Smart Grid Standardization Roadmap and the SGCC Framework for Strong and Smart Grid Standardization amongst many others.

A6.2.2 IEC 61968 – Data models and system for distribution management and automation (secondary IT)

The following lists contain an overview of the standards for the IEC 61968 family.

CENELEC adopted standards (non adopted parts are depicted light grey in Figure A6.1 – Overview of the IEC 61968 IRM family):

- EN 61968-1:2004, Application integration at electric utilities – System interfaces for distribution management – Part 1: Interface architecture and general requirements
- EN 61968-:2004, Application integration at electric utilities – System interfaces for distribution management – Part 3: Interface for network operations
- EN 61968-4:2007, Application integration at electric utilities – System interfaces for distribution management – Part 4: Interfaces for records and asset management
- EN 61968-9:2009, System Interfaces For Distribution Management – Part 9: Interface Standard for Meter Reading and Control
- FprEN 61968-11:2010, System Interfaces for Distribution Management – Part 11: Distribution Information Exchange Model
- EN 61968-13:2008, System Interfaces for distribution management – CIM RDF Model Exchange Format for Distribution

IEC SG3 and NIST recommended standards for DMS operation in smart grids:

- IEC 61968-1, *Application integration at electric utilities – System interfaces for distribution management – Part 1: Interface architecture and general requirements*
- IEC 61968-2 Ed. 1.0, *Application integration at electric utilities – System interfaces for distribution management – Part 2: Glossary*
- IEC 61968-3 Ed. 1, *Application integration at electric utilities – System interfaces for distribution management – Part 3: Interface for network operations*
- IEC 61968-4 Ed. 1, *Application integration at electric utilities – System interfaces for distribution management – Part 4: Interfaces for records and asset management*
- IEC 61968-6, *Application integration at electric utilities – System interfaces for distribution management – Part 6: Interface Standard for Maintenance and Construction*
- IEC 61968-8, *Application integration at electric utilities – System interfaces for distribution management – Part 8: Interface Standard for Customer Support*
- IEC 61968-9 Ed. 1.0, *System Interfaces For Distribution Management – Part 9: Interface Standard for Meter Reading and Control*
- IEC 61968-11 and -12 Advance Copies: *System Interfaces for Distribution Management*
- IEC 61968-13 Ed. 1.0, *System Interfaces for distribution management – CIM RDF Model Exchange Format for Distribution*
- IEC 61968-14, *System Interfaces for distribution management – XML Naming and Design Rules*

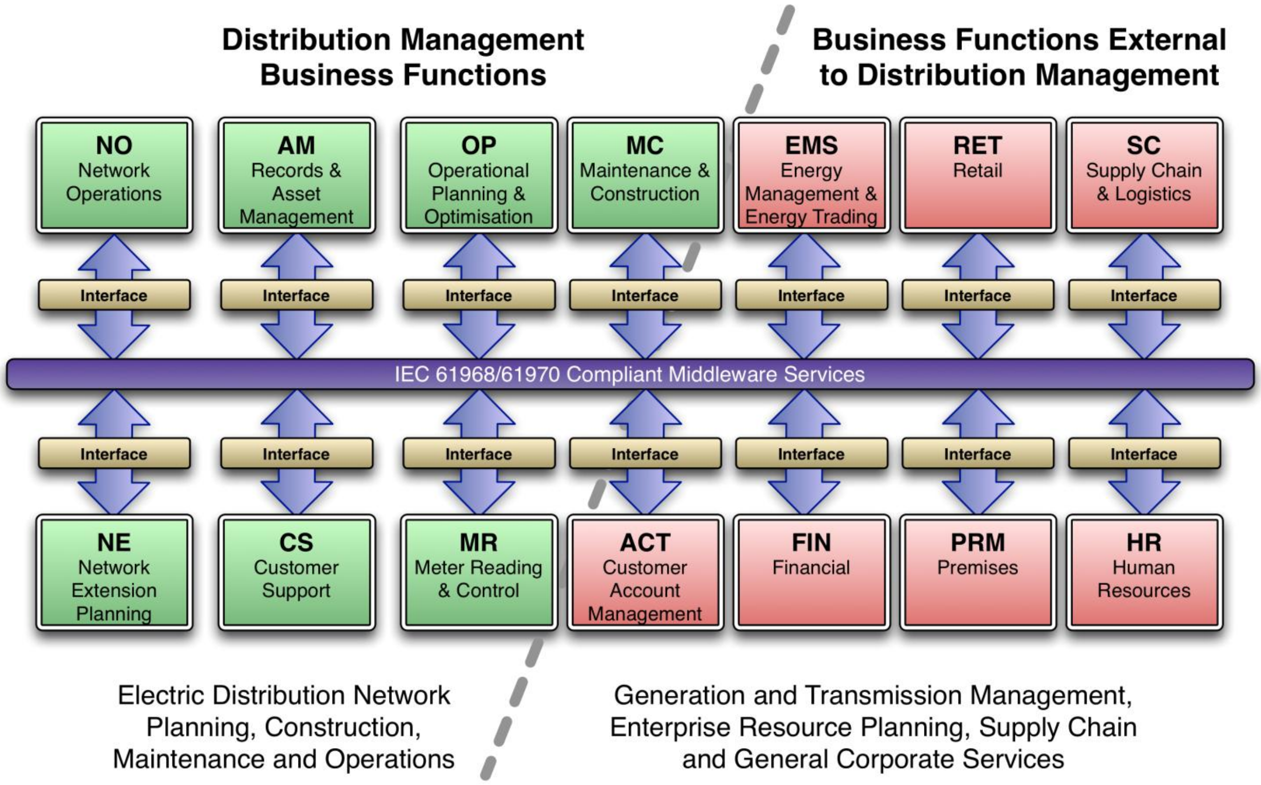

Figure A6.2 – Overview of the IEC 61968 IRM family

A6.2.3 IEC/EN 61850 – Substation Automation

IEC/EN 61850 is much more than just a communication standard; it also deals with configuration, engineering testing for interoperability and data modelling in substations. Figure A6.3: "Overview of the EN 61850 family alongside related standards" provides an indication of how the different parts interact while Figure A6.4 "Logical overview of IEC 61850 from edition 2 upcoming" shows how the modelling is done using the standards and deriving the computational representation from the physical device. The two most important parts are the data model, which has a different model paradigm than the CIM, providing a tree-like structure other than an object-oriented model. Furthermore, the ACSI (Abstract Communication System Interface) provides an abstract interface to the logical model which is implemented by different communication links. Therefore, technological advancement does not break the logical model but merely introduces an new technical communication layer.

