Status of this version 0.2

This report is the draft version, sent on 19 November to the JWG for their comments by 3 December 12H00 CET; this draft is not intended for comments outside the JWG.

Please use the accompanying commenting sheet for your delivering comments.

Comments should be sent to: lvandenberghe@cencenelec.eu

Note: there is still a need to align all appendices into a common consistent style; there is also in some cases still content missing in those annexes; both aspects will be corrected in the final version.

Contents

1. Executive Summary

Europe is committed to the 20-20-20 targets to reduce carbon emissions and to secure the 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 a Smart Grid as key enabler for the required innovation. To promote this transformation the European Commission has taken a number of actions including an upcoming 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 (ESO). This report investigates the status of European standardization. It does not duplicate the extensive work already done in other regions. Its main focus is on high-level recommendations concerning the organization of standardization in Europe:

- **Use a top down approach**
  The different applications need to fit together. This can only be assured by a strong coordination.
- **Build up a flexible framework of standards**
  Solutions are still changing. A flexible model or architecture must be available to map services and use cases.
- **Agree on an European set of use cases**
  Build a single repository of use cases to systematically deduce existing and future standardization needs.
- **Align to international standards**
  Transfer the European results to the international level.
- **Don't reinvent the wheel**
  Reuse existing mature standards.

For Smart Grids, it is not important to change an individual standard, it's far more important to adapt the organization and processes for standardization. The establishment of the Joint Working Group CEN/CLC/ETSI on standards for Smart Grids is a step in this direction.

The aim of this document is to draft a strategic report which shows the standardization requirements for the European vision of Smart Grids, taking especially into account the European taskforce initiatives. It provides an overview of standards, current activities, fields of action, international cooperation and strategic recommendations. Section 2 gives 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 and the procedure taken in the development of the report. Section 4 states general recommendations towards the European Standardization Organizations. Section 5 provides details of the current status of standardization in cross-cutting and domain-specific topics. Finally section 6 informs about next steps.

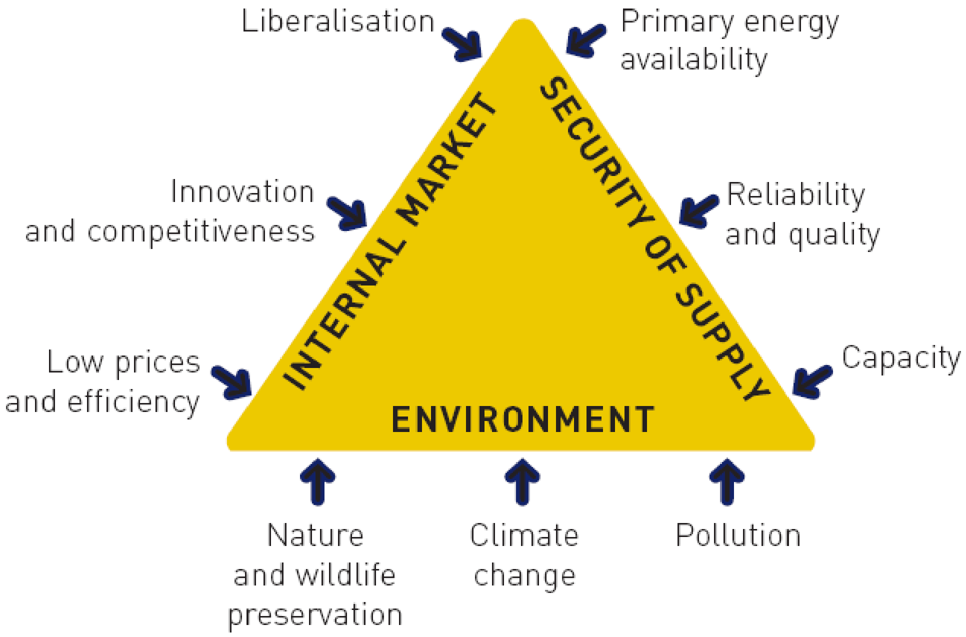
In summary, the report identifies and proposes the necessary steps to be taken concerning standardization of Smart Grids. A prioritization of actions still needs to be performed and the content will continuously be influenced by external events. This is especially true for the upcoming mandate. The content and spirit of the mandate needs to be included in later versions of the report. It is therefore planned to regularly revise this document. 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 make the vision happen.

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 to meet the needs of large, predominantly carbon-based generation technologies, located remotely from demand centres. The energy challenges that Europe is now facing are changing the electricity generation landscape.

The drive for lower-carbon generation technologies, combined with greatly improved efficiency on the demand side, will enable customers to become much more inter-active with the networks. More customer-centric networks are the way ahead, but these fundamental changes will impact significantly 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 [source ETP Smart Grid]. It has identified clear objectives and proposed an ambitious strategy to make a reality of this vision for the benefits 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” [] and the ETP “Vision and strategy for Europe's Electricity Networks of the future” []. 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.



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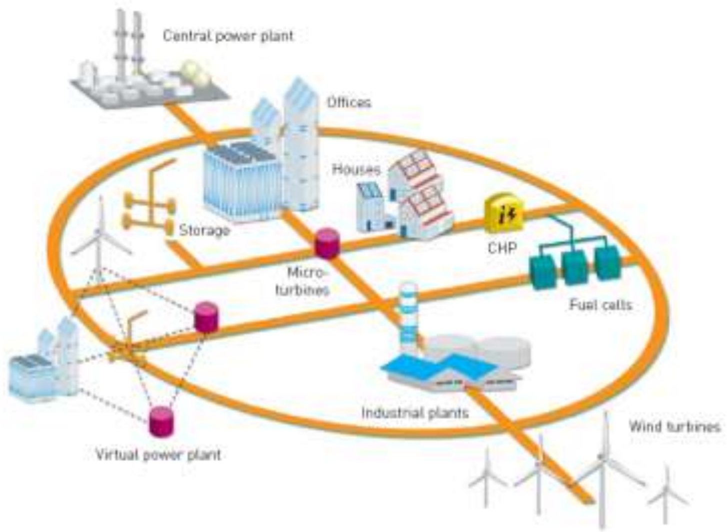
The European Commission Directorate-General (DG) for Energy mandated a group of experts to examine the conditions for a successful deployment of Smart Grids (or smarter grids) in Europe and created an Smart Grids Task force. This task force highlighted the importance of standards for such a successful 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 standardisation bodies providing a not consistent set of standards.

Even if a first set of recommendations was issued by the EC Smart Grid task force, the Expert Group 1 concluded on the need of a joined CEN/CENELEC/ETSI Group on standards for Smart Grids to get deeper in establishing detailed recommendations to selected standardisation bodies.

2.1 Basic idea of a smart grid

The idea of Smart Grid in Europe is described in detail in the publications by the European Technology Platform Smart Grids (ETP []) and the Strategic Deployment Document (SDD[1] []). Details can be found here. The content is only summarized here insofar it is necessary for new concepts and answers of the European standardization system.
Europe's electricity networks must be flexible, accessible, reliable and economic. Furthermore solutions must be scalable, increase capacity for power transfers, reduce energy losses, heighten efficiency and security of supply and be backward compatible to include the installed base. Developments in communications, metering and business systems will open up new opportunities at every level on the system to enable market signals to drive technical and commercial 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.



In the *Strategic Deployment Document* from the ETP Smart Grids [ETPSDD], a Smart Grid is therefore defined as follows:
A Smart Grid is an electricity network that can intelligently integrate the actions of all users connected to it - generators, consumers and those that do both – in order to efficiently deliver sustainable, economic and secure electricity supplies.

The European regulators use and support the approach of the ETP Smart Grids, but emphasise that development must be a means to an end and investments in smarter networks must result in user value and direct benefits to all network users.

The addressed challenges and opportunities include:

- User-centric approach
- Electricity networks renewal and innovation
- Security of supply
- Liberalised markets
- Interoperability of European networks
- Distributed Energy Resources (DER) and renewable energy sources (RES)
- Central generation
- Environmental issues

1.

[1] www.smartgrids.eu/documents/SmartGrids_SDD_FINAL_APRIL2010.pdf

- Demand response and Load management

The vision and the scope of Smart Grid bring together a vast group of stakeholders. These are described in detail in the intermediate report of the Task force's expert Group 3 "Roles and Responsibility in a Smart Grid" []. 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 regarding data exchange, modelling grids, ancillary services and their users.

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

- interoperability,
- defining data models,
- protocols, communication and information exchange as well as
- improving security in the context of critical infrastructure and
- 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[2] of the main energy challenges that the EU will be facing in the coming years. Commission proposed to address these challenges through a new comprehensive European energy policy build 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 was identified as a political priority.

The roll-out of smart meters and implementation of Smart Grids in Europe is an integral part of this political priority. When the Commission in September 2007 unveiled its proposal for Third Energy Package, it made the implementation of intelligent metering systems an obligation for the Member States in both the Electricity and the Gas Directive.[3] Member States must by September 2012 carry out a cost-benefit analysis of the smart meters implementation and ensure the deployment of the new technology to at least 80% of the households by 2020. The progress towards the Smart Grid development is also supported by a whole body of European energy efficiency legislation. Directive on energy end-use efficiency and energy services from 2006 lists deployment of intelligent metering systems as one of the main cross-sectoral measures considerably improving energy efficiency.[4] Likewise, the recently revised Directive on Renewable Energy obliges the Member States to take appropriate steps to develop intelligent transmission and grid infrastructure.[5] The energy performance of buildings Directive strongly supports decentralised energy supply systems based on renewable energy and calls on the Member States to encourage the introduction of intelligent metering systems whenever a building is constructed.[6]

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

1.

[2] COM (2006) 105 final – A European strategy for sustainable, competitive and secure energy.

[3] Annex 1 of the Directive 2009/72/EC and Directive 2009/73/EC

[4] See Annex 3 of Directive 2006/32/EC

[5] See Article 16 of the Directive 2009/28/EC

[6] See Article 8 of the Directive 2010/31/EU

In order to succeed with Smart Grids implementation in Europe, the support of the industry is a key. This is why the Commission came in 2007 with the European Strategic Energy Technology Plan (SET-Plan). Being 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, in June 2010 the Commission together with industry stakeholders launched four industrial initiatives, including one on electricity grids. 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.[7]

However, addressing the technology aspects of Smart Grids is not enough for making Smart Grids in Europe a reality. Important questions regarding data protection, interaction between different actors and regulators needs to be clarified, funding issues addressed. To this aim, the Commission established in November 2009 a Task Force on Smart Grids. It is to advise the Commission on the policy/regulatory directions at European level, coordinating first steps towards the implementation of Smart Grids under the provision of the 3rd Package. Task Force is led by the Commission's Directorate 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 number of relevant issues towards the mid 2011. The Expert Groups that are to identify the need of further Smart Grid standards have already expressed a positive view and recommended to the Commission to initiate drafting of a standardisation 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 Report

The aim of 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 especial into account the ETP (European Technology Platform), SDD (Strategic Development Document), SMCG (Smart Metering Coordination Group), EU Focus Group on Electric Vehicle and the European taskforce 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 answer to the first conclusions of the Expert Group (EG1) of the EC Smart Grids TF, which request to establish a Standardization roadmap. For efficient deployment it is necessary to coordinate all these changes within a coherent framework.
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 necessary. Technical standards have to be defined clearly and fast; if not the desired effect will not occur in the expected time frame. 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."

1.

[7] http://ec.europa.eu/energy/technology/initiatives/doc/grid_implementation_plan_final.pdf

[Source of quote: http://ec.europa.eu/energy/gas_electricity/smartgrids/doc/expert_group1.pdf]

The report summarizes international and national activities in standardization taking into account the specific European requirements derived from the European Smart Grid vision. This draft of a 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 to do this is described in the last section of the report.
The report should support European manufactures and their international reputation in the area of power engineering, automation technologies as well as ICT business.

The concept of the Smart Grid is receiving attention by 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 designed to establish CEN, CENELEC and ETSI as the voice for Smart Grid standardization, especially in the face of the political framework and the announced mandate on Smart Grid by the European Commission.

2.4 Activities around the world

Smart Grid has received a lot of attention in the past years worldwide. The concepts differ a lot 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 mutual agreements are in the focus of the European activities. This is especially true for ISO, IEC and 3GPP as well as the European national committees. The results of these organizations need to be considered with top priority, since they on the one hand influence the work on European level. On the other hand co-operation with ISO, IEC or 3GPP is our main lever to internationalize European standardization work[8]. There are of course further standardization organisations which have to interact in the networks of the Smart Grids technologies. ISO/IEC JTC1 and ITU-T on the international level, NIST, KATS, JISC on the regional level and German DKE standardization roadmap on the national level are especially worthy of mention.
In the following a very short overview on the different studies will be given:

- **IEC Strategic Group 3 “Smart Grid Report” []**
  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 is now officially available in 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 also to disseminate these further and to draw attention to them. A total of over 100 IEC standards were identified, described and prioritised by SMB SG 3. Twelve application areas and six general topic blocks were examined by SG 3, and 44 recommendations for a Smart Grid under 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. Currently the IEC group focusses on use cases and general requirements for a Smart Grid reference architecture.

- **German Standardization Roadmap E-Energy / Smart Grid []**
  In close co-operation of DKE, the German Commission for Electrical, Electronic & Information Technologies of DIN and VDE, together with the German research projects “E-Energy” [] funded by the Federal Ministry of Economics and Technology as well as the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety, a position paper on the German Smart Grid Standardization was worked out by all relevant stakeholders and experts in combination with a public

1.

[8] E.g. Vienna or Dresden Agreement between CEN/ISO and between CENELEC / IEC

hearing and the public possibility to comment on the draft version. Based on a description of the basic concepts of Smart Grids, an overview of relevant standards, current studies and activities the position paper provides recommendations for necessary fields of action, international cooperation and strategy. Main result was the statement that a lot of standards already exist in spite of some public dispute about missing standards. Existing international standards, especially worked out by IEC/TC 57, should be used as far as possible and should be the base for further developments. New developments are seen mainly in the cooperation of different standardization organisations and different Technical Committees due to the needed broad system approach of Smart Grids from generation, transmission, distribution to electrical devices like smart appliances in households. Furthermore, experts pointed out that the system approach has to include or consider other media like gas, heat or water (Multi-Utilities) as well as other domains E.g. in a Smart Home functions of Energy Management, Home Automation and Ambient Assisted Living (AAL) might merge. The paper is publically available in German and English.

- **European Standardization Mandate M441 and the Smart Meter Co-ordination Group []**
  The European Union has issued a mandate for the standardization of smart meter functionalities and communication interfaces for use in Europe [CENELEC], [ETPSDD] for the electricity, gas, heat and water sectors to the organisations CEN, CENELEC and ETSI. The results of Mandate M/441 are 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 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
  - Communication with devices in the household
  - Support of a display or interface in the household for display of the meter data in real time

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

- **NIST Interoperability Framework []**
  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 [EPRI]. Various pieces of equipment, such as Smart Meters for the US Smart Grid, are already being evaluated in field trials. NIST also emphasises 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 [EPRI] 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 organisations 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 []**
  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 organisations 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 organisations.