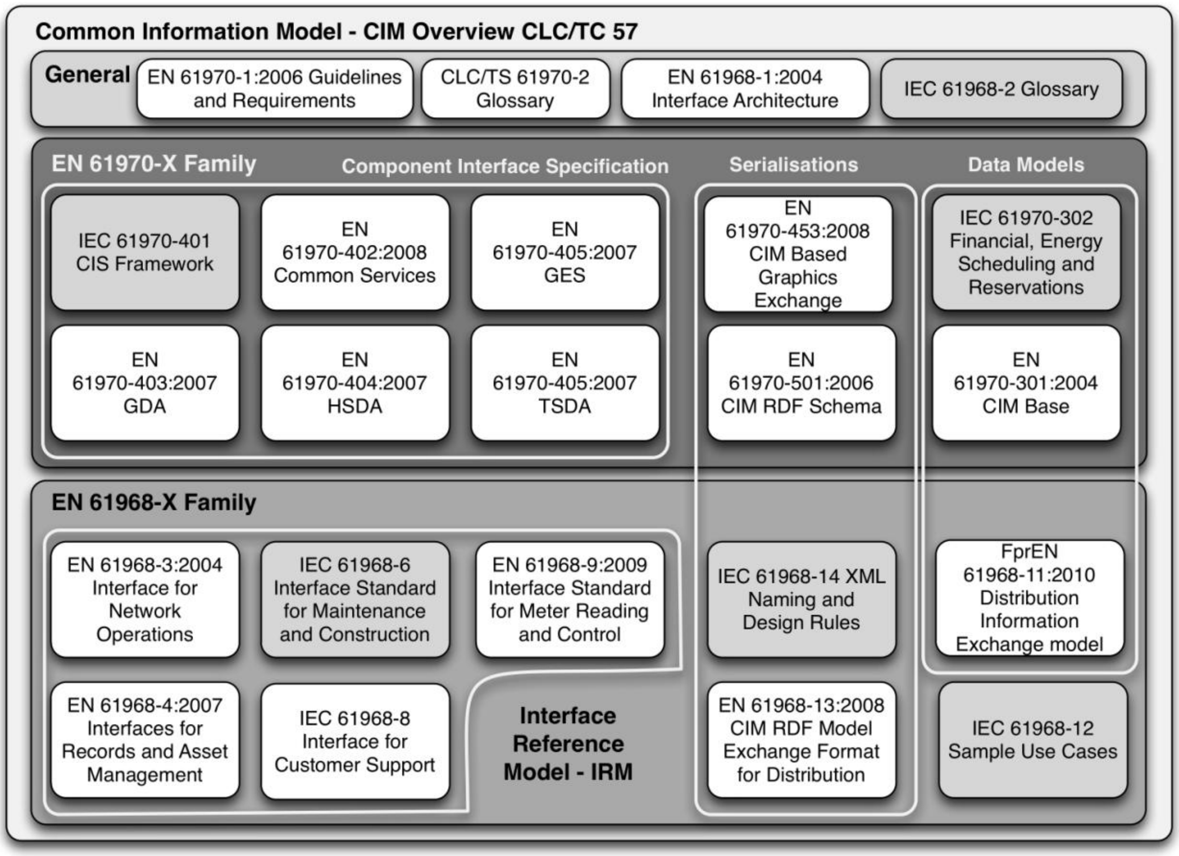

Figure A6.3 – Overview of the EN 61850 family alongside related standards

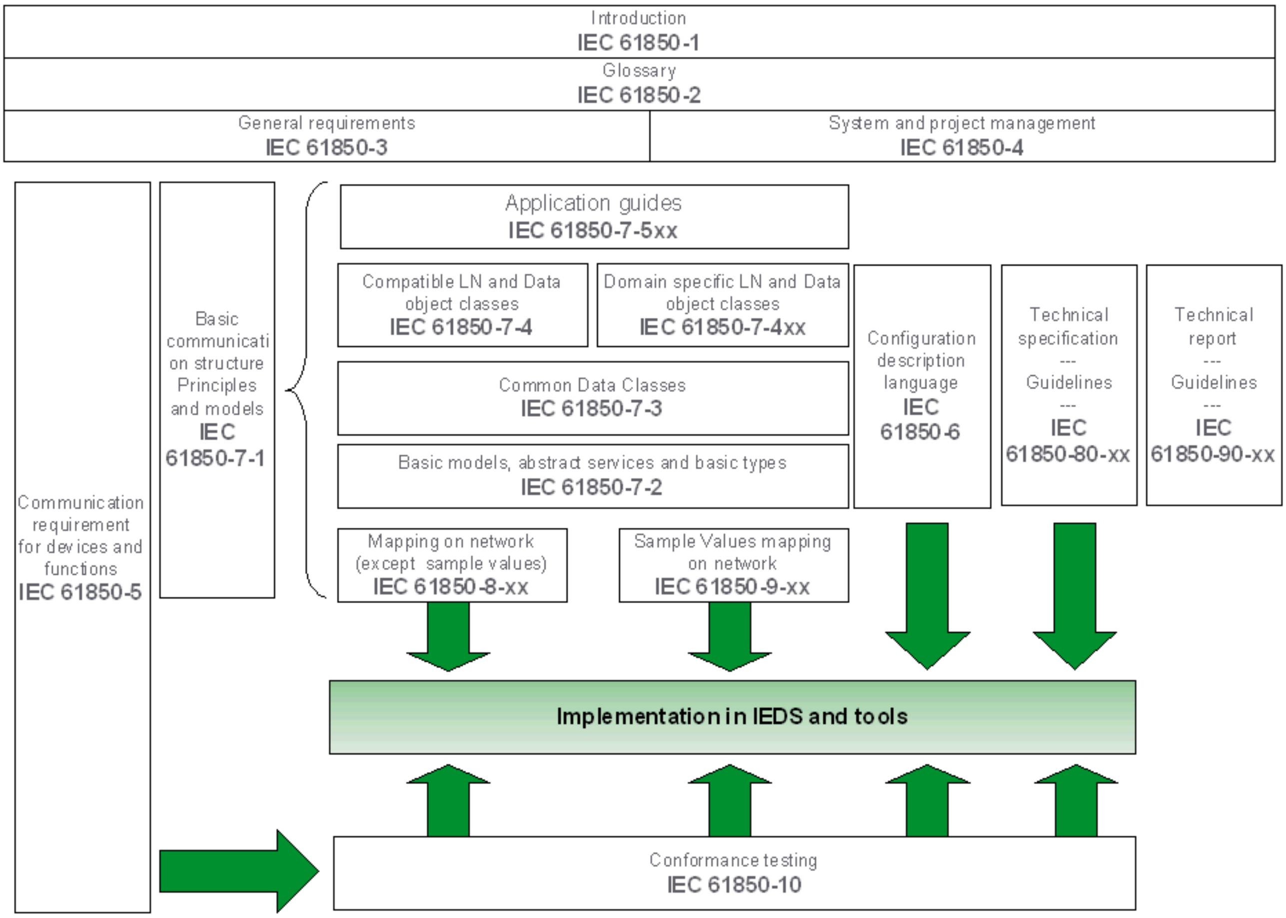

Figure A6.4 – Logical overview of IEC 61850 from edition 2 upcoming

The IEC SG3 and the NIST Framework recommend the following parts :

- IEC TR 61850-1 Ed. 1.0, *Communication networks and systems in substations – Part 1: Introduction and overview*
- IEC TS 61850-2 Ed. 1.0, *Communication networks and systems in substations – Part 2: Glossary*
- IEC 61850-3 Ed. 1.0, *Communication networks and systems in substations – Part 3: General requirements*
- IEC 61850-4 Ed. 1.0, *Communication networks and systems in substations – Part 4: System and project management*
- IEC 61850-5 Ed. 1.0, *Communication networks and systems in substations – Part 5: Communication requirements for functions and device models*
- IEC 61850-6 Ed. 1.0, *Communication networks and systems in substations – Part 6: Configuration description language for communication in electrical substations related to IEDs*
- IEC 61850-7-1 Ed. 1.0, *Communication networks and systems in substations – Part 7-1: Basic communication structure for substation and feeder equipment – Principles and models*
- IEC 61850-7-2 Ed. 1.0, *Communication networks and systems in substations – Part 7-2: Basic communication structure for substation and feeder equipment – Abstract communication service interface (ACSI)*
- IEC 61850-7-3 Ed. 1.0, *Communication networks and systems in substations – Part 7-3: Basic communication structure for substation and feeder equipment – Common data classes*

- IEC 61850-7-4 Ed. 1.0, *Communication networks and systems in substations – Part 7-4: Basic communication structure for substation and feeder equipment – Compatible logical node classes and data classes*
- IEC 61850-8-1 Ed. 1.0, *Communication networks and systems in substations – Part 8-1: Specific Communication Service Mapping (SCSM) – Mappings to MMS (ISO 9506-1 and ISO 9506-2) and to ISO/IEC 8802-3*
- IEC 61850-9-1 Ed. 1.0, *Communication networks and systems in substations – Part 9-1: Specific Communication Service Mapping (SCSM) – Sampled values over serial unidirectional multidrop point to point link*
- IEC 61850-9-2 Ed. 1.0, *Communication networks and systems in substations – Part 9-2: Specific Communication Service Mapping (SCSM) – Sampled values over ISO/IEC 8802-3*
- IEC 61850-10 Ed. 1.0, *Communication networks and systems in substations – Part 10: Conformance testing*
- IEC 61850-80-1 TS Ed. 1.0, *Communication networks and systems for power utility automation – Part 80-1: Guideline to exchange information from a CDC based data model using IEC 60870-5-101/104*
- IEC 61850-90-1 TR Ed. 1.0, *Communication networks and systems for power utility automation – Part 90-1: Use of IEC 61850 for the communication between substations*

CENELEC has adopted the following parts (Also depicted in Figure 9 – IEC TC 57 Seamless Integration Reference Architecture – IEC TR 62357)

- EN 61850-3:2002, *Communication networks and systems in substations – Part 3: General requirements*
- EN 61850-4:2002, *Communication networks and systems in substations – Part 4: System and project management*
- EN 61850-5:2003, *Communication networks and systems in substations – Part 5: Communication requirements for functions and device models*
- EN 61850-6:2010, *Communication networks and systems in substations – Part 6: Configuration description language for communication in electrical substations related to IEDs*
- FprEN 61850-7-1, *Communication networks and systems in substations – Part 7-1: Basic communication structure for substation and feeder equipment – Principles and models*
- FprEN 61850-7-2:2010, *Communication networks and systems in substations – Part 7-2: Basic communication structure for substation and feeder equipment – Abstract communication service interface (ACSI)*
- FprEN 61850-7-3:2010, *Communication networks and systems in substations – Part 7-3: Basic communication structure for substation and feeder equipment – Common data classes*
- EN 61850-7-4:2010, *Communication networks and systems in substations – Part 7-4: Basic communication structure for substation and feeder equipment – Compatible logical node classes and data classes*
- EN 61850-8-1:2004, *Communication networks and systems in substations – Part 8-1: Specific Communication Service Mapping (SCSM) – Mappings to MMS (ISO 9506-1 and ISO 9506-2) and to ISO/IEC 8802-3*
- EN 61850-9-1:2004, *Communication networks and systems in substations – Part 9-1: Specific Communication Service Mapping (SCSM) – Sampled values over serial unidirectional multidrop point to point link*
- EN 61850-9-2:2004, *Communication networks and systems in substations – Part 9-2: Specific Communication Service Mapping (SCSM) – Sampled values over ISO/IEC 8802-3*
- EN 61850-10:2005 Communication networks and systems in substations – Part 10: Conformance testing

Edition 2 of IEC 61850 should be fully available by the beginning of 2011.

Apart from pure substation communication, models for DER (EN 61850-7-420) and WPP (CENELEC TC 88 EN 61400-25-X) exist.

A6.2.4 ETSI M2M communication

The ETSI M2M committee is working on Machine-to-Machine data communication standards (TS 102 690). These standards permit service creation and optimized application development and deployment. M2M Service Capabilities permit local/remote and flexible handling of application information. The M2M architecture intends to offer the best framework for smart grid applications.

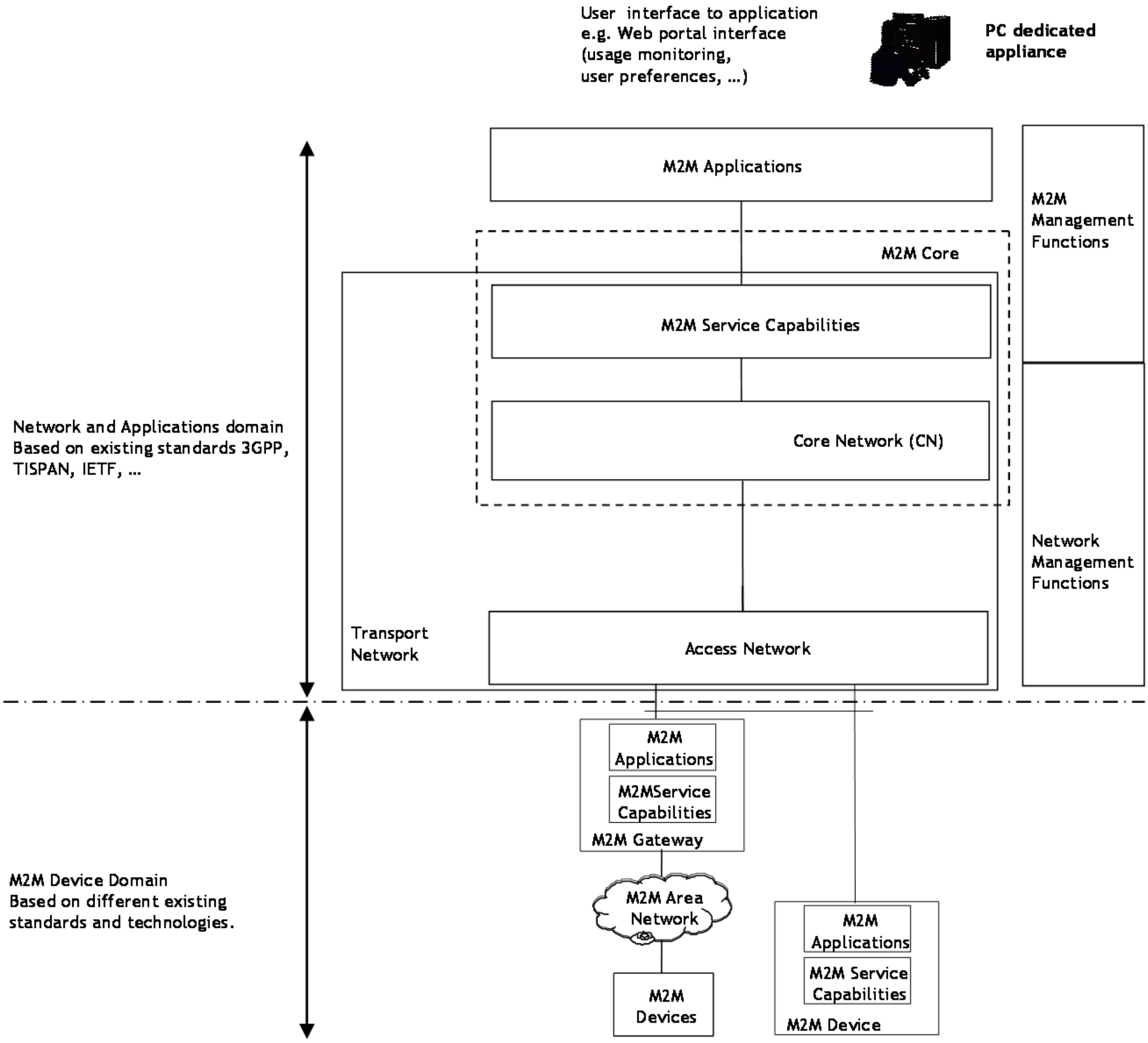

Figure A6.5 – Machine to machine data communication

A6.2.5 General lower layer networking standards

1. Public Cellular Mobile Network (GSM/GPRS/EDGE/UMTS)

Smart Card Platform for mobile communication systems of 2G, 3G and beyond:

- ETSI TS 102 221, *Smart Cards – UICC-Terminal interface – Physical and logical characteristics*
- ETSI TS 102 223, *Smart Cards – Card Application Toolkit (CAT)*
- ETSI TS 102 671 (under development), *Smartcards – Machine to Machine UICC – Physical and logical characteristics*
- ETSI TS 102 225, *Smart Cards – Secured packet structure for UICC based applications*
- ETSI TS 102 484, *Smart Cards – Secure channel between a UICC and an end-point terminal*

2. 3GPP

- TS 41.101, TS21.101, TS21.201, TS21.202

3. ETSI TISPAN

- ETSI TS 184 002 V1.1.1, *Telecommunications and Internet converged Services and Protocols for Advanced Networking (TISPAN) – Identifiers (IDs) for NGN*
- ETSI TR 187 010 V2.1.1, *Telecommunications and Internet converged Services and Protocols for Advanced Networking (TISPAN) – NGN SECurity (SEC) – Requirements*
- ETSI TS 185 005 V2.0.0, *Services requirements and capabilities for customer networks connected to TISPAN NGN*
- Draft ETSI TS 185 003 V2.2.4, *TISPAN Customer Network Gateway (CNG) Architecture and Reference Points*
- ETSI TS 185 006 V2.1.2, *Customer Devices architecture and interfaces and Reference Points*
- ETSI TS 181 005 v3, *Service and Capability Requirements*
- ETSI TS 122 228 v.8.6.0, *Service requirements for the Internet Protocol (IP) multimedia core network subsystem (IMS) – Stage 1*
- ETSI TS 122 173 V8.7.0, *IMS Multimedia Telephony Service and supplementary services; Stage 1*
- ETSI TR 187 002 V2.1.1, *TISPAN NGN Security (NGN_SEC);Threat, Vulnerability and Risk Analysis*
- ETSI TS 187 001 V2.1.1, *TISPAN NGN Security (NGN Sec): Security Requirements*
- ETSI TS 187 003 V2.1.1, *TISPAN NGN Security (NGN Sec): Security Architecture*

4. Integrated Service Digital Network (ISDN)

- ETSI EN 300 356-1 Version 4.2.1, Integrated *Services Digital Network (ISDN) – Signalling System No.7 (SS7) – ISDN User Part (ISUP) version 4 for the international interface – Part 1: Basic services*
- ETSI EN 300 403-1 Version 1.3.2, *Integrated Services Digital Network (ISDN) – Digital Subscriber Signalling System No. one (DSS1) protocol – Signalling network layer for circuit-mode basic call control – Part 1: Protocol specification Services*

Annex 7 – References related to EMC/power quality in the range 2-150 kHz

IEC 61000-3-8, *Electromagnetic compatibility (EMC) – Part 3: Limits – Section 8: Signalling on low-voltage electrical installations – Emission levels, frequency bands and electromagnetic disturbance levels* (IEC SC 77A/ CENELEC TC 210)

IEC 61334-3-1, *Distribution automation using distribution line carrier systems – Part 3-1: Mains signalling requirements – Frequency bands and output levels* (IEC TC 57/ CENELEC SR57)

> 4. Low-voltage mains signalling requirements
> IEC 61000-3-8 shall apply to low-voltage distribution networks.