- **The State Grid Corporation of China - SGCC Framework []**
  The State Grid Corporation of China [36] has defined an own smart grid standardization roadmap which will have a huge impact on all vendors and markets since China will be one of the largest markets and vendors of products for the upcoming smart grid based on open standards. The first version of the SGCC framework takes into account eight domains, 26 technical fields and 92 series of standards.
  The eight domains include planning, power generation, transmission, substation equipment and communication, distribution, utilization, dispatching and ICT. For the initial development, SGCC has taken into account several existing standardization roadmaps, e.g. IEC SG 3, NIST Interoperability Roadmap, IEEE P2030, CEN/CENELEC/ETSI Working Groups, German DKE Roadmap and Japanese METI Roadmap. As motivation for their efforts, several reasons are coined. After the age of information, they see an upcoming age of intelligence where the integration of clean energy requires both a strong and smart grid. The strong and smart grid is considered to be needed to tackle climate change and environment deterioration - the smart grid is essential 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. The strong and smart grids will be a shift in terms of function of the grid. According the the SGCC definition, the grid itself will no longer be a simple carrier of transmission and distribution of electricity, but 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. Stage 1 is the planning and trial phase for the years 2009 and 2010 for technical and management specification formulation, key technology R&D and pilot programs. Stage 2 from 2011 till 2015 focuses on speeding up the construction of the UHV grid, and rural distribution network, to establish preliminary smart grids operation, The aim for stage 2 is to achieve technical breakthroughs and extensive application of key technology and equipment. Stage 3 from 2016-2020 is the leading and enhancing phase, where basically the construction of the strong and smart grid is completed, therefore enhancing resource allocation abilities, security levels and operational efficiency of the grid. Those stages also have reflecting stages in the needed standardization efforts. In stage 1, they plan for standard formulation and establish a preliminary standards framework. The work focused on developing and amending standards to have pilots finish in due time. Stage 2 wants to renew and amend existing standards, complement necessary standards and complete the SG standards framework. Furthermore, one focus will be the promotion of domestic standards into international standards. In stage 3, those should be promoted to world leading standards providing opportunities for Chinese vendors, making domestic standards all-around international ones.
  For the first batch of smart grid standards, SGCC has identified 22 standards overall, 10 domestic ones and 12 international ones. The following one are the international standards:
  - Terminology and modelling of smart grid: ISO/IEC 62559
  - Standard series on Substation Communication network and System: IEC 61850
  - Interface of Power Company Data Exchange Platform - Distribution Management System: IEC 61968

- Specifications on Open Geographical Data Interoperability: OGC Open GIS
- Technology Regulations on Integration of Distributed Generations into Power Grid: IEEE 1547
- Standard Series on Electric Vehicle Charging and Discharging: IEC 61851
- Standard Series on Application Program Interface of Energy Management Systems (EMS): IEC 61970
- Standard Series on Transmission Control Protocol: IEC 60870
- Power System Management and Associated Information Exchange - Data and Communications Security: IEC 62351
- Power System Control and Associated Communications - Object Model, Service Facilities and Protocol Architecture with Reference: IEC 62357
- Standard Series on Information Security Management System: ISO/IEC 27000 series
- Information Technology Security Evaluation Criteria: ISO/IEC 15408

Those standards have also been in the scope with the IEC SG 3, containing their 5 core standards. Of particular interest for the IEC TC 57 might be the Chinese initiative for so called simplified CIM series standards. CIM/E will be a data description specification, CIM/G a power grid description specification, CIM/S a simple service description specification and CIM/M a dynamic message encoding specification. Those items will be proposed to the IEC through the national Chinese committee as NWIPs.

A lot of further activities and roadmaps could be mentioned as well, like Austria, Spain, Korea and others.

In the area of international standardization and interoperability roadmaps, a relevant document is already available in the form of the IEC roadmap, from whose contents standards for a European roadmap can be deduced. 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, especially the taskforce reports commissioned recently by the European Commission are of significance. Report of EG2 on security aspects merely summarises the topic of standards and standardization by means of recommendations, while the report of EG1 describes the recommended standards in detail, with the focus on IEC standards. The recommendations of the two studies extensively agree with each other and are also congruent with the simultaneously, but completely independently compiled NIST/EPRI document. It is therefore to be assumed that certain IEC standards (for example IEC 62357 SIA) will indeed form the core of a future Smart Grid.

It is agreed, that the European Joint Working Group on Smart Grid 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 included in the overall setup of CEN, CENELEC and ETSI anyhow.

3. Description of the overall concept

3.1 Scope

The following document identifies existing standardization and potentials 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 European Commission Task Force on Smart Grids. The European requirements shall fit within the overall smart grid standardization philosophy. The report should not 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 will make maximum reference to international work, where ever it may already suffice for the implementation of Smart Grid 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 prepare 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 for 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 expected and announced 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. A Joint Working Group CEN/CENELEC and ETSI on standards for Smart Grids was formed 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 elaborate function and domain analysis. This is done by the European taskforces, who have elaborated a number of basic functionalities of a future European Smart Grid. From these functionalities high level use cases are derived 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 President's 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 kind of deliverables appropriate for Smart Grid. It will furthermore elaborate on suitable organization of standardization work within the ESOs. Section 5 will describe the recommendations in specific areas. It is divided in three subsections: 5.1 "Cross cutting Topics", 5.2**Error! Reference source not found.** "**Error! Reference source not found.**".
The first subsection covers topics which are of general nature and apply to all domains of Smart Grid. 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 its high level use cases will be given. This is followed by the necessary requirements to realize such functions. Then – if already existing - a number of possible candidate standards, published by ESOs will be

given. The remaining gaps are described and the necessary standardization work or standards missing are outlined. Each subsection will end with recommendations towards the ESOs and - in case – other stakeholders.

The last subsections cover further activities to be started, activities towards an upcoming mandate on Smart Grid and the provisions to be taken to issue a second version of the report.

4. European standardization and regulation landscape

4.1 General recommendation

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.

G-2 International standards as base for promoting EU economy

Standardization of Smart Grid must be based on existing international work, to avoid reinventing the wheel, to accommodate already solutions which are standardized and applied for practical purposes and to secure the interests of European manufactures who are acting globally. This document recognizes that work and therefore builds upon the globally recognized Smart Grid standards as identified in Section 5 (e.g. IEC TC57 family of standards).

G-3 Speed of implementation – reuse existing

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. Focus must be laid on the standard development according to the R&D and deployment priorities of the EU given in the taskforce reports, the ETP and the SDD.

G-4 Concentrate on future proof standardization

Smart Grid 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 flexible 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. Feed this repository with at least:

- the M441 set of use cases
- active liaisons with all European Smart Grid projects
- from the EG1 to EG3 reports of the EU Commission Smart Grid task force
- from experiences of the national committees

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

Define the methodologies: templates, classification, etc.

G-6 Adapt standardization process

Set the needed processes to fit the lack of maturity of many smart grid application. As stated in EG1 report, "smart grids deployment will be a continuous learning process" and standardization should propose clear set of processes to cope with this learning process. E.g. use 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 including covering the whole life cycle of such standards, including how to collect issues, to treat/fix issues, and then to validate and test.

4.2 ESO Organisation

Several facts indicate, that there is increased need for cooperation of the European Standards organizations on the topic of Smart Grid. 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 chapters 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 Grid is a highly dynamic field, where major changes must be expected and accommodated for. And finally a mandate of the EC under preparation has to be worked on. All these facts ask for a structure or organization within the ESOs to cover these tasks.

O-1 Extend timeframe and scope of JWG Smart Grid

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 Grid area.

O-2 Marketing of ESOs effort in Smart Grid

ESOs must enforce their efforts to markets and visualize their already done work on international and different regional levels. This is necessary to keep the high level of influence on international standardization and therefore on solutions. A funding of the external representation of the ESOs should be investigated as international activities are indicating growing dominating roles of US and Asia due to high public funding of respective standardization organizations. Although this might be conflicting with the traditional role of the European standardization the short time frame for actions in face of the international competition 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 SME. Any solution should be based on the co-operation with national standardization organizations and their experts and expertise.

5. Status of Standardization

5.1 Cross cutting Topics

5.1.1 Terminology, Object Identification and Classification

5.1.1.1 Description

Terminology and glossary are a prerequisite for dealing with Smart Grid 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 explicit acronyms. This must be done by –as far as possible- technology neutral definitions.

There is even yet no internationally unified definition of a smart grid. IEC TC8 recently circulated among its members a proposal for a smart grid definition, that supports the conceptual model proposed by the IEC Roadmap:

Draft 617-04-13 **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.

5.1.1.2 Existing Standards

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

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
5.1.1.2.1.1 Communication	Telecontrol Communication systems in substations Interface for Distribution management Energy market communication Data exchange DLMS COSEM Data communication	IEC 60870-1-3, IEV 371 IEC 61850-2 IEC 61968-2 IEC 62325 IEC 62051-1 ISO/IEC 2382-9 **Telecom glossaries to be added**
Information security		NIST key security terms **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
Smart metering		SMCG Glossary IEC 62051
Industry, Energy management	Energy management	CEN/CLC TR 16103
In House automation	Home Electronic System (HES) Intelligent home	ISO/IEC 15044 ISO/IEC 29108 (CD)
Market and actors	Tariffs for electricity	IEV 617 IEV 691

NOTE : List of Terminology publications related to smart grid

- 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*
- CEN/CLC TR 16103, *Energy management and energy efficiency - Terminology*
- 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/IEC 29108 (CD), *Information technology - Terminology for intelligent homes*

5.1.1.3 Gaps

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

Work is already ongoing on a future amendment 1 to IEC 60050(617), which will encompass several basic terms:

Smart grid, intelligent grid
Smart metering
Demand side management
Demand response

Furthermore possible further terms to be added probably 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
(To be complemented after review of the other chapters)

The part 619 of IEC 60050 ,"Tariffs for electricity" needs to be revised.

5.1.1.4 Recommendations

Overview of existing glossaries to be complemented with Telecom domain terms

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

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

Object Identification, Product Classification, Properties and Documentation
(reprint from IEC SG3 Road map)

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:

IEC 81346-1, *Industrial systems, installations and equipment and industrial products - Structuring principles and reference designations - Part 1: Basic rules*
IEC 62507-1, *Requirements for identification systems enabling unambiguous information interchange – Part 1: Principles and methods – Proposed as horizontal standard* (under preparation by TC3)
IEC 61666, *Industrial systems, installations and equipment and industrial products - Identification of terminals within a system*
IEC 61175, *Industrial systems, installations and equipment and industrial products – Designation of signals*

Classification of objects:

IEC 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 is required.

Electronic product description activities:

IEC 61360-1, *Standard data elements types with associated classification scheme for electric items - Part 1: Definitions - Principles and methods*
IEC 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 technical committee TC 184 (Technical Industrial automation systems and integration), sub-committee SC 4 (Industrial data).
NOTE ISO 13583 and IEC 61360-2 are identical.
IEC 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*
IEC 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.

Recommendation

PPC-1 Electronic Data models
To align as much as possible glossaries with Electronic Data Models (TC 57, SC 3D)

5.1.2 Reference Architecture

5.1.2.1 Description

Not 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 into Smart Grid will provide expended applications management capabilities over an integrated secure, reliable and high-performance network.

This will result in a new architecture with multiple stakeholders, multiple applications, 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 paragraph as Reference Architecture.

In essence, the purpose a Reference Architecture is to allow for a *separation* of a complex system (as the 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.

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.
- *Security Architecture*. A detailed description of all aspects of the system that relate to 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*. A flexible set of design principles used during the phases of systems development and integration.

All these architectures are necessary, at various degrees, to the complete description of the Smart Grid. A presentation of the available architectures for Smart Grid as well as an evaluation of their current status is made below, together with recommendations.

It has to be clear upfront that such a set of architectures cannot be defined once and for all. It will have to be evolving 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.

To support its analysis, NIST has adopted a Conceptual Model with a few major characteristics:

- The visible role of the Customer (encompassing both the traditional role of Consumer and the growing role of Prosumer) and the need to tailor the Smart Grid to its needs;
- A division in seven domains: Customer, Bulk Generation, Transmission and Distribution (including Substation Automation and Protection, EMS, etc.), Markets, Operations and Service Providers;
- The exchange of electrical flows as well as information flows between these domains, making it clear that both have to be treated coherently;
- The explicit need for Secure Communications, thus highlighting the essential concern on Security.

Each Smart Grid domain (that can be refined in sub-domains) encompasses actors and applications. *Actors* include systems, devices or programs that make decisions and exchange information in order perform applications (example are smart meters, solar generators, and control systems) while *Applications* are tasks performed by one or more actors within a domain (corresponding examples are home automation, solar energy generation and storage, and energy management).

The NIST Conceptual Model has been defined in the North American context and puts focus on some specific requirements. As stated in the NIST Framework and Roadmap document: “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".

Such a model is descriptive, not prescriptive. It is not supposed to provide design or implementation choices.

In the European context, specific requirements are shaping the Smart Grid in a different manner compared to North America. For instance:

- Distributed Energy Resources are an essential part of the EU 20/20/20 objectives and will be significant actors (and therefore playing a specific role in the model);
- On the same line of reasoning, Industries could be also seen as a specific actor;
- The role of Electrical Vehicule, a key expected change in Europe may also require such an addition;
- It might e needed to rename some of the actors, e.g. 'Operation' into 'Grid Operations';
- Etc.

To achieve similar goals as the NIST model, the corresponding EU model encompasses the following aspects illustrated in the Figure below:

- The set of major actors (and associated roles) in the European Smart Grid. The EU Task Force Expert Group 3 (EG3) has identified a list of Roles and Responsibilities from which the actors/roles below are extracted. The list of actors/roles selected is the following:
    - 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.
    - 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.
    - Supplier / DER.
    - Transmission / Distribution. From a standardization standpoint, Transmission and Distribution are requiring the same set of activities and do not need to be differentiatied.
    - (Bulk) Generators.
    - Operations.
- The underlying role of the 'ICT Support' that refers to the set of ICT capabilities (networks, software, applications, etc.) that will enable the business relationship 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 is regarding control, optimization of the power flows.

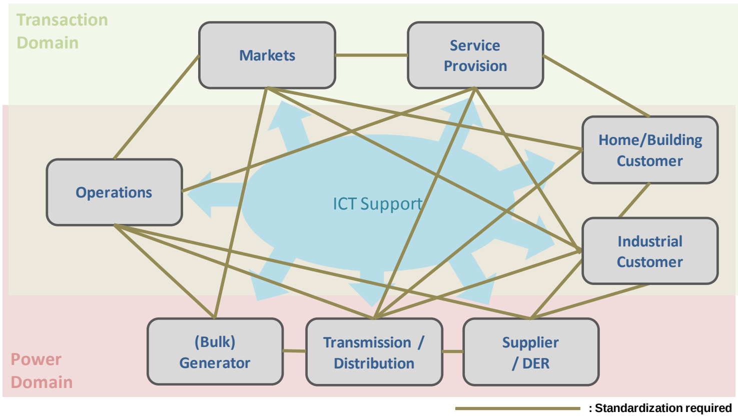


Figure Ref-1: an EU Conceptual Model

Recommendation
Ref-1: **European Conceptual Model**
Identify the relevant actors that will be instrumental to the European Smart Grid targets and build a European Conceptual Model to describing those major stakeholders and their interactions.*(This should be done within this document in its first official release)*

5.1.2.1.2 Functional Architecture

Based on the requirements (in particular security, 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 be in turn divided into sub-functions and the interfaces refined as to describe external and internal interfaces.

IEC SG3 has been working on such a model. It addresses the major Applications (e.g. Distributed Energy Resources, Demand Response or Smart Home Automation) and the associated Sub-systems. A Sub-system is a group of related functions that are a self-contained part of a larger system. These Sub-systems are linked by Interfaces.

The Sub-systems above can be refined by the description of their internal architecture and interfaces. This leads to a more complete – and complex – overall architecture. An extract of the IEC SG3 global architecture is shown below to illustrate this:

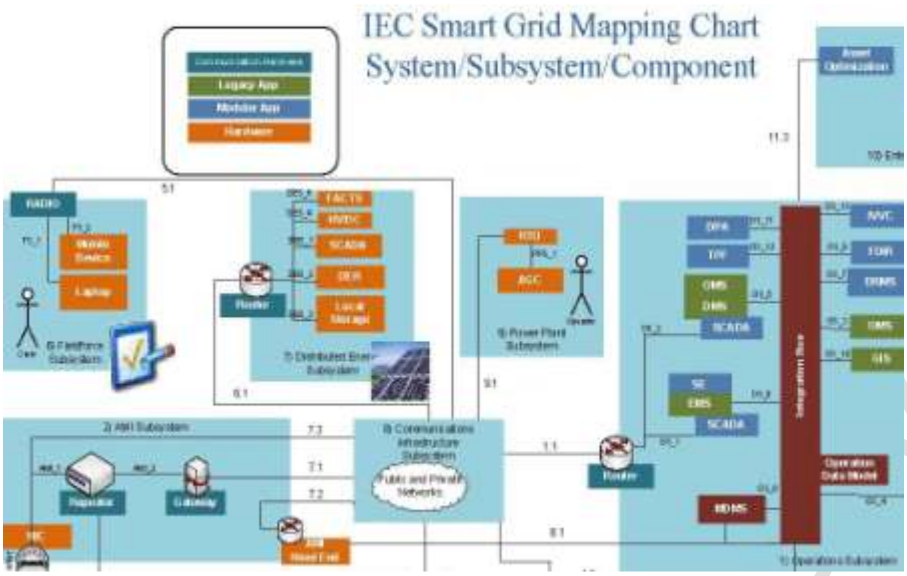


Fig Ref-2: A part of IEC SG3 Functional Architecture

A simplified view of the IEC SG3 model is shown below.

- It shows the high-level Sub-systems referred to only by their names. It only shows the high-level Sub-systems and none of their internal Sub-systems and Interfaces;
- It also shows some of the major interfaces (referred to by numbers, e.g. 7.1) between these Sub-systems.
- It does not comprise Sub-systems like the Industrial Consumer Sub-system or the E-mobility Charging Infrastructure Sub-system, etc.).
- The communications networks (WAN and Internet) are not represented as Sub-systems.

In addition, the diagram shows some of the interfaces identified by the CEN/CENELEC/ETSI Smart Metering Coordination Group (SM-CG) referred to by letters (e.g. S). Smart Metering is an example of Application: an Application is a distributed service provided to end-users using functions provided by one or several Sub-system(s). The Functional Architecture for Smart Metering is a subset of the Smart Grid Functional Architecture.

It is important to remember that some specific Applications or Applications subset can be addressed – in this case, Smart Metering - by specific teams and may lead to additional (or alternative) interfaces specification: this may be a challenge to the global coherence of the Reference Architecture.

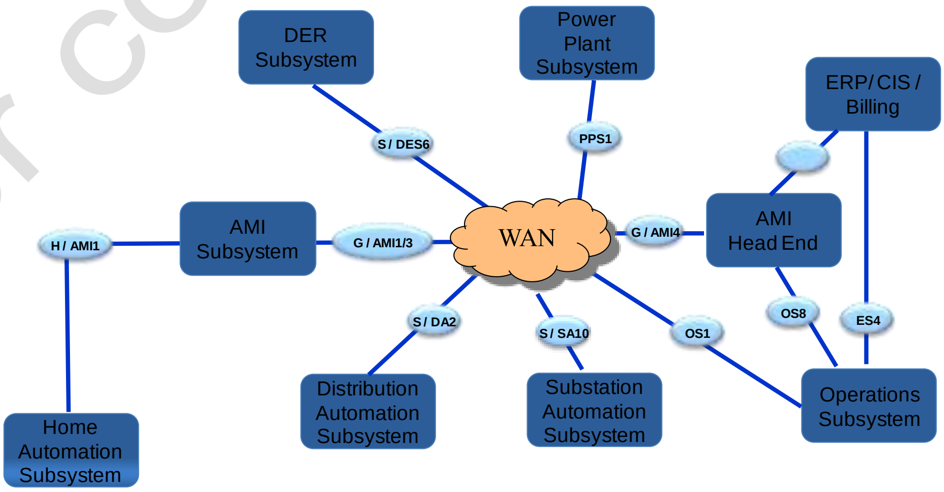


Figure Ref-3 – Smart Metering within Smart Grid Subsystems and Interfaces

Recommendation
Ref-2: **European Functional Architecture**
Develop, possibly based on the IEC SG3 model, a European Functional Architecture that take into account all the generic, global aspects of Smart Grid as well as all the European specificities, in particular those outlined in the European Conceptual Model..

5.1.2.1.3 Communication Architecture

The role – and impact - of ICT in Smart Grid is a key element in the way 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 Sub-systems such as the Communications Infrastructure Sub-system (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), Entreprise LAN, Neighborhood Area Networks (NAN), Powerline Communication Networks, Wireline Access Networks, Wireless Access Networks, Core Network;
- There are many possible connectivity scenarios between Functional Sub-systems, generally involoving only a subset of the communication networks;
- The choice of specific technologies (i.e. Internet Protocol) has a deep impact on the internal organization of Sub-systems.

A more specific Communication Architecture can help understanding the impact of the communication standards on the organization of the Sub-systems.

Such an architecture could look like the (simplified) one below (that needs to be deeply reworked):

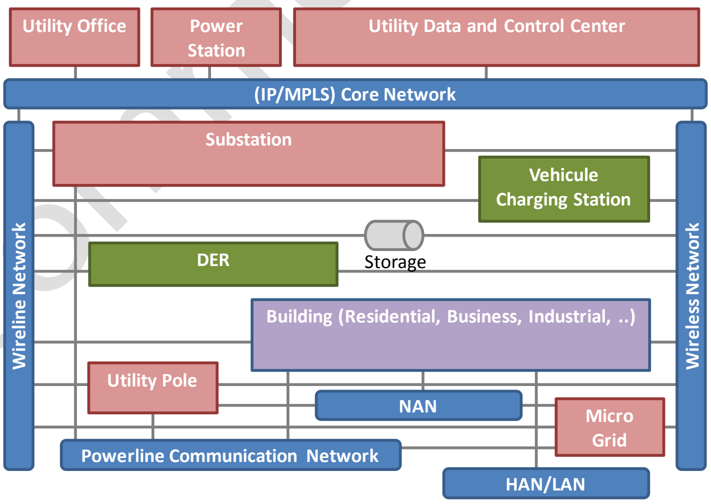


Fig. Ref-4 – Connectivity Architecture

The above figure highlights the large variety of possible communication paths: a particular deployment scenario will use a subset of these.

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

5.1.2.1.4 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 (NISTIR-7628) that addresses in particular:

- Strategy, Architecture and High-Level Requirements;
- Privacy.

The approach taken is summarized in the diagram below:

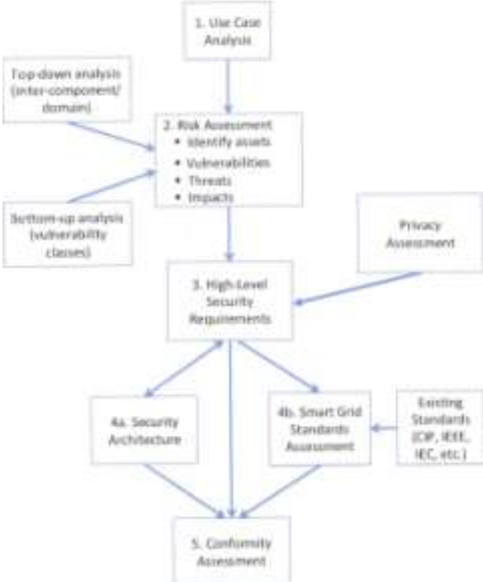


Fig. Ref-5: NIST approach to Security

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 in 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 Chapter 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 European Smart Grids Task Force Expert Group 2 (EG2) has also developed a set of recommendations 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 getting globally secure systems is proposed. The corresponding Security Architecture is not only proposing Standards (existing or to be developed) but it also addresses the methodology and conformity assessment techniques required.

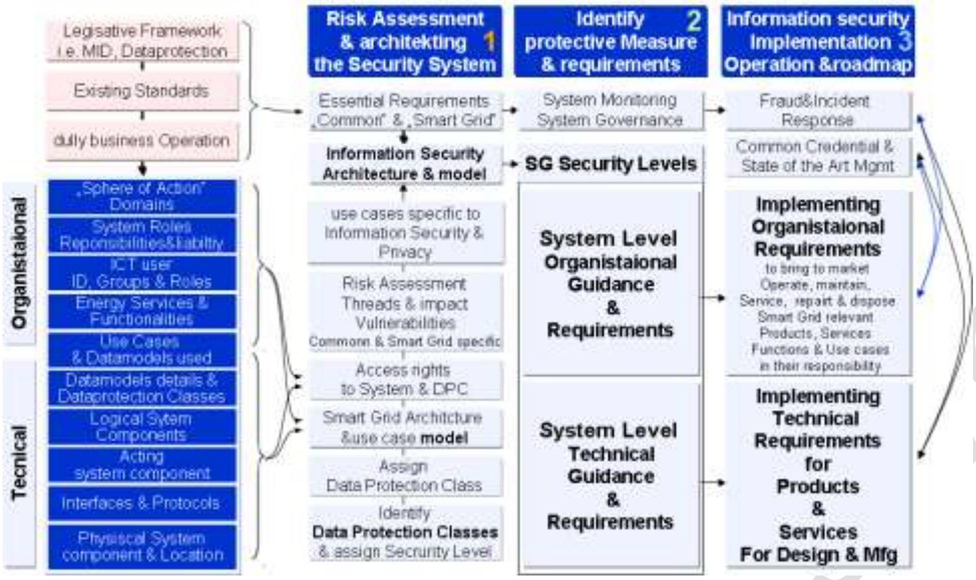


Fig. Ref-6: The EU Task Force Expert Group 2 approach to Security

Recommendation

Ref-4: **Security Architecture**

Expand the work done in the European Smart Grids Task Force to create a Security Architecture also taking into account the NIST complementary approach whenever applicable.

5.1.2.1.5 Information Architecture

The representation of the entities that interact within or between Sub-systems is mandatory for ensuring a required level of interoperability. Ensure this is the role of Information Models.

Several data model for the Smart Grid have been and are being defined. Among which:

- 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, DLMS and COSEM, … for Smart Metering
    - SAE J1772, J2847-1 work (tbc), IEC work (tbc) for Electrical Vehicle
    - …

A critical issue is the coherence of data models and the risk of too specific models leading to silo-ed applications. The diagram below shows the challenge of a coherent set of Information Model specification. It is even more complicated when different organizations have defined in parallel similar models for the same range of applications. 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.

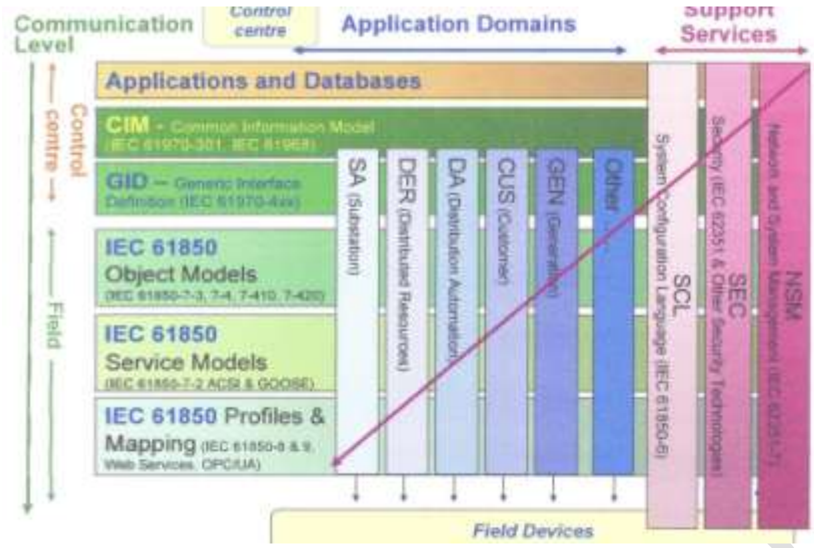


Fig. Ref-7: IEC SG3 Information Architecture

Recommendation

Ref-5: **Consistent Information Model**

Ensure that the Information.Architecture is relying both on precisely identified Standards but also that the consistency of 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.

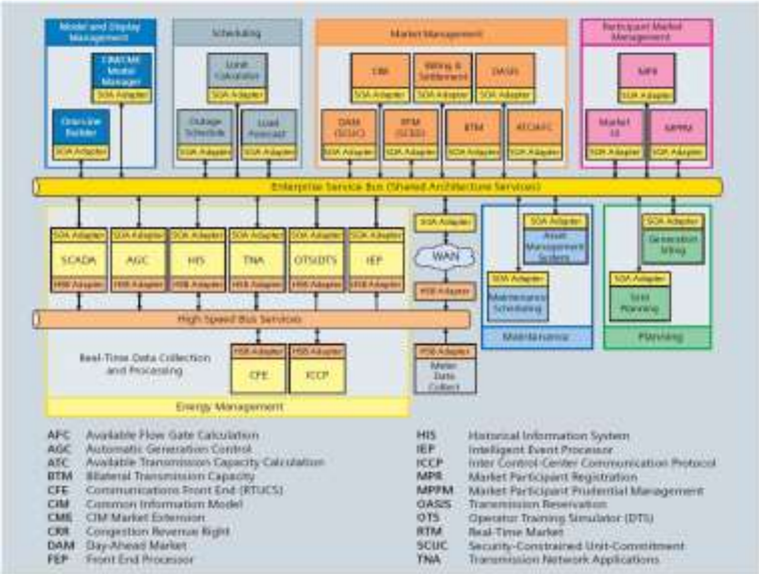


Figure Ref-8: IEC SG3 Service-Oriented Architecture

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 SG3 is presented here 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 is done in a comprehensive way
- The global coherence of these models be ensured by a coordinated approach

Ref-1: **European Conceptual Model**
Identify the relevant actors that will be instrumental to the European Smart Grid targets and build a European Conceptual Model to describing those major stakeholders and their interactions.*(This should be done within this document in its first official release)*

Ref-2: **European Functional Architecture**
Develop, possibly based on the IEC SG3 model, a European Functional Architecture that take into account all the generic, global aspects of Smart Grid as well as all the European specificities, in particular those outlined in the European Conceptual Model..

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 Smart Grids Task Force to create a Security Architecture also taking into account the NIST complementary approach whenever applicable.