NOTE In some countries national regulations prevail over the requirements of IEC 61000-3-8.

EN 50065-2-1, *Signalling on low-voltage electrical installations in the frequency range 3 kHz to 148,5 kHz – Immunity requirements for mains communications equipment and systems operating in the range of frequencies 95 kHz to 148,5 kHz and intended for use in residential, commercial and light industrial environments* (CENELEC SC 205A)

> No requirement for conducted disturbances below 150 kHz

EN 50065-2-2, *Signalling on low-voltage electrical installations in the frequency range 3 kHz to 148,5 kHz – Immunity requirements for mains communications equipment and systems operating in the range of frequencies 95 kHz to 148,5 kHz and intended for use in industrial environments* (CENELEC SC 205A).

> No requirement for conducted disturbances below 150 kHz

EN 50065-2-3, *Signalling on low-voltage electrical installations in the frequency range 3 kHz to 148,5 kHz – Immunity requirements for mains communications equipment and systems operating in the range of frequencies 3 kHz to 95 kHz and intended for use by electricity suppliers and distributors* (CENELEC SC 205A)

> No requirement for conducted disturbances below 150 kHz

EN 61000-4-16, *Electromagnetic compatibility (EMC) – Part 4-16: Testing and measurement techniques – Test for immunity to conducted, common mode disturbances in the frequency range 0 Hz to 150 kHz* (IEC SC 77A/ CENELEC TC 210)

> Scope :
> The immunity to harmonics and interharmonics, including mains signalling, on a.c. power ports (in differential mode) is not included in the scope of this standard and is covered by IEC 61000-4-13. The immunity to conducted disturbances generated by intentional radio-frequency transmitters is not included in the scope of this standard and is covered by EN 61000-4-6.

EN 61000-4-13, *Electromagnetic compatibility (EMC) – Part 4-13: Testing and measurement techniques – Harmonics and interharmonics including mains signalling at a.c. power port, low frequency immunity tests* (IEC SC 77A/ CENELEC TC 210)

> Current scope limited to 2 kHz
> Current scope limited to 16 A

EN 61000-2-2, *Electromagnetic compatibility (EMC) – Part 2-2: Environment – Compatibility levels for low-frequency conducted disturbances and signalling in public low-voltage power supply systems* (IEC SC 77A/ CENELEC TC 210)

> 4.10.3 Medium-frequency power-line carrier systems (3 kHz to 20 kHz)
> (Under consideration)
> 4.10.4 Radio-frequency power-line carrier systems (20 kHz to 148,5 kHz)
> (Under consideration)

EN 61000-2-12, *EMC – Environment – Compatibility levels for low-frequency conducted disturbances and signalling in public medium-voltage power supply systems* (IEC SC 77A/ CENELEC TC 210)

> 4.10.3 Medium-frequency power-line carrier systems (3 kHz to 20 kHz)
> (Under consideration)
> 4.10.4 Radio-frequency power-line carrier systems (20 kHz to 148,5 kHz)
> (Under consideration)

CISPR 11/EN 55011, *Industrial, scientific and medical equipment – Radio-frequency disturbance characteristics – Limits and methods of measurement* (CISPR/CENELEC TC 210)

> 6.2.1.2 Frequency range 9 kHz to 150 kHz
> For group 1 equipment, no limits apply in this frequency range.
> 6.2.2.2 Frequency range 9 kHz to 150 kHz
> For group 1 equipment, no limits apply in the frequency range 9 kHz to 150 kHz.
> 6.3.1.2 Frequency range 9 kHz to 150 kHz
> In the frequency range 9 kHz to 150 kHz, limits for mains terminal disturbance voltages apply to induction cooking appliances only.
> 6.3.2.2 Frequency range 9 kHz to 150 kHz
> In the frequency range 9 kHz to 150 kHz, limits apply to induction cooking appliances only.

CISPR 15/EN 55015, *Limits and methods of measurement of radio disturbance characteristics of electrical lighting and similar equipment* (CISPR/CENELEC TC 210)

> 4.3.1 Mains terminals
> The limits of the mains terminal disturbance voltages for the frequency range 9 kHz to 30 MHz are given in Table 2a.

EN 61000-6-1, *Electromagnetic compatibility (EMC) – Generic standards – Immunity for residential, commercial and light-industrial environments* (IEC TC77/CENELEC TC 210)

> No requirement between 2 and 150 kHz

EN 61000-6-2, *Electromagnetic compatibility (EMC) – Generic standards – Immunity for industrial environments* (IEC TC77/CENELEC TC 210)

> No requirement between 2 and 150 kHz

EN 61000-6-3, Electromagnetic compatibility (EMC) – Generic Standards – Emission standard for residential, commercial and light-industrial environments (CISPR/CENELEC TC 210)

> No requirement between 2 and 150 kHz

EN 61000-6-4, *Electromagnetic compatibility (EMC) – Generic Standards – Emission standard for industrial environments* (CISPR/CENELEC TC 210)

> No requirement between 2 and 150 kHz

CISPR/I/330/NP, *Electromagnetic Compatibility of Multimedia equipment Immunity Requirements* (CISPR/CENELEC TC 210)

> No requirement under 150 kHz

IEC TR 61000-2-5(77/382/CD), *Electromagnetic compatibility (EMC) – Part 2-5: Environment – Classification of electromagnetic environments*

CENELEC SC205A, *Study report on electromagnetic interference between electrical equipment/systems in the frequency range below 150 kHz*

IEC TS 62578, *Power electronics systems and equipment – Operation conditions and characteristics of active infeed converter applications* (IEC TC 22)

Annex 8 – Standards related to low frequency EMC or power quality

EN 50160, *Voltage characteristics of electricity supplied by public electricity networks* (CENELEC TC 8X)

IEC TR 62510, *Standardising the characteristics of electricity* (IEC TC8)

EN 61000-2-2, *EMC – Environment . Compatibility levels for low frequency conducted disturbances and signalling in public low-voltage power supply systems* (IEC SC 77A/CENELEC TC 210)

EN 61000-2-12, *EMC – Environment – Compatibility levels for low-frequency conducted disturbances and signalling in public medium-voltage power supply systems* (IEC SC 77A/CENELEC TC 210)

IEC TR 61000-3-6, *EMC – Limits – Assessment of emission limits for the connection of distorting installations to MV, HV and EHV power systems* (IEC SC 77A)

IEC TR 61000-3-7, *EMC – Limits – Assessment of emission limits for the connection of fluctuating installations to MV, HV and EHV power systems* (IEC SC 77A)

IEC TR 61000-3-13, *EMC – Limits – Assessment of emission limits for the connection of unbalanced installations to MV, HV and EHV power systems* (IEC SC 77A)

Draft IEC TR 61000-3-14, *EMC – Assessment of emission limits for the connection of disturbing installations to LV power systems* (IEC SC 77A)

Draft IEC TR 61000-3-15, *EMC – Limits – Assessment of low frequency electromagnetic immunity and emission requirements for dispersed generation systems in LV network* (IEC SC 77A)

EN 61000-4-30, *EMC – Testing and measurement techniques – Power quality measurement methods* (IEC SC 77A/CENELEC TC 210)

8/1284/NP, *Power Quality of Energy Supply – Characterization of power quality from the point of view of the electrical energy suppliers* (IEC TC 8)

IEC TR 61000-2-5(77/382/CD), *Electromagnetic compatibility (EMC) – Part 2-5: Environment – Classification of electromagnetic environments*

Annex 9 – Generation

A9.1 From high level services to use cases

Generation is involved in many high-level smart grid services as described in the matrix below.