Ref-5: **Consistent Information Model**
Ensure that the Information.Architecture is relying both on precisely identified Standards but also that the

consistency of Information Model is guaranteed by an appropriate mechanism for re-aligning separately developed (and possibly diverging) models.

General Recommendations

Ref-6: Create a Reference Architecture Task Force within the Joint Working Group to develop and maintain a European Smart Grid Reference Architecture, at least for some of the major views (Conceptual Model, Functional, Communication and Security Architecture).

5.1.3 System Aspects

5.1.3.1 General Description

Considering all the potential applications supported by the Smart Grid, some of them can be handled mostly in Smart Grid sub-domains, with a low level of interactions with the other sub-domains. But some other applications can't be addressed without considering them at top level first, because they request tight interactions between sub-domains, and they involve multiple sub-domains along the value chain. In such case, top-down approach should prevail.
However going down that path raises many questions:

- Which are the real market 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?
- How to ensure that the finally delivered set of standards produced by the concerned ESOs are interoperable and match the high-level system requirement?

These specific questions which definitely need such a top-level systemic analysis, can be split into two main classes :

- The **application related cases** : these cases are associated to a main mission (high-level service) of the Smart Grid. We can easily consider the here-under cases entering this family :
    - Demand-Response type applications (for active power and ancillary services). It should include the needed mechanism to support :
        - Consumer load shaping
        - Ancillary services for electrical network management (associated to DER and bulk generation)
        - Electrical vehicle deployment application
    - Smart metering system (dealt with in section 5.2.4)
- The **system enabler cases**, which are pre-requisite for an efficient deployment of the Smart Grid and are mostly application independent :
    - Data modelling -> common semantic definition and data presentation between all actors
    - System management and security -> processes and techniques providing aim to manage the Smart Grid system (start-up , connection of devices, disconnection, Role Based Access Control, maintenance of devices, system activity log, hot re-start, …) and the expected level of security of the Smart Grid

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

Gap

In general, ESOs don't have the adequate bodies and process 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 raised market requests. 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 concerned TCs in charge of producing standard contributing to these Use cases
- To manage the increasing maturity of the request, and then implement an incremental way of proceeding. This means having the right processes ready for managing new Use Cases, or Use cases modifications, with the ability to identify their impacts on the existing sets of standards.
- To ensure that all the concerned TCs of relevant ESOs have the exact same understanding of the functionality to implement (i.e are considering the set of use-cases, described above, as the main functional requirement to take into account for specifying a standard), and then are 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 standard. These processes should cover the overall life cycle of standard from upstream requirement definitions, down to interoperability testing.

Provide incremental way of proceeding and maximum flexibility for addressing unknown future usages. (List of proposed domains to address are defined below)

Feed as soon as possible the TC8 X with these Top-down Smart Grid use cases, to be taken into account by ad'hoc IEC TCs 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 paragraphs is to address more in details, these specific issues, and to identify associated standardisation recommendations.

5.1.3.2 Description of individual system aspects

5.1.3.2.1 Demand-Response applications

Description

Demand response includes the needed mechanisms and incentives for utilities, power generators, power storage, Energy market, Energy resellers, industrial, building and residential customers, to contribute to the **Grid level optimisation** i.e :

- to shape energy load profiles over time by requesting changes in current use
- to shape the generation (bulk and DER) profiles depending on selected criteria (Production constraints, emission regulation, energy price, ..)
- or to perform 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, the balance of reactive power supply and demand and appears as one corner-stone of Smart Grid deployment, as shown in section 7.6 (Appendix 5). Demand response standards shall 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 widest Smart Grid top-down application to set-up.

Demand Response technologies has 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 changes in depth the level of requirement for Demand-response:

One of the characteristics of these types of resources is the unpredictable energy production. Successfully integrating these resources is supported by improved methods of forecasting of 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 resources increases the need for balancing reserve, spinning reserve, but also offers new means to participate to ancillary services. It also increases the expected level of responsiveness of the system.
The context for Demand-Response is really new for the market, and then will be based on business models which will need years for being matured.
One of raising typical load shaping requirement will come from the deployment of the Electrical Vehicle.
The integration of electrical vehicle related applications is one of the focal points of Smart Grid 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 make 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 optimisation of the charge of the electrical vehicle must support some mechanisms to avoid load peak, and take maximum benefits of renewable energy. In that sense, the Electrical Vehicle may potentially support quick charging mechanism and operator based load levelling.
- From a consumer point of view, it is of importance not to force any EV consumer to overpass its home main electrical supply subscription rate. In order to have as user friendly a system as possible, there should be focus on ‘Plug and charge’ solutions, with operator based information exchange (MODE 3 in IEC 61851).
- In addition the EV can become a storage device and then participate to ancillary services under certain conditions (may appear by 2015)

Gaps
Standard new energy supply products like pricing signals, DR signals and DR process interfaces as part of CIM, COSEM and IEC 61850 are missing
It appears then relevant to consider only one body to address Demand-Response applications including the integrations of DER and the coming need of integration of EV. However the EV deployment has its specific set of constraints

- Standardisation environment is different, and involves other standardisation 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 Standardisation is set between IEC (mostly TC69) and ISO (mostly TC22, SC3, JWG1)
- The European Commission has already mandated (M/468) the European Standardisation Organisations bodies (CEN-CENELEC and ETSI) to work on electric Vehicle charging system.

Recommendations
Sys-2 Create DR task force
Create a single DR task force at CEN/CENELEC/ETSI level encompassing the adaptation of DR signal 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 standardization bodies for communication exchange with the EV
When coming to “How to proceed”, some more detailed insights are given in annex 7.6.

Sys-3 Avoid European mandates overlapping
Define clear interface and responsibilities between the Smart Grid mandate and the EV mandate and associated standardization bodies (part of Smart Grid mandate). Ensure interoperability between the different standards

5.1.3.2.2 Data modelling and description language
Description

Data modelling and description language are typical "System enabler" transverse use-case and then should be seen in priority from 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 Grid, increase its costs, reduce its reliability, reduce in flexibility for future and finally speed down the over all market acceptance
- Avoid mis-understanding between domains, and increase the global reliability of the system
- Increase the flexibility of the system
- Increase the speed of spreading the Smart Grid, by reducing the amount of engineering time per additional point of connexion

Providing harmonised data model and description language leads to think "transverse" to be efficient, with the constraint not only to define an "ultimate" target but also the migration path from the existing situation.

Gaps

Harmonised electronic data model and description language are missing

Recommendation

Sys-4: Create "Smart Grid Data model taskforce

Create a single "Smart Grid Data model task force" at CEN/CENELEC/ETSI level to support Smart Grid system level applications. Contribute to data model and description language at IEC levels

5.1.3.2.3 System management and security

Description

As detailed in the coming section, system management and security will become very soon the corner stone of any Smart Grid installation. However such aspect of smart grid 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

Recommendations

Sys-5: Create a single "Smart Grid System Management and security" task force

Create a single "Smart Grid System Management and security" task force at CEN/CENELEC/ETSI level. International harmonization of identification numbering series for cross country ID management International organization of Certification Authority (CA) to ensure cross country end-to-end security interoperability

5.1.3.2.4 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 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
- a requisite quality of service: reliability, time performance, privacy, and security.

Many levels of interoperability can be considered , but in any cases Smart Grids are requiring one of 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 Smart Grid relevant standards, which may not:

- cover an accurate definition of the semantic, with no risk of ambiguity
- define the behaviour of the object which implement the standard (state machine), consistently with the system behavior
- include conformance statement, to check the implementation of the standard against the standard specification
- offer conformance verification procedures handled by independant laboratories

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

- select sets of use cases at system level, together with system architectures, with the target to test interoperability of applications. Define expected results/performance approbation rules
- potentially define standard profiles (optional sub-set of standards, or standard package may becoming mandatory)
- define functional testing procedure
- execute test and evaluate the results through independent laboratories

Highest priority Gaps	Recommendations
SY8 : few material available to go down real interoperability path	Pave the road for implementing step-wise approach of interoperability.

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

Recommendations
Sys-6 Check comprehensiveness of standards towards interoperability
Check the coverage of selected standards against semantic, behavior, conformance testing and fill gaps when needed
Sys-7: Systematically address system interoperability
Pave the road for implementing step-wise approach of interoperability.
Sys-8: 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 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 standard. These processes should cover the overall life cycle of standard from upstream requirement definitions, down to interoperability testing. Provide incremental way of proceeding and maximum flexibility for addressing unknown future usages. (List of proposed domains to address are defined below)
Feed as soon as possible the TC8 X with these Top-down Smart Grid use cases, to be taken into account by ad'hoc IEC TCs 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 Create DR task force
Create a single DR task force at CEN/CENELEC/ETSI level encompassing the adaptation of DR signal 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 standardization bodies for communication exchange with the EV

Sys-3 Avoid European mandates overlapping

Define clear interface and responsibilities between the Smart Grid mandate and the EV mandate and associated standardization bodies (part of Smart Grid mandate). Ensure interoperability between the different standards

Sys-4: Create “Smart Grid Data model taskforce

Create a single “Smart Grid Data model task force” at CEN/CENELEC/ETSI level to support Smart Grid system level applications. Contribute to data model and description language at IEC levels

Sys-5: Create a single “Smart Grid System Management and security” task force

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Pave the road for implementing step-wise approach of interoperability.

Sys-8: 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

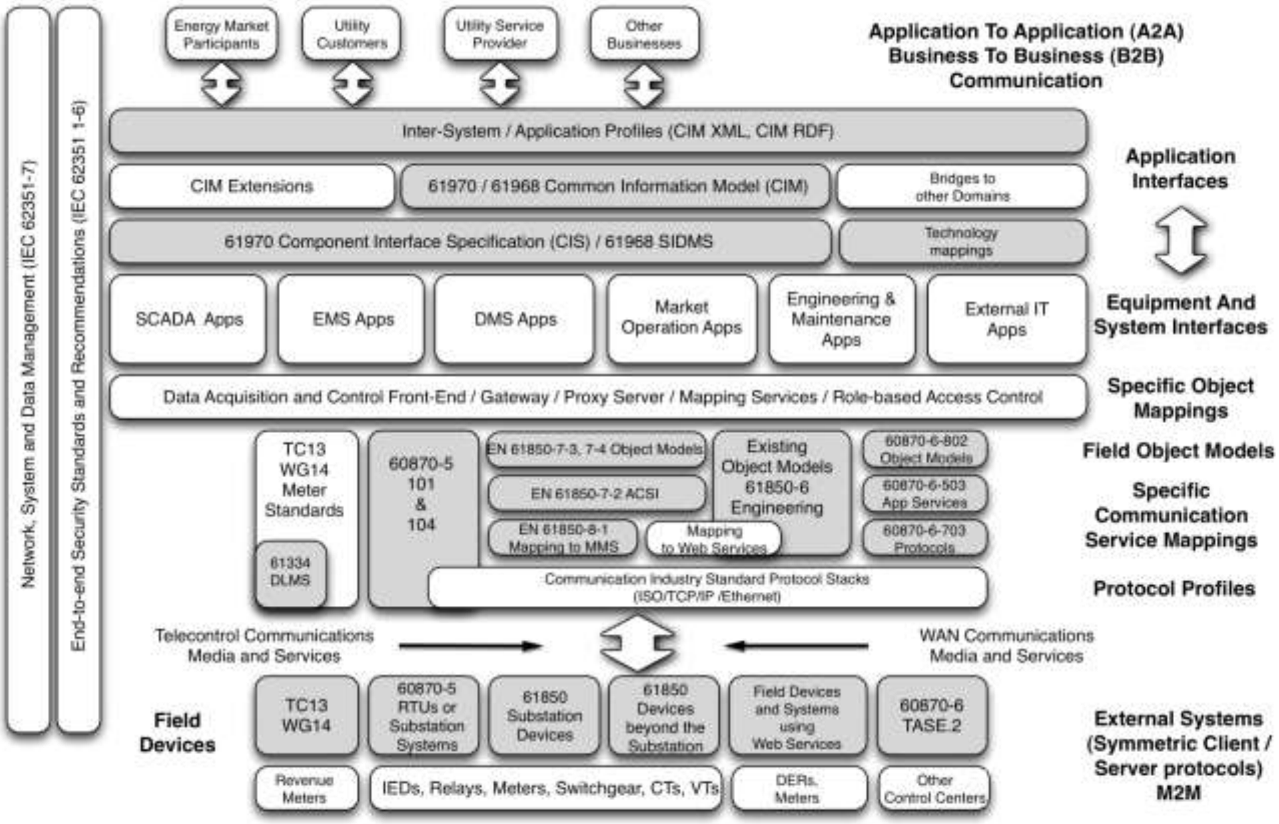
5.1.4.1 General Description

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 (eg Use Cases) requirements have to be defined. It is recommended that this work is performed in a later stage under a new Mandate.

The contents of this section is closely linked with section 5.1.3. 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 complete listing of available standards per interface is included in appendix 6.

The diagram below is designed by IEC TC 57 and gives an overview of their focused and maintained communication and data model standards and the application functions 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 Automation and EV are not included yet.



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

Figure 5.1.4.1: IEC TC 57 Seamless Integration reference Architecture - IEC TR 62357

5.1.4.2 Intra-Sectional Standards

In terms of intra-sectional standards, this documents chapter refers to what is also known as domains from other standardization bodies and smart grid roadmaps. An intra-sectional standard therefore refers to non-cross cutting issues which have a limited and defined scope. The following paragraphs provide examples of the standards being available for data communication interfaces between the subsystems depicted in the functional architecture drawing in section 5.1.3..

5.1.4.2.1 WAN interface to Operations Subsystem

For this interface mainly the IEC standards 60870-5 and 60870-6 are being used. While the newer 60870-6 standard has been developed for application in Wide Area Networks , the older 60870-5 has originally been designed for point-to-(multi)point connections. Its -104 version however operates over TCP/IP networks. 60870 has also been ruled out by NIST and IEC to be one of the core standards of the future smart grid.

5.1.4.2.2 Local interface between AMI and 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 decentralised 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 it connects 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 standardised protocol on several media, or connection on IP LAN, or serial/proprietary communication.
For further information refer to section 5.2.4 regarding Smart Metering.

5.1.4.2.3 WAN interface to Distribution Automation

One of the most known standards in Smart grid roadmaps all around the globe is the Common Information Model CIM (IEC 61970 and 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 61970 suites cover several sections of the Smart Grid landscape, such as Distribution, Transmission, Generation and Metering, they are included in the cross sectional paragraph 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, also the IEC 61850 communication standard offers functionality for the Distribution Automation domain. Since also this standard covers multiple domains, it is included in paragraph 5.1.4.3. of this report.

5.1.4.2.4 WAN interface to Substation Automation

IEC 60870-5 and 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 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 sectional 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 and derived form 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 is currently existing as Edition 1 and has become the most growing standards 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 is standardised with the Mandate M/441 whilst the interface from head-end systems towards central energy and meter data management systems is covered by others IEC TCs, e.g. IEC TC 57. More information about M/441 covered standards can be found in section 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, 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 appendix 2.

5.1.4.3 Cross Sectional 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 Appendix 6.

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.

5.1.4.4 Gaps

Power/Distribution Line communication

Many (conflicting) technologies are available and under development (S-FSK, OFDM, DCSK) and the same is true for protocols (PRIME, MORE, G3, DLC-2000, Renesas).
For lower frequencies the EMC guidelines/regulations are missing, which results of disturbances of domestic appliances.
Broadband is under development but frequencies should be reserved for utility applications.
On PLC communications only the band from 3kHz to 148.5kHz is currently specified in the standards
Furthermore, on the broadband PLC, with frequency ranges from 0,3MHz to 50MHz, nothing is specified.

Data transport technologies

Currently the development by ETSI and the data communication related IEC and CEN/CENELEC activities within IEC and CEN/CENELEC are not coordinated. The Service Capabilities defined by ETSI are not integrated with the Smart Grid related application protocols mentioned in 5.1.4.2.

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.
For lower frequencies the EMC guidelines/regulations should be developed.
Frequencies for broadband should be reserved for utility applications.
For PLC communication the use of the frequency range up to 540kHz should be specified, as is already the case in the US.
Furthermore, a definition of the broadband PLC for ranges from 0,3MHz to 50MHz is necessary. Here it would be beneficial to reserve the medium range (0.3MHz to 3MHz) frequencies for the utilities, 3 to 30MHz for in home applications.

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.

5.1.5 Smart grid information security (SGIS)**9**

5.1.5.1 Description

This section is a result of a comprehensive analysis and bottom up summary, derived from inputs from many sources, namely the results of the EU Taskforce on smart grid expert group 2 (EG2)[10], for data protection, the German standardization roadmap "E-Energy / smart grid" research demonstration projects[11] for E-Energy (some of them have very detailed studies of smart grid specific scenarios, as well as the research demonstration projects for integration of electric vehicles into the smart electricity grid. Further more various national and international standards and reports related to information security in smart grids where reviewed and impacted the conclusions derived.(i.e. IEC 62351,ISO/IEC 27000, US-NIST 7628, DE-BDEW Whitepaper, DE BDEW Whitepaper, ..)

5.1.5.2 Gaps and required focus areas

The conclusions are described here, please see annex to 5.1.5 for more details.

1. Threads and vulnerabilities (common with ICT sector – but also specific to the energy sector) exist – those provide risks, that may have negative impact on the "smart grid information security" and subsequently on data protection/privacy that operations potentially become unlawful.
2. The smart grid information security essential requirements need to be ensured – for both
    a. essential requirements and primary protection goals common with the ICT sector
    b. essential requirements specific to the energy sector
    Those sector specific essential requirements are different from the common requirements
    In the electricity grid it also needs to be differentiated between requirements for
    critical infrastructures and those for Infrastructures supporting smart grid energy services.

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

3. Existing standards for products/solution/services or organisations do not sufficiently information security or data protection / privacy requirements (technical or organisational). This is a horizontal cross cutting issue.
4. There are several classes of data handled in smart grids that need appropriate security levels
    For details about the data protection classes (SG-DPC) and required security levels (SG-ISL)
    Please refer to detailed annex of section 5.1.5.
5. The "smart grid information security" model (SGIS) and data protection / privacy model (DPP) is a fundamental requirement and needs to ensure that the smart grid information system provides "state of the Art" protective measures and support compliance requirements for all legal requirements. (i.e. data protection / privacy laws, measurement instruments directive , dully e-business operations and more)
6. Top down "system level" technical and organisational requirements for the SGIS need to be defined by regulatory authorities or strategic guidance group

1. ____________________

[1] SGIS Smart Grid Information Security

[10] Expert Group 2 "REGULATORY RECOMMENDATIONS FOR DATA SAFETY, DATA HANDLING AND DATA PROTECTION"

[3] some of them have very detailed studies of smart grid specific scenarios

7. 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 organisations in their specific market roles.
8. An operational model for SGIS and DPP is required. This shall be updated and synchronized according to the evolution and innovation dynamics of both
    a. the smart grid operational and business models, its functions and use cases as well as
    b. the changes to the “system level” requirements.
9. An overarching governance model is required to identify and handle fraud / incidents with immediate and medium / long term actions on SGIS and DPP operations and “credential management” and to identify new requirements on “system level”.
10. 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 focus areas to be addressed in order to develop a standards framework for a sustainable, “state of the art” SGIS and DPP.

ESOs should provide standards for all actors in the smart grid – products, solutions, services or organizations respectively their participating market roles. Those standards need to include information security and data protection/ privacy requirements.
This is required to assure SGIS and DPP operations are sustainable compliant or compatible with all legal requirements inherently secure by design and default , further more 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 DPP - requirements describing protective measures (SG-ISL, SG-DPC) to be included in both areas - technical and organizational

5.1.5.3 Recommendations

“State of the art” smart grid information security (SGIS) has a direct impact on the ability to ensure data protection, data security and privacy requirements. It also has a direct impact on interoperability and inter-changeability and to the availability of Energy Services.

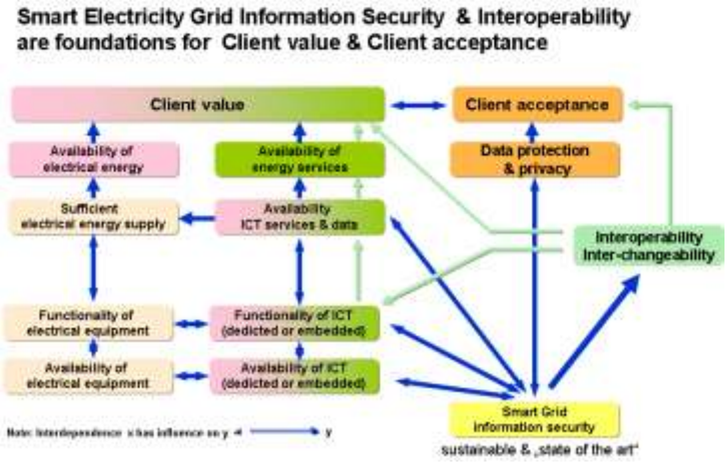


Figure 1: Overview of information security impact relations

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. Due to that the information system and the requirements for information security and data protection / privacy will keep evolving.

It is undisputed, that client acceptance is strongly and directly impacted by the client perception of the system eminent concepts for data protection data security and privacy on one hand and by high interoperability and inter-changeability of system components and participating organisations on the other hand.
Both can only be assured by a “state of the art” ”SGIS” and DPP, but also by the concepts and governance models to keep it at a “state of the art” level at all times.

Interoperability/ inter-changeability is not addressed in this section - in any case a harmonization of “system level” requirements for SGIS / DPP are a prerequisite for interoperability and inter-changeability goals, for bringing products / solutions / services into market and update the assets in the market / field in a synchronized way.

It is obvious that the lack of harmonised system requirements leads to a wide variety of technological implementation in products/solutions/services or organisations , that are participating or plan to participate as actors in the smart grid either as market role or provider of system components.
Variations of provided products, solutions, services and variations of processes / interactions of the participating organisations may result in risks not to fulfil coherently all legal requirements for the information system and it information security, the data-protection/privacy or interoperability & inter-changeability 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 thread levels increases over time.

The JWG provides concepts and proposals on how to derive those requirements – as illustrated in Figure 2 and outlined in the annex, but the definition of the set of requirements must be done top down by the EU. The JWG is prepared send representatives in the “guidance group” outlining the System level requirements for SIGS and DPP. The following recommendations to EU summarize the JWG expectations.

General recommendations to EU (Smart grids task force EG2 or the recommended EU strategic guidance group for SGIS and DPP)

(EU-ISec-1) Define European information security requirements on “system-level”
EU needs to provide to ESOs a detailed set of system-requirements (technical and organizational) for SGIS and DPP that should cover multiple security levels (SG-ISL 1-low to,5-top secret), as input to the ESO as they need to provide standards ALL actors interacting in smart grids – i.e. all system -components (products, solutions, services) and organizations participating in their respective smart grid role.
The “system level” requirements should address all areas required to ensure standards provided by ESOs support a sustainable “state of the art” smart grid information security and data protection operational model covering all legal requirements and compliance,

- interoperability and inter-changeability
- the “system level” requirements and
- the “products and organization level” requirements

This need to be synchronized at all times.

Milestones to achieve this are

a. EU should identify overall ownership for the integrated & interactive energy & energy efficiency management and its SGIS and DPP operations.
b. EU should establish a SGIS Guidance group or enlarge the scope of EU smart grid taskforce EG2 to address overall and system level SGIS and DPP with appropriate security levels (SG-ISL1=low-SG-ISL2=medium-SG-ISL3=high-SG-ISL=very high SG-ISL=top secret , by analyzing EU documents as well as national and international documents i.e. Nist 7628 to provide an maximum on international commonality or compatibility.
c. EU to detail out 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 & services – as well as system requirements for organizations &legal entities participation as „system / market roles“

d. EG2 should identify the different national requirements in member states i.e. 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

e. Please refer to section 5.1.5 Annex for more details

(EU-ISec-2) Guidance on information security and data protection / privacy governance

EU should provide guidance on the governance model (incident /fraud responses) and credential (ID / key..) management options.

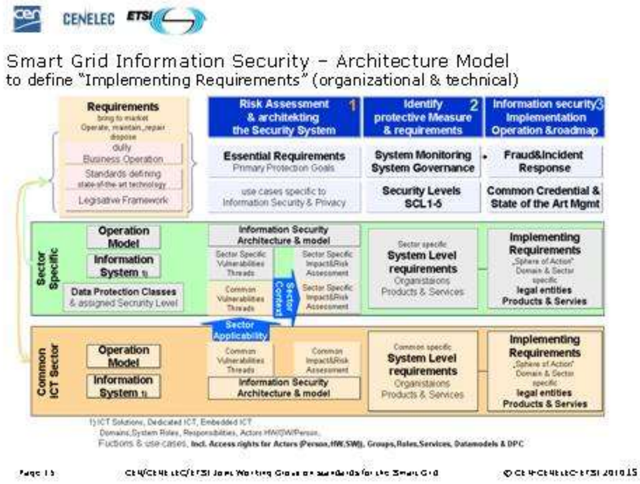


Figure 2: Modeling smart grid information security implementing requirements

Recommendations to ESO

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 security levels) into

I. Product, Solution & Service standards of all „sphere of action“ domains
II. “Sphere of action” domain specific Organizational standards for Market roles participating in smart grid, according to their Responsibilities, and functions

Ensure consistency between those and sustain “state of the art” by synchronizing all standard with changing EU input.

ISec-2 Smart grid functions and use cases require binding to information security requirements

For several Data protection classes (SG-DPC) legal requirement exist, and require the appropriation of the DPC i.e. Personal data, Control Data. Therefore the concept of the smart grid information security needs to provide the enablement for binding between – the usages of data. The rights & justification(i.e. contractual /regulatory), 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 its specific SG-DPC and SG-ISL. Therefore the concept of the JWG is to interconnect the use case repository with the repositories of the UML data models(this describes the data usage) and obligate the ESOs to bind the data models to their specific data protection classes (SG-DPCs), further more the SG- DPCs need to be bound to specific information security level requirement (SG-ISL).

It is recommended that ESOs provide interlinked repositories to achieve the required binding. Figure 3 illustrated the above mentioned binding process.

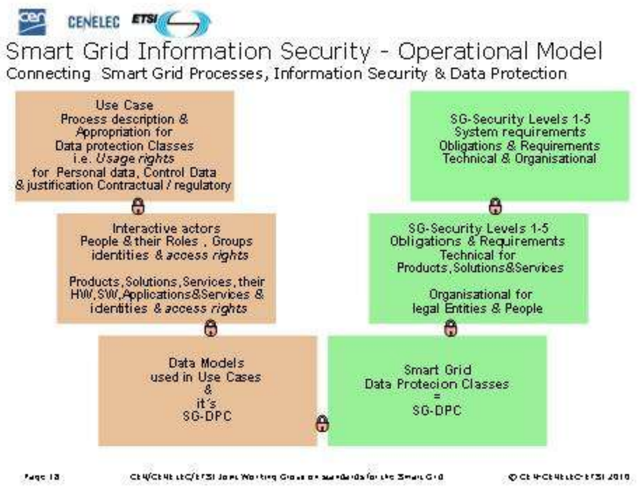


Figure 3: Binding Use Cases, data models to SG-DPC and SG-ISL

Innovation dynamics drive changes in smart grid functions, use cases and data models used. On the other side, the guidance on System level requirements for “smart grid information security” and privacy will evolve due to current legislative projects on data protection and privacy but also due to increasing knowledge from the governance model on how to protect against Fraud and incidents on information security and privacy.

ISec-3 SGIS and DPP upgrade and synchronization requirements

ESO need to provide a sustainable mechanism to update and synchronize the binds of data models used by functions and use cases to the SG-DPC 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 need to be in sync with changing System requirements for the “smart grid information security” and data protection/privacy,. Figure 4 illustrates this process.

,

Figure 4: Overall smart grid Informatinon security Operational Model

ISec-4 ESO Provide IT Tools to support SGIS and DPP modeling and application

ESO should also SGIS and DPP specific tools and repositories to Information security experts communities to assist them in modeling security and maintaining and upgrading the 5 system security levels (SG-ISL), the smart grid data protection classes (SG-DPC) – synchronized with the evolving set of "System Level" SIGS and DPP requirements on one hand and the linkage of the repositories various repositories for smart grid functions, use cases, data models & data models provided to experts in smart grid functions and use cases (discussed in other section of this report) on the other hand.

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 (CLC 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

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

5.1.6.1.1 Recommendations

Dep-1 Check relevance of existing methodologies on Smart Grid

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

5.1.6.2 EMC

General

Electromagnetic Compatibility is a prerequisite for all applications, products and systems and is therefore not limited and not unique to Smart Grid.
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.

Power quality

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.

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.

Standards exist for the characteristics of electricity supplied to customers (at the entry point of user’s installation) , up to 150 kV, and are used for contractual relationship and for regulation. The specified levels are generally close to the Compatibility levels given in EMC standards, used as reference for products EMC requirement (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 shows some gaps for:

- immunity and emission in the frequency range from 2 kHz to 150 kHz, in order to insure proper functioning of electronic equipment and protection of PLT services (PLT emission levels are covered by IEC 61000-3-8 and 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

Following the thorough change in use of the electricity, especially by the introduction of modern electronic equipment having 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 Committee (CLC 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, TC57 …), to review the existing standards (see Appendix 7) in view of covering the abovementioned gaps in EMC standardization.

EMC-1 Review existing standards
CLC 210 and Product Committees to review existing standards concerning an appropriate modification for closing gaps in order to also ensuring EMC in the frequency ranges from 2 kHz to 150 kHz (in practice 2-9 kHz and 9-150 kHz).
Note: available technical information is poor (only an internal report within CLC SC205A : *SC205A/Sec0260/R*), and preliminary studies are necessary before standards can be established.

Furthermore the following actions of the standardisation communities are suggested to support Low frequency EMC/Power Quality in the context of Smart Grid.

EMC-2 Review EMC 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 Grid.

EMC-3 Consider distorting current emissions from DER equipment
Standardise how 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 network(s). 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 domain was initially mostly focusing on Transmission Grid applications, but has been progressively expanded towards Distribution as well as Distributed Generation and Demand side Portfolio Management while de-regulation implied to consider 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 [12], Power Generation domain will have to lead many transformations

- in the way to operate their units, especially in their interactions with the overall Smartgrids system.

1.