Table A9.1 – Top level services - Generation

Top-level services	N°	Main SG applications	Typical Generation application
Integrate users with new requirements	1	Facilitate connections at all voltages / locations for any kind of device	Connection of DER at all voltages/any locations
	2	Use of network control systems for network purposes	Generation (incl DER) ressources are all dispatchables
Enhancing efficiency in day-to-day grid operation	3	Enhance monitoring and control of power flows and voltages	Generation (incl DER) is actively participating in network ancillary services: power flow and voltage control
	4	Enhance monitoring and observability of grids down to low voltage levels	Generation (incl DER) connection point to the grid is monitorable
	5	Exchange of information on actual active/reactive generation / consumption	same as above
Ensuring network security, system control and quality of supply	6	Allow grid users and aggregators to participate in ancillary services market	Generation (incl DER) is actively participating in network ancillary services
	7	Operation schemes for voltage/current control	same as 3
	8	Intermittent sources of generation to contribute to system security	same as 6
	9	Allow demand response for system security purposes at sufficient speed	same as 6
Improving market functioning and customer service	10	Participation of all connected generators in the electricity market	Generation and DER can participate in the (active) energy market
	11	Participation of VPPs and aggregators in the electricity market	VPP can participate in the (active) energy market
More direct involvement of consumers in their energy usage	12	Availability of individual continuity of supply and voltage quality indicators	Generation (incl DER) participate in islanding mode

A9.2 Existing standards and gaps

Table A9.2 – Use cases - Generation

Standards: Interface to the grid and grid operation

Use cases	Existing	Gaps	priority
All	IEC 61850[19)] EN 61400-25 IEC 61968- IEC 61970[20)] IEC 60870-5 series IEC 62351	G1 : Harmonized glossary, semantic & modelling between back-office applications (CIM) and field applications (61850) G3 :Efficient and consistent communication means compatible with narrow bandwidth / intermittent communications G4 : Extended data modelling standard (part of IEC 61850) to have more complete description of generation elements (nuclear, hydro, DER, …), G5 : Extended data modelling standard (part of IEC 61850) beyond the substation, to have a more general automation system description,	1 2 2 2
Connect the power generator to the grid *(Electrical interface)*	National Grid Codes	G6 : Standard for electrical connection rules and installation rules to ensure energy availability and security, in presence of high ratio of DER	1
Make the power generator monitorable (Enable the network operator to monitor the electrical point of connection of the generation)	IEC 61850 IEC 60870-5 series	Already covered by G1-G5	
Make the power generator dispatchable (Enable the network operator to send control to the generation facility)	IEC 61850 IEC 60870-5 series	Already covered by G1-G5	
Make the Virtual Power Plant dispatchable (Enable the network operator to send control to generators organized in clusters (VPPs))		G11 : Extended CIM to model more accurately Generation Fleet Management Applications in the case of Bulk Generation, and to integrate DER and VPPs	1

19 IEC 61850 series standard provides a model for substation automation system (part 7-4) and renewable energy resources (PV, hydro & wind and other – part 7-410, 7-420 and IEC 61400-25), a basis for field equipment communications, including semantics, and encompasses real-time operations as well as non-operational data, such as condition monitoring.

20 IEC 61968 and IEC 61970 series standards provide models of transmission, distribution systems and energy markets, as well as partial models of power generation, models known as the CIM (Common Information Model), structure and semantics for integrating a variety of back-office applications.

Standards: Interface to the Energy market

Use cases	Existing	Gaps	priority
All	IEC 62056	G7: Harmonization between IEC 62056-XX (DLMS/COSEM) data model and IEC 61850/CIM	1
Make the power generator dispatchable (Enable the generator to participate in the energy market, including ancillary services)		G8 : Extended field data modelling standard (part of IEC 61850) to support demand response schema G9 : Extended field data modelling standard (part of IEC 61850) to enable DER (and VPPs) to contribute to network ancillary services	1 1
Make the Virtual Power Plant dispatchable (Enable the cluster of generators (VPP) to participate in the energy market including ancillary services)	IEC 61968-61970 IEC 62325 series	G9 : See above G10 : Standard to allow all connected generators associated in VPPs to participate to new ways of operating grid	1 1

Annex 10 – Transmission high level services: details/explanations

a) Enabling the network to integrate grid users with new requirement

Outcome: Guarantee the integration of intermittent generation and of distributed renewable energy sources connected to the transmission network.

Provider: TSOs

Primary beneficiaries: Grid users (Generators, DSOs).

Functionalities – use cases:

- Facilitate connections at high voltages, in all locations for RES (including off-shore installations), for AC grids as well as for DC grids.
- Registers of the technical capabilities of connected users/devices with an improved network control system, to be used for network purposes (ancillary services).

Explanations:

European energy policy enhances the share of renewable energy in electricity, leading to a huge change in generation mix and its location.

Moreover, interconnection of national transmission systems is encouraged in order to enlarge the electricity market.

Therefore, the change in the mix of generation across Europe has an impact not just on the large amounts of renewable and distributed generation, but on all those that are part of the synchronous transmission system.

The requirements for transmission grid connection are still defined by national standards, also called grid codes.

The necessity of grid codes arose with the new context of market liberalization and the unbundling of network and generation functions. Now electricity transmission and distribution grids are separated from generation. Grid operators have no direct influence on the location or operation of generation plant.

Consequently, grid connection rules are now transparent, but defined according to national experience and with some differences between countries.

Grid connection requirements are still predominantly defined by specific national legislation and/or grid codes and by bilateral contracts between network operators and grid users. Now harmonization is required by the Third Package in order to facilitate the integrated European electricity market.

By EU Directive 714/2009, ENTSO-E is mandated to develop network codes which will in future form the legally binding framework for the issues addressed by the Directive. Grid connection rules are one of the issues to be covered by network codes. Grid connection requirements for generators are currently under development in a pilot project to exercise the processes given by the EU Directive and respective codes for other grids will follow shortly.

Nevertheless, the grid code is a regulation issue, and not a standardization issue.

Moreover, the technical capabilities of connected users/devices with an improved network control system to be used for network purposes (ancillary services) are still defined by requirements in contracts of grid users.

With the growing levels of renewable generation connecting to the enlarged transmission system in Europe, there is now a need for harmonized responses from system users across synchronous areas, to avoid or at least minimize the impact of widespread faults, in order to maintain security of supply and to remain in line with the objectives of European policy.

The objective is hence to establish an appropriate minimum degree of standardization of connection requirements applicable across all synchronous areas that maintains the existing standards of security and quality of supply. This should ensure equitable treatment in the connection of generators and consumers.

b) Enhancing the observability and the monitoring of the transmission grid

Outcome: Improve the observability of the real-time control of an enlarged system, including Distributed Energy Resources, more TSOs interconnected, more relevant parameters of transmission assets to monitor and facilitate the active participation of stakeholders in the electricity market.

Provider: Grid users, TSOs.

Primary beneficiaries: TSOs.

Functionalities – use cases:

- Enhance monitoring and control of the transmission systems.
- Enhance the supervision of a pan-European grid by exchange of information between TSOs.
- Monitor the relevant parameters of DER with an impact on the global system stability,
- Collect and transmit relevant information about clusters of customers in order to facilitate the active participation of consumers in the electricity market.
- Improve monitoring of network assets for a better optimized use.
- Develop new real-time measurement-based algorithms for Energy Management Systems (EMS).
- Integrate data from different sources (asset management, grid operation, ….) at EMS level.
- Use of WAMS, WACS, WAP based on Phasor Measurement Units (PMU) technologies - develop real time application.

Explanations:

The purpose of the transmission grid is the transfer of electrical power from generation sources to the distribution areas, while maintaining stability on the grid by balancing generation with load.

In their process, transmission operators need information from generation and load centres.

Therefore, observability is not a new issue for transmission grids.

The transmission networks are yet equipped for obtaining a large number of measurement values. They are typically monitored and controlled through a supervisory control and data acquisition system composed of a communication network, monitoring devices and control devices.

But due to the new challenges transmission has to face, this observability will have to be hugely enlarged.