[12] 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

- in welcoming an dramatically increased number of operators with probably a decreasing level of knowledge

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 linger term, Virtual Power Plants) are critical capability to develop as part of Power Plant Control and Management Solutions.

Up to now, real-time performance imperatives and limited industry standardisation for data exchanges with the energy eco system outside the Power plant naturally led the industry towards highly customised solutions built upon proprietary system platforms.

Furthermore, fleet and Plant Scheduling will provide generation asset owners with decision support tools which will optimize production schedule of the 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.

5.2.1.2 The high level services and use cases

Setting up in Europe a smarter Grid, matching the requested high-level services as defined in appendix 8, leads to consider four main uses cases with, for each, two aspects two consider: interfaces with the Grid and interfaces to the Energy market (details are provided in appendix 4) :

Uses 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 generation	
Make the Power generator dispatchable	Enable the network operator to send control to the generation	Enable the generator to participate to the energy market, including ancillary services
Make the Virtual Power Plant dispatchable	Enable the network operator to send control to generators organized in cluster (VPPs)	Enable the cluster of generators (VPP) to participate to the energy market including ancillary services

5.2.1.3 Existing standards and gaps

When getting into the detailed analysis of existing standards to face the above challenge (ref annex x), some gaps appear. Ranking them between highest and lower priority leads to consider the here-under list.

- Gap 1: Harmonized glossary, semantic & modeling between back-office applications (CIM[13]) and field applications (61850[14])
  Glossaries & data modeling between the control centers (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 shall be addressed by CENELEC TC57X with a full alignment of other worldwide initiatives in this same domain. Europe should support the first step which is to get a UML modeling of IEC 61850.
  A clear message to the market is expected on the corresponding roadmap to get the first fixes.

1.

13 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,

14 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,

- Gap 7: Harmonisation between DLMS/Cosem data model and IEC 61850/CIM
  There is currently no common data modeling and description language between generation and metering. Considering that many actors of the grid will become both generators and consumers, a common data modeling 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 DLMS/COSEM data model harmonization with CIM/IEC 61850, within the IEC body (through CENELEC TC57X and TC13X)

- Gap 8 : Extended field data modeling standard (part of IEC 61850) to support Demand-Response schema
  Gap 9 : Extended field data modeling standard (part of IEC 61850) to enable DER (and VPPs) to contribute to network ancillary service
  Gap 11 : Extended CIM to model more accurately Generation Fleet Management Applications in the case of Bulk Generation, and to integrate DER and VPPs
  Standard data modeling is missing in three main areas which are key for Smart Grid 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 fulfil this gap, European SDOs should clearly express and formalize to CENELEC TC 8X, the selected use cases the Smart Grid system has to support.
  Then IEC TC 57 WG17 body (through CENELEC TC57X) should provide expected answers by proposing IEC 61850 data modeling extensions. European SDOs should also support TC57 WG13 initiatives to define uses cases and modeling (such as AI715)

- Gap 6 : Standard for electrical connection and installation rules to ensure energy availability and security, in presence of high ratio of DER
  Gap 10 : Standard to allow all connected generators associated in VPPs to participate to new ways of operating grid
  Unified standard for electrical connection and installation rules of generators (including DER) to ensure energy availability and security, in presence of high ratio of DER, are missing. The Europe shall •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 get maximum benefits of the newly installed distributed energy resources. However standards are missing to allow such new ways of operating grids. Thus CENELEC shall adapt installation rules in order to make such grid operation possible.

5.2.1.4 Recommendations

Gen-1 Harmonized glossary, semantic & modeling between back-office applications (CIM[15]) and field applications (61850[16])
Provide experts to IEC TC57 body to boost CIM/IEC 61850 harmonisation 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.

1. ______________________

15 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,

16 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,

Gen-2 Harmonisation between DLMS/Cosem data model and IEC 61850/CIM
Take the lead on this DLMS/COSEM data model harmonization with CIM/IEC 61850, within the IEC body (through CENELEC TC57X)

Gen-3 Extended field data modeling 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 the Smart Grid system has to support and ensure IEC TC 57 WG17 body (through CENELEC TC57X) will provide expected answers in IEC 61850 data modelling regarding: Demand-response for generators, for ancillary services, including VPPs and aggregators. Support TC57 WG13 initiatives to define uses cases and modelling (such as AI715)
Gen-4 Standard for electrical connection and installation rules to ensure energy availability and security, in presence of 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 (TC64X and TC8X)

5.2.2 Transmission domain

5.2.2.1 Description of scenario

The evolution of the electricity market in Europe emphasizes the needs 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 lower synchronous peak loads than 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 domain 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, as for example solutions to off-shore wind power plants, long connections, etc... But the interoperability with the present grid is also required.
The solutions expected are not limited to the installation of new Transmission system components and functionality. 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 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 distribute 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 extend coordination with flexible loads are foreseen to be an essential function for the stability in 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 the society and limitation of impact for the environment.

5.2.2.2 The high level use cases/services

The document[17] 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 light 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 requirement (**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 functional requirement associated are provided in appendix 9A.

5.2.2.3 Existing standards

a) Grid connection

In the domain of wind energy, the relevant standard is IEC 61400 *Communication for monitoring and control of wind power plants,* based on IEC 61850.

b) Grid observability

The relevant standards already existing in telecommunication domain as well as in equipment domain are in appendix 9B.
In Appendix 9C, the figure n°6, extracted from IEC 62357, gives an overview on the reference architecture (present and future) addressing the communication requirements of the application in the power utility domain.

1. ___

[17] EU Commission Task Force for Smart Grids : Functionalities of Smart Grids and Smart Meters,

c) Grid security of supply and optimization

In complement to the standards already mentioned for grid observability, the relevant standards for the capacity of transmission assets are in appendix 9B.

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 appendix 9B.

e) Grid market

The relevant standards are in appendix 9B.

f) Prosumers

The relevant standards are in appendix 9B.

5.2.2.4 Gaps

a) Grid connection

The potential need for the development of new 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 Source, an important part of generation is moved from conventional power plants in the proximity of loads, to new power plants far away. It 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 induce soon 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.
And the reduction of converters DC/AC, 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,
- 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. We support this initiative and encourage to start the development of standards and technical guidelines for DC grids, as soon as possible. These tasks should be perform by TC 22 SC22F (converter), TC 17 SC17A (circuit-breaker), TC38 (current&voltage measurement), TC99 (general installation), TC8/TC115 (grid design), TC33 (capacitor), TC115 & TC8x (coordination) and TC95 (protection relay). To be noticed that there is not yet a European Group for TC95.

In addition to DC issues, it must be noticed a lack of standards regarding interface issues for AC equipment in intermitting generation domain (wind, tidal and photo voltaic generations).

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 the IEC 61970/86) and the data transmission protocol IEC 61850.

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.

In all the issues to be faced by standards, the 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 Edition 1 and 2 of IEC 61850, interchangeability it out of focus. All Solutions 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 is required for the same function on the station-bus, independent of the IED’s.

On-line monitoring technologies provide useful information in order to optimize the use of the assets. But the present communication architecture inside the substations does not go as far as the sensors of asset, useful for on-line monitoring.
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 TC involved are TC14 (transformer), TC17 (switchgear), TC38 (transformer measurement), TC11 (OHL), TC7 (conductor), TC20 (underground-cable), TC57 (data&communication) and protection relay (TC95).

c) Grid security of supply and optimization

The present standards for load capacity concern generally 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 should 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 sub-marine connections have been present since a long time, the off-shore substation on platform is a new issue for 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 cover properly the specific requirement of off-shore environment.

Concerning DC issue, the gaps concern equipment standards (AC/DC converter, DC/DC converter, circuit-breaker, protection, ….) as well as grid topology standard (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, protections,….) as well as for grid topology (grid design, voltage level, grid code,…) in High Voltage DC domain. A present Study Group, hosted by the German National Committee will elaborate the basis for the standardization work to be continued Cenelec. This initiative should be encouraged.

T2 – Smart assets

Condition monitoring of components of substations or of lines, provides technical information, useful for the optimized used 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 an 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 a decision making.

The on-going IEC 61850-90.3 work, devoted to condition monitoring in power energy domain, should be encouraged, the present standard and protocol for communication in substations, should involve communication and relevant data model, 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 on-going IEC standard involves on the one hand, the experts of equipment to monitor for the technical aspects and the prediction models and on the other hand representatives of users in order to assess the relevant decision making.

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 would be adapted.
These tasks should be notably performed by TC14 (transformer), TC17 (switchgear), TC38 (instrument measurement) and TC20 (underground-cable).

5.2.3 Distribution domain

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 renewable integration and power energy storage technologies will have to be deployed. Energy efficiency will have to be a general driving vector, the 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, DSOs will need to actively participate as major enablers for services and integration.

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 3rd Energy Package, Directive 2009/72/EC.

Though elements of smartness also exist in many parts of existing grids, the difference between a 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 optimising 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.
- Foster market integration towards European integrated market.

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, 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 consumer), storage owners.
- Other actors: suppliers, metering operators, ESCOs, aggregators, ICT hub providers, power exchange platform operators.

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

A smart grids service identifies, and can be commonly considered, the outcome a user needs/will need from the electricity grid in a fully developed liberalised 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 bricks through which services can be implemented and delivered to beneficiaries.

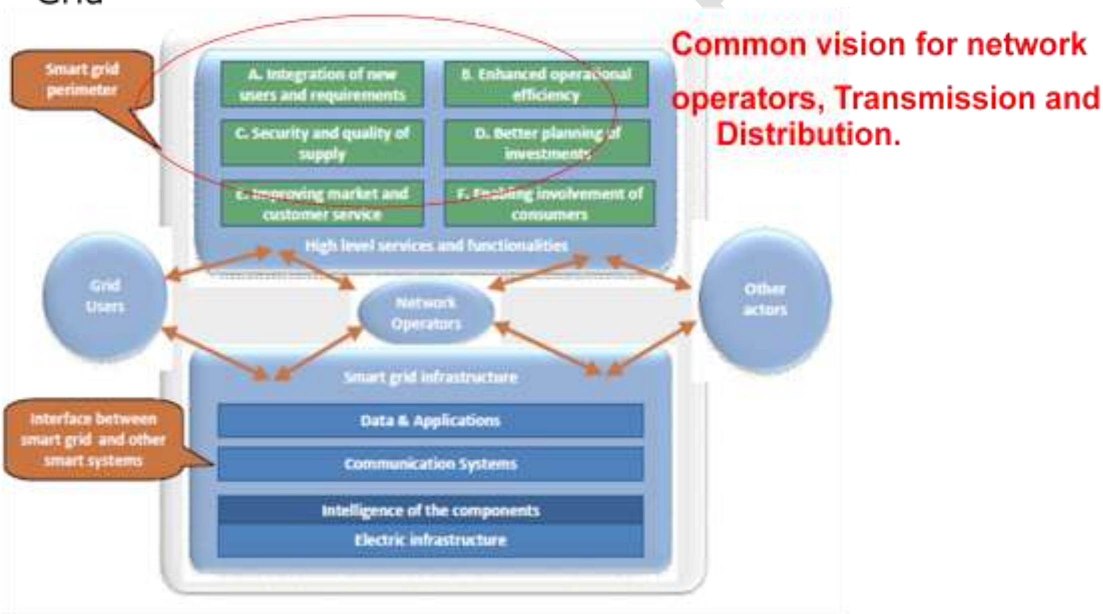
5.2.3.2 The high level use cases/services – the functional requirements

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 requirement = **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 (DG, flexible loads)**
e) Improving market and customer service = **Grid market (Aggregators, EV recharging, support 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 functional requirement associated are provided in Appendix 10.

▪Reference = EU Commission TF, EG1-Functionalities of Smart Grid



Different functionalities of Smart Grid as extracted from the EG1 Report, and how they fit into the vision of the future network

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.

Description of the situation is given in IEC Document 57/991/DC, Roadmap for WG14: System interfaces for distribution management (SIDM).

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

NISTIR-7628 vol. 1, 2, 3, Cybersecurity guidelines

IEC 61400, Wind turbines

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

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

IEC 61334, Distribution Automation Using Distribution Line Carrier Systems

Interoperability standards

The 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

The following gaps regarding functions described in IEC 61968 are present:

- Operational Planning & Optimization (OP) – Part 5
- Maintenance & Construction (MC) – Part 6
- Network Extension Planning (NE) – Part 7
- Mapping between Multispeak 4.0 – Part 14-1
- CIM profile for Multispeak 4.0 – Part 14-2
- Distributed Energy Resources – possible Part 10
- IEC 61968 needs to be extended regarding modeling of DR command signals, different signals, e.g. for interruptible load, emergency DR and DR bidding are not in the standard.

Further gaps are described in the IEC TC 57 WG 14 roadmap: Vision for the Next Generation of CIM and Related Standards.

An strong need for better harmonization between CIM and IEC 61850 is needed because all modelling work in different areas should be consistent and possible to re-utilize.

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
Give high priority of harmonisation of CIM /IEC 61850.

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

Dis-4: Integrate Cyber security in IEC 62351
Work on standard for cibersecurity as long as intensive public communication services (from Telecom Operators) will be used in Distribution, advance in the 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. On-going work in TC57: IEC 61850-90-3 (TR)

Dis 6: Integrate Condition monitoring capabilities
Condition monitoring of components of substations or of lines, provides technical information, useful for optimized loading and help 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.

5.2.4 Smart metering

5.2.4.1 Description

Definitions

A smart grid has been described as an electricity network that intelligently integrates the behaviour and actions of all users connected to it – generators, consumers and those that do both – in order to efficiently ensure a more sustainable, economic and secure electricity supply.

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 organisation(s) via an advanced metering infrastructure. They are thus an important enabler for smart grids,

Standardisation mandate M/441

Smart meters have been the subject of standardisation 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.

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

Smart meter standardisation addresses six broad areas of additional functionality, namely:

Functionality 1:	Remote reading of metrological register(s) and provision to designated market organisations
Functionality 2:	Two-way communication between the metering system and designated market organisation(s)
Functionality 3:	To support advanced tariffing and payment systems
Functionality 4:	To allow remote disablement and enablement of supply and flow/power limitation
Functionality 5:	Communicating with (and where appropriate directly controlling) individual devices within the home/building
Functionality 6:	To provide information via web portal/gateway to an in-home/building display or auxiliary equipment

Note that this list of additional functionalities should not be seen as a minimum list of smart meter 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 n the context of smart grids however, two-way communications are 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.

In smart grids, the meter acts as a remote sensor, enabling information flows between the meter and grid operators. 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 account of the services needed to support smart electricity grids in homes and buildings (see 5.2.4.6 below) although not all the interfaces are fully covered by the M/441 mandate. Recommendations to address this are included in section 5.2.4.3.

5.2.4.2 Use cases

The additional functionalities identified for smart meters 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 e.g. monitoring of supply quality and electricity outages

- receiving messages from designated market organisation(s), both standard and ad hoc, e.g. on planned interruptions, messages on price changes) and other information

- 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 the home/building

- interfacing with home communications systems / home area network, enabling the meter to export metrological and other information for display and potential analysis

- potential home and building control applications and sophisticated energy management systems

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

Smart grid interfaces

The M/441 standardisation work makes specific provision for communications interfaces with smart electricity grids – see Figure 1 below.

Figure 1:

[Diagram from M/441 Technical Report to be inserted once agreed]

While the smart metering functionalities necessary to support smart grids are already envisaged, the final design of smart grids is not yet defined and standardisation 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 5.2.4.9).

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 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

As noted in Figure 1 above, 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
- ANSI C12 suite

A harmonisation of these standards is necessary to prevent further development of different (and competing) standards for the same purpose.

SM 2: Smart metering, home automation and electric vehicles are envisaged as elements in smart electricity grids. It is recommended that CEN/CENELEC/ETSI consider the use cases envisaged for smart grids involving these elements and take care in their standardisation work in these areas to ensure the needs and applications of smart grids are addressed in a harmonised 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 standardisation in these areas is necessary, taking care to ensure harmonisation with existing metering models and other relevant standardisation initiatives.

5.2.5 Industry

5.2.5.1 Description of Scenario

In Europe, the part of electricity demand for industry is around 40% of the total electricity demand (Source Eurelectric 2005 - Primes baseline). 70% of this electricity consumption is related to motors, 9% for electrolysis, 4% for lighting and 17 % for different other uses. Now, if we look at the breakdown of motor consumption, 30% are for compression, 20% fore pumps, 13% for ventilation and 37 for different 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 power quality of the network.

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

Every industrial application can be split into three major parts:

- The industrial process (motors, electrolysis…)
- The electrical part link to the process (the electrical distribution from the main supply connection (could be High or Medium voltage, could be 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 mean, combined or not with the process.
- The auxiliary equipment supply (gas, compressed air…)

<u>Energy management</u>

The first and the 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 electricy, and provides a first level of understanding on how the electrical network is loaded (monitor load consumption, switchboard load and spare capacities), which is the current power quality (monitor harmonics, sags, …), which source is currently active, and possibly offers remote manual and/or automatic mean 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 process, electrical part link to the process, auxiliary equipment.
In many cases the same technology is used at Power Utilities 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, curtailment demand response.

<u>Industrial micro grids</u>

Industrial facilities are often built in areas conducive for the installation of renewable power generation such as wind, solar, geothermal, 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.
Sometime, the development of a 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

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
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 decision 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 to 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 channel down to the Energy Management system
2	In case of power cut off 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 able to built a micro grid in order to increase power availability and contribute to reduce power variation on 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
ISO 16484 (BACnet) : Building automation and control systems (CEN TC247)

5.2.5.4 Recommendations

Going into detail to fill the requirement of the above use cases, the following gaps appear and related recommendations are proposed

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

Ind-2: DR information
Demand-response mechanism is not considered yet to support network ancillary services. We recommend to extend IEC 61850 model (DER) and other DR information channel 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 Standards Organisations should ensure coordination between CEN TC247 and TC13

Ind-4: Harmonized data model for industry and power grid
Too many protocols already exist without mapping between them. We recommend to harmonise data model related to energy management between Industry and Electricity (EN 61158, EN 61850).This work should be coordinate between TC65 and TC57.

Ind-5: Electrical installation allowing for DER integration
The usage of distributed energy resources as part of electrical installation and part of micro grid for industry induces new safety and protection issues. The multi sources aspect is not covered by current installation rules. We recommend TC64 to work on new installation rules for safety aspects and TC8 to work on common rules for grid protection.

5.2.6 Home and building automation

5.2.6.1 Description of scenario

This part describes the scenarios for home and building installations that require information to be shared between the other domains of the smart grid.

The term Home and Building is used in general for any kind of building independent of the size or type of use. A JWG (CEN TC 247 / CENELEC TC 205) appointed the term HBES/BACS for systems used in this field of installations and applications. The expression HBES/BACS covers any combination of HBES/BACS products (including their separate connected/detachable devices) linked together via one or more

HBES/BACS networks. Other names used such as “home control network“, “home control systems“, “home and building electronic systems“, “building systems“, “building automation system“ etc. describe types of HBES/BACS system.

Energy management in home and building applications should consider visualization of energy consumption, load management but also local generation and possible storage. The resulting scenarios are described with use cases resulting from the following objectives:

Main Objectives

- The average level of energy consumption shall be reduced as much as possible in order to save money and to reduce CO_2 emission (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)

Conclusions:

- A new balance of supply and consumption has to be established. The energy consumption domain’s should get enough information to be able to organize the use of power according to generation. Peaks of energy supply shall be reduced by management of energy consumption
- Energy consumption should be organized in such a way that power generation is used at its optimum level especially considering power generation within own facilities (e.g. PV, CHP) or distributed energy resources.

5.2.6.2 Use Cases

The following 4 major use cases for home and building automation arise from these considerations. They continue and specify the work of the Expert Group 1 ("Functionalities of smart grids and smart meters“)

1. Visualization of energy consumption (see EG1 report page 11)
   The user should be aware of the consumption: water, gas, electricity. For electricity, it is fundamental to inform the consumer of energy consumption per usage (heating, cooling, lighting, ventilation, …) This gives us the possibility to empower people to manage better the utilisation of their energy based on this transparency. In order to visualize meter data communication between energy management and metering is necessary. This use case also leads to a request for sub-metering within home 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, digital transmitted electricity tariff enables smart appliances, HBES/BACS 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 be investigated also for water, heat or gas supply.

3. Increasing of use from own 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 HBES/BACS is seen as an advantage. This allows a first balancing within each house 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 not economic. Experience from telecommunications shows also that completely new ideas will arise as soon as an open infrastructure is available and wide spread. In order to gain 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 the 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 following recommendations, which are subdivided into 6 statements in general and 2 concrete recommendations for standardization.

- In order to reach very fast a wide spread use of new energy management functions 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 as radio frequencies (RF) or communications using the already existing wiring for electrical power (Mains Signalling, PLC power line carrier). For new buildings additionally a special communication wiring like TP system for communication can be used. Especially in commercial buildings, wiring solutions has to be seen as advantageous.

- For future smart homes and buildings the energy management systems should be part of the infrastructure of these. 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 surrounding again –together with new suppliers of energy and their new price signals / tariffs. The smart grid functions of devices and appliances must be available even after a removal. Therefore standardization is of highest interest in order to realize customer acceptance.

- The main requirement for such kind of infrastructure must be lowest 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 specialising 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 an external control of their equipment. This means that the final control of his applications by himself is necessary (charging of electric vehicles, washing machine, lighting, HVAC, shutters, alarms, intrusion and safety, etc...).
  In this case energy management shall be part of the domain “home and building”, not part of the domain “grid”
  Also in case of commercial buildings, standardization concepts shall 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 (refer as well to the chapter “Industry” of this report) external energy services might be offered which include controlling the devices. This kind of control only works on agreed preconditions and contractual agreements.

- The standardization must be done in a way that incentives for efficient power usage may be provided by the utility itself or a third party service provider. Also the described optimized use of an inhouse generation (e.g. photovoltaic) might be an incentive for the energy management.

- Consumer privacy and security shall be maintained; therefore, issues of IT security and data privacy must be considered. It is not necessary, that any device inside the home/building is 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 existing gaps in the existing standards (refer as well to the chapter “Information Security” of this report)

Recommendations for standardization

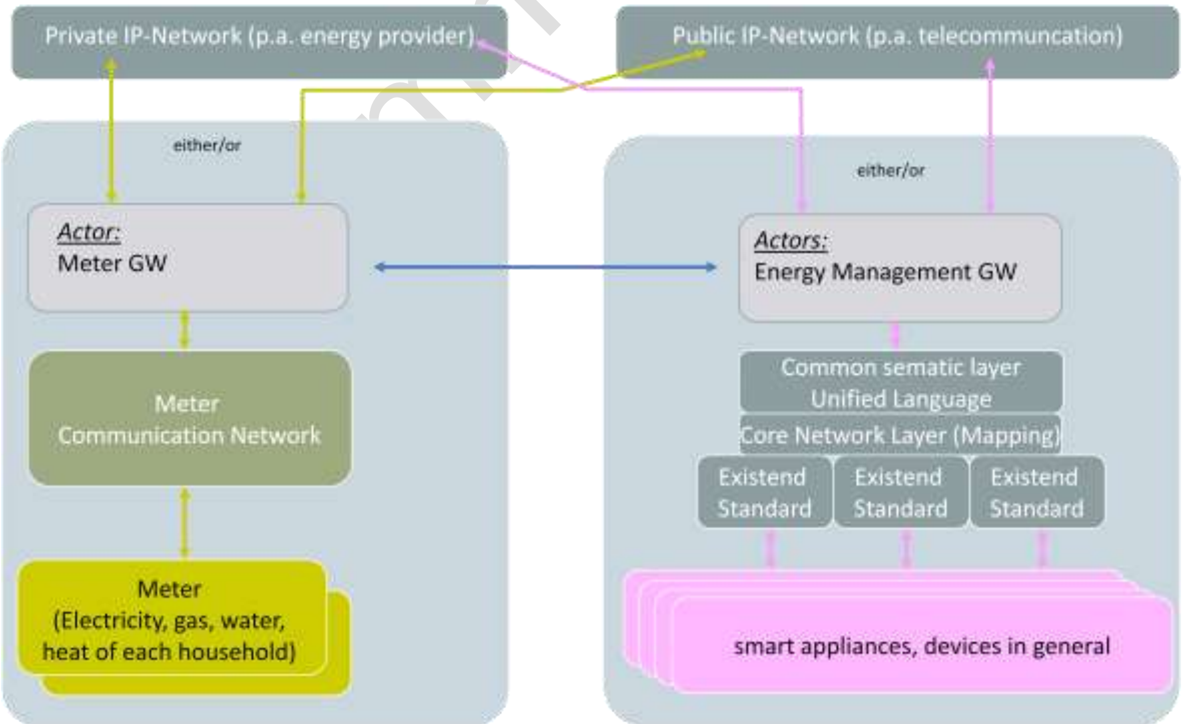
HBES-1: Separate realization from standards description

The use cases described above interface to 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 blocs, since both fields are driven by different kinds of interests and innovation speeds. Competition is likely to result in different devices & 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 cases this is needed for communication between different market roles or devices.

HBES-2: Unified language for tariff information

A unified language (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-widely or even world wide unified data model for these aspects would be favorable considering the global market for smart appliances, devices and automation systems. For that, 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 to this task.
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 isn’t the case today.

The following diagram 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. Smartmetering or Service provider architecture, relationship with Smart Metering Mandate M/441 is therefore granted):



Please, note that the figure above is not related to a specific hardware design, but is just showing a logical separation of functions without predefining where and how those functions are implemented.

5.3 Markets and Actors

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[18] required for Smart Grids deployment. A special attention is paid to the issues of relevance for standardization, indicating where applicable a relation to the electricity and / or ICT standardization aspects.

5.3.1 Roles & Responsibilities – Current Status

Transmission System Operator (TSO) is responsible[19] for operation, maintenance and development of the transmission network in 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) is responsible[2] for operation, maintenance and development of the 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).

Generator[20] 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 equally 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 into: 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 of 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.

1.

18 In terms of scope, actions adn governance with particular focus on regulatory aspects.

19 Cf. Article 2.4 respectively 2.6 of the Electricity Directive 2009/72/EC

20 Cf. Articles 2.7 – 2.11 of the Electricity Directive 2009/72/EC

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 to the actors above include: 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 rransportation / 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 market, 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.

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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 authorisation 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 & Responsibilities – Recommendations to other actors

In relation to the Smart Grids deployment and in view of the necessary standardization, the following specific issues need to be addressed appropriately:

- *Technical issues,* including electricity and ICT standardization activities, where ways to make the transmission and distribution grids smarter and stronger are proven at appropriate scales for replication in Europe;
- *Market design issues,* where variable energy sources and active demand side management are integrated into new market rules, incentivizing consumers and (small) producers to actively participate in the electricity market;
- *Necessary changes* that allow grid operators, retailers, small generators and customers to make use of state-of-the-art communication technologies to improve data transparency and actively participate in the energy market;
- *Regulatory measures allowing* the development of smarter grids and more active participation of small players by e.g. giving proper incentives to grid and energy providers and users to contribute to an efficient system
- *Customer engagement with Smart Grid issues,* especially focusing on public acceptance of smart metering and reassuring consumers on any privacy and/or security issues that may arise.
- *Societal issues,* such as acceptance and engagement with technological changes, ensuring that all consumers including vulnerable and low income consumers can access the benefits of Smart Grids. The way forward is to inform grid users, especially households, which in turn is a responsibility for all actors: “watchdogs” services, regulators, suppliers, distribution networks and manufactures.
- *Supporting consumers* to understand and value the environmental benefits related to the deployment of Smart Grids.

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

TSOs and DSOs

Whereas Smart Grids deployment is the issue of both, TSOs and DSOs, it appears that the DSOs will have to face the biggest changes to make Smart Grids a reality. The reasons for that are 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 & 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. It also follows that the TSOs will have to gradually develop further power system control standards and applications as well as market information management, including forecasting.

Both TSO and DSO should be able to execute their active role in Smart Grid management by ensuring more sophisticated mechanisms to interfere with the planned market activities in case of disturbed or emergency operational conditions, without “automatic” socialization of the related costs to other grid users.

Finally, the role of grid communications and respective real and “industrial” standards will significantly increase as much more data will have to be gathered and exchanged frequently.

The standardization of communication protocols as well as clear rules for handling and security of this data will have to be developed and enforced.

Generation

With its increasing share, the responsibility of distributed generation in contributing to grid stability and operational security will increase, hand in hand with the technology progress which will enable that in a cost/effective manner.

Electricity Installers / Contractors

With a massive deployment of IT-technology at the medium voltage level of distribution networks (e.g. for automated maintenance, asset management support, etc.) and for the integration of new applications and market participants at the medium and low voltage level (e.g. Virtual Power Plants), the role of electricity contractors in ensuring proper functioning of the future Smart Grids will increase further. Because of the large scale / number of respective installations and equipment used, standardization is an essential issue in order to ensure on one hand effective and efficient fulfillment of their role and on the other reduce costs.

Customers / Consumer

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.

DSR has also significant implications for the DSOs as well as equipment suppliers and electricity retailers. Moreover, based on the increased information on consumption, consumers will make more informed decisions on how & when they can save energy, either by changing their behavior 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. To make DSR possible, standard load profiles will have to be replaced by more 'dynamic' ones, with flexible energy prices. Moreover, this information will need to be complemented with the actual information about market activities of consumers, producers and those that do both, to the DSOs/TSOs.

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 to smaller participants.

It can be expected that an increasingly flexible formation of energy prices and ancillary services (both in time and space) as well as increasingly flexible and specific prices will ultimately deliver the full potential of customer benefits from Smart Grids.

Traders

Trade will be characterized with 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 at the customers' side contributing also 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 for market development with standards set at the European level, through a transparent process. New technologies will fulfill functionalities that had not been available in the past (e.g. relying on advanced power electronics).

The actors specifying the requirements for Smart Meters and the manufacturers of such devices must be aware that they are developing products for a regulated market environment in which European integration, consumer privacy, security of supply and regulated returns on investment must be taken into account.

The ability to better understand the customers' needs and behavior, will enable new innovative business models and services 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 class of devices and services, contract based products to consumers based on their individual usage pattern of energy, etc.