Optimum representation and visualization as well as decision-supporting tools must be developed in order to support the operators of such complex systems. The massive amount of data must be transmitted, synchronized, analyzed and represented in such a way as to safeguard the system integrity of the overall transmission network.

The combination of distributed generation with intermittent sources, long lines between generators and loads and an increase in interconnections, illustrates the new situation and emphasizes the change in the observability challenge.

In order to maintain adequacy, security and quality levels, the new situation requires us to know the state of the electrical system on a greater scale, with more accurate and rapidly supplied data than in the past, in order to identify critical contingencies precisely and in a timely manner, as well as to activate the power network protection as soon as possible in the case of system faults or restore power in the case of black-outs.

This enlargement concerns all the stakeholders of the electricity chain, from generation through transmission operators to end-users. Information exchange may be necessary across large geographical areas and across traditional system operation boundaries.

The needs for a wider observability of the transmission grid are indicated below.

Enlargement between TSOs

Closer cooperation between European TSOs is encouraged by European legislation in order to develop methods and to take actions to improve the system security of the European transmission grid as it becomes more and more meshed.

IT platforms for data exchange and performance of common security assessments are required, and therefore also interoperability is expected.

Enlargement with new generation centres

The main renewable sources, wind and solar, have specific generation characteristics: intermittent and distributed.

In order to carry out their missions, TSOs need to ensure the suitable contribution of local resources to global system security.

The Virtual Power Plant (VPP) concept has emerged for a better management of distributed generation installations. VPPs provide location-specific services to the network operators by aggregating local Distributed Energy Resources (DER).

Therefore VPPs appear as a new contributor in the transmission system with specific characteristics for observability: frequency, voltage, power flow controls.

Enlargement with clusters of customers

The smart grid initiative will encourage “end-users” to participate more actively in the electricity market.

As for DER, clusters of consumers should be introduced in order to optimize the management of the useful information. Nevertheless, new contributors will appear with an impact on the management of the global transmission grid.

To master this challenge, relevant information should be communicated to stakeholders and therefore the observability of the transmission system should be improved.

Optimizing grid operation and usage

In order to face the new challenges in a cost-efficient way, TSOs need to improve the use of the existing infrastructure.

Condition monitoring of components of a substation or of lines provides technical information useful for optimized loading and helps to increase the lifetime of the transmission assets.

Therefore condition monitoring should be developed, involving more components of transmission assets, and prediction models should be improved.

The improvement of observability is not limited to the hardware domain but also includes the software aspect, and especially the data model for real time processing.

c) Ensuring network security of supply in a more complex and optimized grid

Outcome:

- Ensure security of supply of the European electricity system in an enlarged grid, including Distributed Energy Resources, with more interconnections and in the most cost-effective way possible.
- Optimize the use of the present infrastructure.

Provider: Generators, DSOs, TSOs.

Primary beneficiaries: Consumers.

Functionalities – use cases:

- Monitor the contribution of the intermittent generation sources to system security.
- Improve the methods and the knowledge of the real load capacity of assets in order to withstand load changes without the replacement of assets.
- Implement new scheduling algorithms and decision tools (user interface, remedial action scenarios) at the control centre level.
- Improve models for condition monitoring.
- Ensure the suitable contribution of local resources to global system security.
- Consumer flexibility in ancillary services.

Explanations:

As the production of intermittent energy sources is not synchronized with consumption, the management of the electricity supply-demand balance will be more complex with the development of new renewable energy sources.

Nevertheless, the development of RES must not jeopardize the security of supply of the whole system. Therefore contributions from grid users are expected, also including intermittent sources, in order to provide the useful ancillary services which are a key issue for the security of supply.

Hand in hand with the development of RES, new investments in the transmission grid are obviously required for grid access. But the introduction of large scale renewable energy sources and also the development of interconnections is indeed having an impact on the present assets. The load flows could change and some bottlenecks could temporarily appear in some parts of the transmission grid.

In order to avoid costly solutions for bottlenecks with the replacement of assets, optimized solutions are required for a better use of the present transmission assets. Especially better knowledge of the real load capacity of assets should avoid some replacements.

Ageing equipment, dispersed generation as well as load increases might lead to high equipment utilization during peak load conditions. If the upgrade of the power grid is to be reduced to a minimum, new ways of operating power systems have be found and established. New ways to operate power systems, mainly based on the efforts of modern information and communication technologies, are required to secure a sustainable, secure and competitive transmission grid.

Condition monitoring can improve the use of existing infrastructure, thanks to all the relevant technical information to maintain availability and at the same time maximize performance, including optimized loading and lifetime benefits.

It provides valuable information for the reliability of the grid. In addition, capacity data analysis can provide recommendations on how to maximize asset performance and can lever existing overloading capabilities, especially of transformers and overhead lines. This optimizes grid operation and grid asset management.

While it is always possible to increase capacity margins to ensure secure operation, this will be costly. With better system modelling, it will be possible to optimize capacity margins and, therefore, costs.

d) Planning of the future network

Outcome:

- Relevant architecture for the transmission grid, integrating efficient solutions to face the challenge of interoperability between the different profiles of the grid users, traditional and new, in a sustainable way.
- The deployment of the new solutions needs seamless integration into the overall system architecture of an energy management system, for optimized load flow and network stability.

Provider: Manufacturers, TSOs.

Primary beneficiaries: Grid users (Customers, Generators, DSOs)

Functionalities – use cases:

- Enhance flexibility and controllability of power flows.
- Identify solutions for increased transmission capacity over long distances.
- Facilitate the introduction of new technologies (HVDC, FACTS,…) in the present AC meshed transmission grid.
- Solutions for the architecture of a submarine grid, in order to optimize the integration of off-shore wind farms.
- Improve asset management, maintenance and replacement strategies in order to take into account the requirements of new solutions.
- Adapt network simulation tools to new constraints (renewable integration, DC networks,…).
- Adapt the network for use with bidirectional flows.
- Develop new design of overhead lines, with a higher degree of environmental compatibility and social acceptance.
- Specify the adapted requirements for equipment installed in off-shore platforms, in order to withstand maritime stress,
- Enhance the integration of HVAC overhead lines combined with underground cable sections.
- Develop the most efficient architecture for a DC grid,
- Develop network architecture with new transmission solutions as a complement to classic solutions.
- Mitigate the social and environmental impact of the transmission infrastructure.
- Develop new methodologies and criteria for power system operation and planning, allowing the use of new technologies.
- Develop solutions for conversion of HVAC (≤ 420 kV) overhead lines to HVDC overhead lines.

- Define the voltage level for DC underground (or submarine) cables.

Explanations:

With the development of RES, the priority for TSOs is to provide access to the grid for the new grid users, with respect to the necessary requirements and in the most cost-effective way possible.

Nevertheless, the architecture and the design of the transmission grid should change to take account of new constraints in a more efficient way.

The new constraints concern technical aspects (longer distance for connections, off-shore connections, ….), environmental aspects (high sensitivity to environmental issues) and also system aspects (flexibility and controllability of load flows).

Nevertheless, the traditional challenges of transmission grids, i.e.

- ensuring network operational security,
- providing an optimum amount of network capacity,
- minimizing transmission losses,
- minimizing demand for ancillary services, and
- guaranteeing satisfactory quality of electricity supply

are still valid for the future.

Innovation is required to develop new grid solutions (e.g. new design for overhead lines, AC and DC underground cables) and to improve network operations, making the power flows follow new routes to avoid congestion.

Som solutions already exist:

- FACTS technologies allow fast voltage control, increased transmission capacity over long lines, power flow control in meshed systems and power oscillation damping.
- HVDC technologies offer new solutions for transmission of bulk power over long distances.
- Components for DC grids.
- Phase shifting transformers, etc.

But the deployment of the new solutions needs seamless integration into the overall system architecture of an energy management system, for optimized load flow and network stability.

Moreover, with the development of distribution generation, standards for DER interconnection with power networks are required. In particular, with the development of off-shore wind farms, DC grids should grow for technical and economical reasons.

Nevertheless, DC technology is quite new in the transmission domain. Several issues should be studied, in order to find sustainable and efficient solutions for the transmission grid.

These issues concern DC equipment as well as DC grid topologies and of course interoperability of equipment.

e) Improving market functioning and customer service

Outcome: Increase the performance and reliability of current market processes through improved data and data flows between market participants, and so enhance customer experience. The impact for the transmission network should be a reduction of congestion.

Provider: Generators, power exchange platform providers, DSOs, electricity installers/contractors.

Primary beneficiaries: Customers, suppliers, network operators.

Functionalities – use cases:

- Improve the participation of all connected generators in the electricity market.
- Develop solutions for participation of VPPs in the electricity market.
- Improve new options for congestion management.
- Develop solutions for consumer participation in the electricity market, including information on critical peak situations.

Explanations:

Increasingly efficient allocation of cross-border interconnection capacity.

Solution to involve stakeholders in the ancillary services issue.

f) Enabling and encouraging direct involvement of consumers in energy usage

Outcome: Facilitate the active participation of all actors in the electricity market, through demand response signals and a more effective management of variable and non-programmable distributed generation. Obtain the consequent benefits: peak reduction, reduced transmission network and generation investments, ability to integrate more intermittent generation.

Provider: DSOs, generators.

Primary beneficiaries: Consumers, network operators.

Functionalities – use cases:

- Aggregate distributed loads and distributed generation (Virtual Power Plants).
- Improve provision of energy usage information, including levels of green energy available at relevant intervals and supply contract carbon footprint.
- Elaborate signals for grid users in order to avoid constraints in the grid.

Explanations:

With the 20-20-20 goals, changes in customers' behaviour are expected.

Customers should be encouraged to modify their load profiles according to the constraints present in the electricity market.

Accompanying the developments in transmission systems, smart grids should provide a solution to improve the management of the transmission load flow by involving the consumers.

With signals sent to the consumers, transformed into "prosumers", the increase in peak load could at least be reduced.

Moreover, the "operational security" or reserve provided by DER for ancillary services in the transmission grid could also be involved in the "prosumers" category.

In order to achieve this change of behaviour, TSOs should contribute by providing relevant information, data or signals to the grid users.

Aggregators, like DSOs, should be a useful interface between distributed consumers and TSOs.

Annex 11 – Transmission – Existing standards

a) Grid connection

- IEC 61400, *Communication for monitoring and control of wind power plants, based on IEC 61850*

b) Grid observability

Telecommunication domain:

- IEC 60870-5, *Telecontrol equipment and systems – Part 5: Transmission protocols*
- IEC 60870-6, *Telecontrol equipment and systems – Part 6: Telecontrol protocols compatible with ISO standards and ITU-T recommendations;TASE-2*
- EN 61400-25, *Wind turbines – Part 25-X: Communications for monitoring and control of wind power plants*
- IEC 61850, *Communication networks and systems in substations*
- IEC 61970, *Energy management system application program interface (EMS-API)*
- IEC 61968, *Application integration at electric utilities – System interfaces for distribution management*
- IEC 62357, *Power system control and associated communications – Reference architecture for object models, services and protocols*

Equipment domain :

- IEC 61869 and IEC 60044-x, *Instrument transformers*
- EN 62271-3*, High-voltage switchgear and controlgear – Part 3: Digital interfaces based on IEC 61850*

c) Grid security of supply and optimization

IEC 60076-7, *Loading guide for oil-immersed power transformers*

EN 62271-1, *High voltage switchgear and controlgear – Part 1: Common specifications*

IEC 60287-1, *Electric cables – calculation of the current rating*

Besides the IEC standards, there are some publications by TSOs addressing the security of supply issue (for instance by the French Transmission System Operator): http://www.rte-france.com/fr/nos-activites/notre-expertise/gestion-du-reseau/securiser-le-reseau/veiller-a-la-surete-du-systeme

d) Grid planning of the future network

On new technologies applicable to transmission:

- EN 60633, Ed 2.0, *Terminology for high voltage direct current (HVDC) transmission)*
- IEC TR 60919 (series) *Performance of high voltage direct current (HVDC) systems with line-commuted converters*
- EN 60700-1, Ed.1.2, *Thyristor valves for high voltage direct current (HVDC) power transmission – Part 1 : Electrical testing*
- EN 61954, Ed.1.1, *Power electronics for electrical transmission and distribution systems – Testing of thyristor valves for static VAR compensators*
- EN 61803, Ed.1, *Determination of power losses in high-voltage direct current (HVDC) converter stations.*
- IEC 60255, *Electrical relays*

- IEC 60834, *Teleprotection equipment of power systems*
- EN 60495, *Single sideband power-line carrier terminals*
- IEC 61869, *Instrument transformers*
- IEC 60909, *Short Circuit currents in three phase AC systems*

For interoperability with other domains:

- IEC 61727, *Photovoltaic systems – characteristics of the utility interface*
- IEEE 1547 series, *Interconnected Distributed Resources with Electric Power Systems*
- IEC 60870-5, *Telecontrol equipment and systems*
- IEC 61850, *Communication networks and systems in substations*
- IEC 61970, *Energy management system application*
- IEC 62357, *Power system control and associated communications – Reference architecture for object models, services and protocols*
- IEC 62351, *Power systems management and associated information exchange*

For secure communication:

IEC 62351, *Power systems management and associated information exchange – data communication security*

White paper "*Requirements for secure control and telecommunication system*" BEDW-Germany.

e) Grid market

- IEC 62325, *Framework for energy market communications*

(To be completed)

f) Prosumers

(To be completed after checking the list of other topics)

Annex 12 – Transmission – Advanced EMS architecture

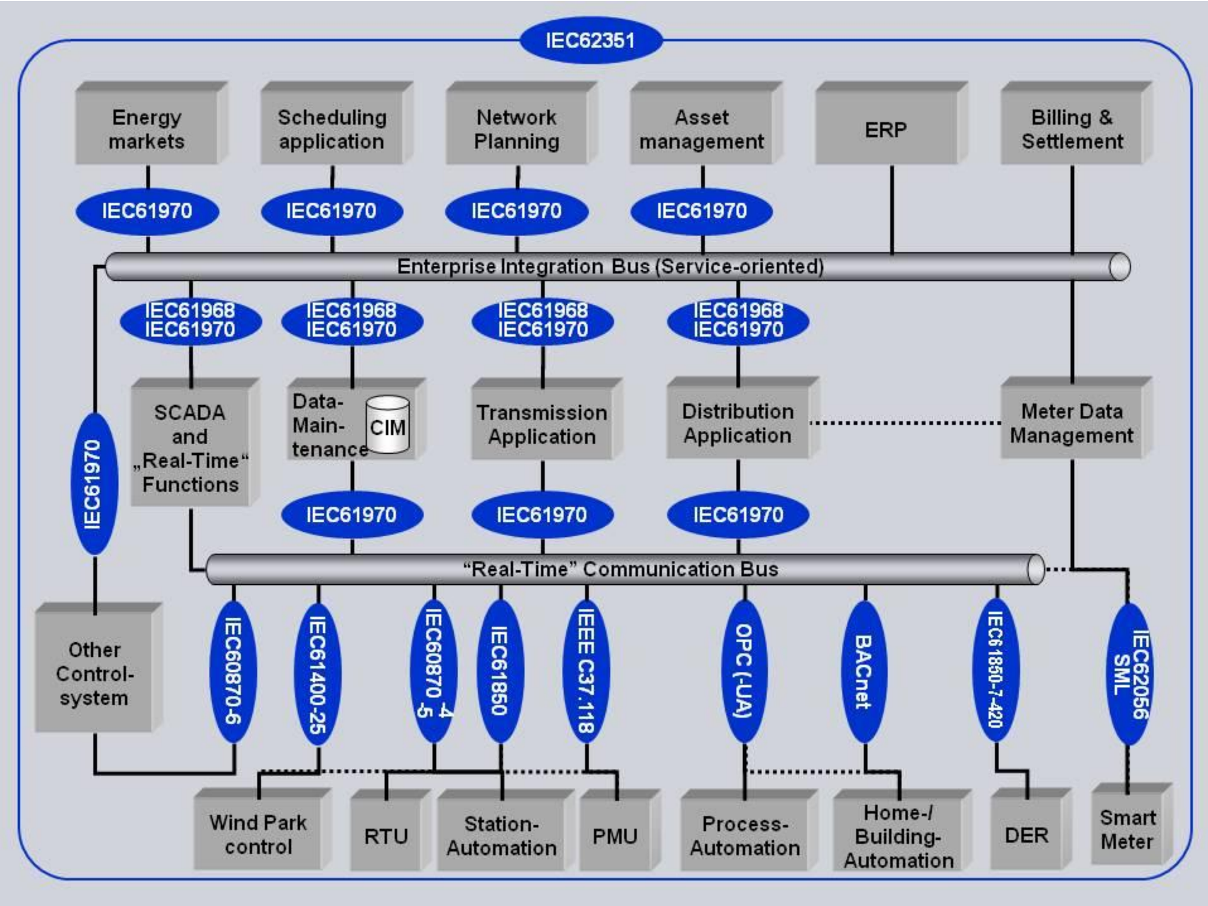

Figure A12.1 – Overview of advanced EMS architecture

The IEC 62357 Reference Architecture gives an overview (figure above) of the useful standards in the domain of interoperability for power utilities.

Annex 13 – Distribution high level services: details/explanations

a) Enabling the network to integrate users with new requirements

Outcome: Guarantee the integration of distributed energy resources (both large and small-scale stochastic renewable generation, heat pumps, electric vehicles) connected to the distribution network.

Provider: DSOs

Primary beneficiaries: Generators, consumers (including mobile consumers), storage owners.

Functionalities – use cases:

- Facilitate connections at all voltages/locations for all existing and future devices with SG solutions through availability of technical data and additional grid information to facilitate connection of new load types, particularly EVs.
- Better use of the grid for the users at all voltages/locations, including in particular renewable generators.
- Allow the network control systems to be able to register the technical capabilities of connected users/devices; allow using them for network purposes (ancillary services).
- Updated network performance on continuity of supply and voltage quality to inform connected users and prospective users.

b) Enhancing efficiency in day-to-day grid operation

Outcome: Optimize the management of distribution assets and improve the efficiency of the network at MV as well as LV level through enhanced automation, information on assets performance, monitoring, protection and outage management. Faster fault identification/resolution will help improve continuity of supply levels.

Better understanding and management of technical and non-technical losses, and optimized asset maintenance activities based on detailed operational information.

Provider: DSOs, metering operators

Primary beneficiaries: DSOs, consumers

Functionalities – use cases:

- Improved automated fault identification and optimum grid reconfiguration after faults reducing outage times:
    - using dynamic protection and automation schemes with additional information in the presence of distributed generation;
    - strengthening Distribution Management Systems of distribution grids.
- Enhanced monitoring and control of power flows and voltages.
- Enhanced monitoring and observability of grids down to low voltage levels, also with the use of smart metering infrastructure.
- Improved monitoring of network assets in order to enhance efficiency in day-to-day network operation and maintenance (proactive, condition based, operation history based maintenance).
- Identification of technical and non technical losses through power flow analysis, network balances calculation and smart metering information.

- Frequent exchange of information on actual active/reactive injection/withdrawals by generation and flexible consumption between DSOs and TSO.

c) Ensuring network security, system control and quality of supply

Outcome: Foster system security through an intelligent and more effective control of distributed energy resources, ancillary back-up reserves and other ancillary services. Maximize the capability of the network to manage intermittent generation, without adversely affecting the quality of supply parameters.

Provider: DSOs, metering operators, aggregators, suppliers, generators, consumers, storage owners.

Primary beneficiaries: Generators, consumers, suppliers, ESCOs.

Functionalities – use cases:

- Develop smart grids solutions to allow grid users and aggregators to participate in an ancillary services market to enhance network operation.
- Solutions for demand response and load control, in order to guarantee quality and continuity of supply.
- Improved operation schemes for voltage/current control taking ancillary services into account.
- Solutions to allow intermittent sources of generation to contribute to system security through automation and control.
- System security assessment and management of remedies, including actions against terrorist attacks, cyber threats, actions during emergencies, exceptional weather events and force majeure events.
- Improve monitoring of safety particularly in public areas during network operations.
- Solutions for demand response for system security purposes in required response times.

d) Enabling better planning of future network investment

Outcome: Collection and use of data to enable more accurate modelling at LV level in order to optimize infrastructure requirements and so reduce their environmental impact. Introduction of new methodologies for more ‘active’ distribution, exploiting active and reactive control capabilities of distributed energy resources.

Provider: DSOs, metering operators.

Primary beneficiaries: DSOs, consumers, generators.

Functionalities – use cases:

- Better models of distributed generation, storage, flexible loads (including EV), and ancillary services provided by them for an improvement of infrastructure planning.
- Improved asset management and replacement strategies by information on actual/forecast network utilization.
- Additional information on grid quality performance and consumption made available by smart metering infrastructure to support network investment planning.

e) Improving market functioning and customer service

Outcome: Increase the performance and reliability of current and incoming new market processes related to, for instance, billing, change of supplier and change of tenancy, through improved data and data flows between market participants and the necessary framework to enable and promote energy efficiency and services development, and so enhance customer experience.

Provider: DSOs, ICT hub providers, power exchange platform providers, suppliers

Primary beneficiaries: Consumers, suppliers, ICT hub providers

Functionalities – use cases:

- Solutions for participation of all connected generators in the electricity market.
- Solutions for participation of VPPs and aggregators in the electricity market, where appropriate through access to the register of technical capabilities of connected users/devices.
- Solutions for consumer participation in the electricity market, allowing market participants to offer:
    - time of use energy pricing, dynamic energy pricing and critical peak pricing;
    - demand response / load control programmes.
- Grid solutions for EV recharging:
    - Open platform grid infrastructure for EV recharge purposes accessible to all market players and customers.
    - Smart Control of the recharging process through load management functionalities of EVs.
- Improved industry systems for settlement, system balance, scheduling and forecasting and customer switching.
- Grid support to intelligent home/facilities automation and smart devices by consumers.
- Individual advance notice for planned interruptions.
- Customer level reporting in the event of interruptions (during, and after event).

f) Enabling and encouraging stronger and more direct involvement of consumers in their energy usage

Outcome: Foster greater consumption awareness though improved customer information, in order to allow consumers to modify their behaviour according to price and load signals and related information.

Promote the active participation of all actors in the electricity market, through demand response programmes and a more effective management of the variable and non-programmable generation. Obtain the consequent system benefits: peak reduction, reduced network investments.

Provider: Suppliers (with metering operators and DSOs), aggregators, ESCOs.

Primary beneficiaries: Consumers, generators, suppliers, DSOs.

Functionalities – use cases:

- Sufficient frequency of meter readings, measurement granularity for consumption/injection metering data (e.g. interval metering, active and reactive power, etc).
- Remote management of meters.
- Consumption/injection data and price signals via meter, via portal or other ways including home displays, as best suited to consumers.
- Improved provision of energy usage information, including levels of green energy available at relevant intervals and supply contract carbon footprint.
- Improved information on energy sources.
- Individual continuity of supply and voltage quality indicators via meter, via portal or other ways including home displays.

Annex 14 – Home and building automation

The following standard series define communication, functions or services for the home and building domain that might be adapted or supplemented in view of the smart grid requirements:

Table A14.1 – Standards relevant to Home Automation (HBES)

Series EN 50090	Home and building electronic systems (HBES)	CLC/TC205
Series EN 50491	Home and Building Electronic Systems, HBES and Building Automation and Control Systems (BACS)	CLC/TC205
Series ISO/IEC 14543-3	Information technology – Home electronic system (HES) architecture	ISO/IEC JTC 1/ SC 25

Table A14.2 – Standards relevant to Building Automation and Control (BACS)

Series EN 13221	Open Data Communication in Building Automation, Controls and Building Management — Home and Building Electronic Systems (KNX)	CEN/TC247
Series EN ISO 14908	Open data communication in building automation, controls and building management – Building network protocol (LONWORK)	CEN/TC247 ISO/TC205
EN ISO 16484-5	Building automation and control systems – Part 5: Data communication protocol (BACnet)	ISO/TC205 CEN/TC247
Series EN ISO 16484	Building automation and control systems (BACS)	CEN/TC247 ISO/TC205
EN 15232	Energy performance of buildings — Impact of Building Automation, Controls and Building Management	CEN/TC247
EN 12098-3	Controls for heating systems — Part 3: Control equipment for electrical heating systems	CEN/TC247

Table A14.3 – Other relevant (consortia) standards

ISO/IEC 29341	UPnP	
IEEE 802.14.4	ZigBee	
IEC 61970	CIM	TC 57

Annex 15 – Index of standards referred to in this Report

EN 50K series are "homegrown CENELEC standards"

EN 60K series are standards based on IEC or equivalent to IEC