The products and services related to electrical cars will induce further innovation both in terms of technology and business models. While feasible business models are still under development, the physical impact of large numbers of electrical cars participating both as 'consumers' and 'storage' actors in the grid needs to be fully understood and may further add to the complexity of maintaining overall grid stability and security of supply.

Finally, information and communication service providers will offer more sophisticated services addressing the electricity industry needs. Given the critical role of the electricity supply, those communication services must deliver the necessary quality of service, security of information and privacy – it is in this area, where the standardization in the field of ICT and at cross-areas with electricity market will play a crucial and key role for the Smart Grids deployment.

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. As explained in Chapter 4, 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.

Given that more actors will participate in the marketplace, regulators will also need to further support designing and implementing the direct regulatory measures and market rules required for the market place of the future and for ensuring utilization of all the new services and opportunities to the highest possible welfare.

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 for preserving competitive environment, ensuring non-discriminatory treatment and guaranteeing proper functioning of all markets in a sustainable way, to the benefit of all actors and society as a whole.

It should also be recognized that some EU, national or regional initiatives related to energy policy, economic policy, environmental policy, etc. may actually be counterproductive to meeting all the benefits of Smart Grids. Where such issues arise, then the framework and template for evaluation of specific Smart Grids activities and projects, defined by the Expert Group 3 of the EU Commission's Task Force for Smart Grids should be used.

5.3.3 Recommendations to the ESOs

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 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 inter-operability problems or issues related to intellectual property rights.

Mkt -1 Defined actors and roles as base for Smart Grid use-cases

Standardization should play a role also in other areas where technical enforcement for market decisions by regulators or private sector actors is needed. Moreover, Standardization Organisations have to provide the needed flexibility to accommodate with 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 of fulfilling the services and functionalities. Besides general interest for standardization bodies and all other stakeholders, this issue is of utmost interest for all market players (suppliers, generators, traders, etc.) but 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 ICT sector together, who will need to review and identify all the required improvements and further development in this area.

Mkt-3 <still under consideration>

There is a debate on the "standing" of the ESO's standards, similar as is the case for the New Approach directives (see http://www.newapproach.org/): presumption of conformity etc). This does not exist for smart grids.

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 to develop such a reference architecture should be performed by a subgroup of the JWG. Therefore a taskforce “Reference Architecture” will be formed by the JWG starting its 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 taskforce “Use Cases” will be formed by the JWG starting its operation from 01/2011. Close cooperation with the activities of IEC TC 8 and respectively CLC TC 8X is needed.

6.2 Mandate

A mandate on Smart Grid standardization is being drafted to be presented to the Commission’s Smart Grid Task Force Steering Committee meeting on 17 December 2010; the formal approval process will take start beginning of 2011.

Efforts have been made to ensure that 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. The acceptance of the mandate will influence the further work on the later versions of the report and the actions taken by the JWG.

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 lies on the overview of already usable European standards to support the basic functionalities given by the taskforce work []. Some high level recommendations have been derived in the respective domains and the cross cutting issues. The report is currently the working result of the joint working group. Other comments have up to now not been collected. The report will be circulated to technical committees of the ESOs and other interested parties.

Therefore a number of reasons exist, why this report needs continuous update:

- comments from a wider audience need to be incorporated (e.g. TC's / NSO's)
- the initial report was developed in a parallel work mode, which could not avoid some overlaps or even inconsistencies
- the requirements of the actual 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 in periodic time intervals

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

7. Appendices

7.1 Appendix 1 – Summary List of 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.

G-2 International standards as base for promoting EU economy
Standardization of Smart Grid must be based on existing international work, to avoid reinventing the wheel, to accommodate already solutions which are standardized and applied for practical purposes and to secure the interests of European manufactures who are acting globally. This document recognizes that work and therefore builds upon the globally recognized Smart Grid standards as identified in Section 5 (e.g. IEC TC57 family of standards).

G-3 Speed of implementation – reuse existing
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. Focus must be laid on the standard development according to the R&D and deployment priorities of the EU given in the taskforce reports, the ETP and the SDD.

G-4 Concentrate on future proof standardization
Smart Grid 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 flexible 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. Feed this repository with at least:

- the M441 set of use cases
- active liaisons with all European Smart Grid projects
- from the EG1 to EG3 reports of the EU Commission Smart Grid task force
- from experiences of the national committees

Check if the re-use of use cases coming from other countries or region may lead to single worldwide use-cases definition
Define the methodologies: templates, classification, etc.

G-6 Adapt standardization process
Set the needed processes to fit the lack of maturity of many smart grid application. As stated in EG1 report, "smart grids deployment will be a continuous learning process" and standardization should propose clear set of processes to cope with this learning process. E.g. use 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 including covering the whole life cycle of such standards, including how to collect issues, to treat/fix issues, and then to validate and test.

O-1 Extend timeframe and scope of JWG Smart Grid
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 Grid area.

O-2 Marketing of ESOs effort in Smart Grid
ESOs must enforce their efforts to markets and visualize their already done work on international and different regional levels. This is necessary to keep the high level of influence on international standardization and therefore on solutions. A funding of the external representation of the ESOs should be investigated as international activities are indicating growing dominating roles of US and Asia due to high public funding of respective standardization organizations. Although this might be conflicting with the traditional role of the European standardization the short time frame for actions in face of the international competition 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 SME. Any solution should be based on the co-operation with national standardization organizations and their experts and expertise.

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

PPC-1 Electronic Data models
To align as much as possible glossaries with Electronic Data Models (TC 57, SC 3D)

Ref-1: **European Conceptual Model**
Identify the relevant actors that will be instrumental to the European Smart Grid targets and build a European Conceptual Model to describing those major stakeholders and their interactions.*(This should be done within this document in its first official release)*

Ref-2: **European Functional Architecture**
Develop, possibly based on the IEC SG3 model, a European Functional Architecture that take into account all the generic, global aspects of Smart Grid as well as all the European specificities, in particular those outlined in the European Conceptual Model..

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 Smart Grids Task Force to create a Security Architecture also taking into account the NIST complementary approach whenever applicable.

Ref-5: **Consistent Information Model**
Ensure that the Information.Architecture is relying both on precisely identified Standards but 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 Task Force within the Joint Working Group to develop and maintain a European Smart Grid Reference Architecture, at least for some of the major views (Conceptual Model, Functional, Communication and Security Architecture).

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 standard. These processes should cover the overall life cycle of standard from upstream requirement definitions, down to interoperability testing. Provide incremental way of proceeding and maximum flexibility for addressing unknown future usages. (List of proposed domains to address are defined below)
Feed as soon as possible the TC8 X with these Top-down Smart Grid use cases, to be taken into account by ad'hoc IEC TCs 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 Create DR task force
Create a single DR task force at CEN/CENELEC/ETSI level encompassing the adaptation of DR signal 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 standardization bodies for communication exchange with the EV

Sys-3 Avoid European mandates overlapping
Define clear interface and responsibilities between the Smart Grid mandate and the EV mandate and associated standardization bodies (part of Smart Grid mandate). Ensure interoperability between the different standards

Sys-4: Create "Smart Grid Data model taskforce
Create a single "Smart Grid Data model task force" at CEN/CENELEC/ETSI level to support Smart Grid system level applications. Contribute to data model and description language at IEC levels

Sys-5: Create a single "Smart Grid System Management and security" task force
Create a single "Smart Grid System Management and security" task force at CEN/CENELEC/ETSI level. nternational harmonization of identification numbering series for cross country ID management International organization of Certificat Authority (CA) to ensure cross country end-to-end security interoperability

Sys-6 Check comprehensiveness of standards towards interoperability
Check the coverage of selected standards against semantic, behavior, conformance testing and fill gaps when needed

Sys-7: Systematically address system interoperability
Pave the road for implementing step-wise approach of interoperability.

Sys-8: 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

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.
For lower frequencies the EMC guidelines/regulations should be developed.
Frequencies for broadband should be reserved for utility applications.
For PLC communication the use of the frequency range up to 540kHz should be specified, as is already the case in the US.
Furthermore, a definition of the broadband PLC for ranges from 0,3MHz to 50MHz is necessary. Here it would be beneficial to reserve the medium range (0.3MHz to 3MHz) frequencies for the utilities, 3 to 30MHz for in home applications.

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.

(EU-ISec-1) Define European information security requirements on "system-level"
EU needs to provide to ESOs a detailed set of system-requirements (technical and organizational) for SGIS and DPP that should cover multiple security levels (SG-ISL 1-low to,5-top secret), as input to the ESO as they need to provide standards ALL actors interacting in smart grids – i.e. all system -components (products, solutions, services) and organizations participating in their respective smart grid role.

(EU-ISec-2) Guidance on information security and data protection / privacy governance
EU should provide guidance on the governance model (incident /fraud responses) and credential (ID / key..) management options.

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 security levels) into

III. Product, Solution & Service standards of all „sphere of action“ domains
IV. “Sphere of action” domain specific Organizational standards for Market roles participating in smart grid, according to their Responsibilities, and functions

Ensure consistency between those and sustain “state of the art” by synchronizing all standard with changing EU input.

ISec-2 Smart grid functions and use cases require binding to information security requirements

For several Data protection classes (SG-DPC) legal requirement exist, and require the appropriation of the DPC i.e. Personal data, Control Data. Therefore the concept of the smart grid information security needs to provide the enablement for binding between – the usages of data. The rights & justification(i.e. contractual /regulatory), 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 its specific SG-DPC and SG-ISL. Therefore the concept of the JWG is to interconnect the use case repository with the repositories of the UML data models(this describes the data usage) and obligate the ESOs to bind the data models to their specific data protection classes (SG-DPCs), further more the SG- DPCs need to be bound to specific information security level requirement (SG-ISL).
It is recommended that ESOs provide interlinked repositories to achieve the required binding.

ISec-3 SGIS and DPP upgrade and synchronization requirements

ESO need to provide a sustainable mechanism to update and synchronize the binds of data models used by functions and use cases to the SG-DPC 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 need to be in sync with changing System requirements for the “smart grid information security” and data protection/privacy,.

ISec-4 ESO Provide IT Tools to support SGIS and DPP modeling and application

ESO should also SGIS and DPP specific tools and repositories to Information security experts communities to assist them in modeling security and maintaining and upgrading the 5 system security levels (SG-ISL), the smart grid data protection classes (SG-DPC) – synchronized with the evolving set of “System Level” SIGS and DPP requirements on one hand and the linkage of the repositories various repositories for smart grid functions, use cases, data models & data models provided to experts in smart grid functions and use cases (discussed in other section of this report) on the other hand.

Dep-1 Check relevance of existing methodologies on Smart Grid

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

EMC-1 Review existing standards

CLC 210 and Product Committees to review existing standards concerning an appropriate modification for closing gaps in order to also ensuring EMC in the frequency ranges from 2 kHz to 150 kHz (in practice 2-9 kHz and 9-150 kHz).
Note: available technical information is poor (only an internal report within CLC SC205A : *SC205A/Sec0260/R*), and preliminary studies are necessary before standards can be established.

Furthermore the following actions of the standardisation communities are suggested to support Low frequency EMC/Power Quality in the context of Smart Grid.

EMC-2 Review EMC 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 Grid.

EMC-3 Consider distorting current emissions from DER equipment

Standardise how 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 network(s). 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.

Gen-1 Harmonized glossary, semantic & modeling between back-office applications (CIM) and field applications (61850)

Provide experts to IEC TC57 body to boost CIM/IEC 61850 harmonisation 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 Harmonisation between DLMS/Cosem data model and IEC 61850/CIM

Take the lead on this DLMS/COSEM data model harmonization with CIM/IEC 61850, within the IEC body (through CENELEC TC57X)

Gen-3 Extended field data modeling 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 the Smart Grid system has to support and ensure IEC TC 57 WG17 body (through CENELEC TC57X) will provide expected answers in IEC 61850 data modelling regarding: Demand-response for generators, for ancillary services, including VPPs and aggregators. Support TC57 WG13 initiatives to define uses cases and modelling (such as AI715)

Gen-4 Standard for electrical connection and installation rules to ensure energy availability and security, in presence of 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 (TC64X and TC8X)

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, protections,….) as well as for grid topology (grid design, voltage level, grid code,…) in High Voltage DC domain. A present Study Group, hosted by the German National Committee will elaborate the basis for the standardization work to be continued Cenelec. This initiative should be encouraged.

T2 – Smart assets

Condition monitoring of components of substations or of lines, provides technical information, useful for the optimized used 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 an 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 a decision making.

The on-going IEC 61850-90.3 work, devoted to condition monitoring in power energy domain, should be encouraged, the present standard and protocol for communication in substations, should involve communication and relevant data model, 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 on-going IEC standard involves on the one hand, the experts of equipment to monitor for the technical aspects and the prediction models and on the other hand representatives of users in order to assess the relevant decision making.

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 would be adapted. These tasks should be notably performed by TC14 (transformer), TC17 (switchgear), TC38 (instrument measurement) and TC20 (underground-cable).

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
Give high priority of harmonisation of CIM /IEC 61850.

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

Dis-4: Integrate Cyber security in IEC 62351
Work on standard for cibersecurity as long as intensive public communication services (from Telecom Operators) will be used in Distribution, advance in the 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. On-going work in TC57: IEC 61850-90-3 (TR)

Dis 6: Integrate Condition monitoring capabilities
Condition monitoring of components of substations or of lines, provides technical information, useful for optimized loading and help 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.

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
- ANSI C12 suite

A harmonisation of these standards is necessary to prevent further development of different (and competing) standards for the same purpose.

SM 2: Smart metering, home automation and electric vehicles are envisaged as elements in smart electricity grids. It is recommended that CEN/CENELEC/ETSI consider the use cases envisaged for smart grids involving these elements and take care in their standardisation work in these areas to ensure the needs and applications of smart grids are addressed in a harmonised 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 standardisation in these areas is necessary, taking care to ensure harmonisation with existing metering models and other relevant standardisation initiatives.

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

Ind-2: DR information
Demand-response mechanism is not considered yet to support network ancillary services. We recommend to extend IEC 61850 model (DER) and other DR information channel 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 Standards Organisations should ensure coordination between CEN TC247 and TC13

Ind-4: Harmonized data model for industry and power grid
Too many protocols already exist without mapping between them. We recommend to harmonise data model related to energy management between Industry and Electricity (EN 61158, EN 61850).This work should be coordinate between TC65 and TC57.

Ind-5: Electrical installation allowing for DER integration
The usage of distributed energy resources as part of electrical installation and part of micro grid for industry induces new safety and protection issues. The multi sources aspect is not covered by current installation rules. We recommend TC64 to work on new installation rules for safety aspects and TC8 to work on common rules for grid protection.

HBES-1: Separate realization from standards description

The use cases described above interface to 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 blocs, since both fields are driven by different kinds of interests and innovation speeds. Competition is likely to result in different devices & 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 cases this is needed for communication between different market roles or devices.

HBES-2: Unified language for tariff information

A unified language (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-widely or even world wide unified data model for these aspects would be favorable considering the global market for smart appliances, devices and automation systems. For that, 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 to this task.
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 isn’t the case today.

Mkt -1 Defined actors and roles as base for Smart Grid use-cases

Standardization should play a role also in other areas where technical enforcement for market decisions by regulators or private sector actors is needed. Moreover, Standardization Organisations have to provide the needed flexibility to accommodate with 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 of fulfilling the services and functionalities. Besides general interest for standardization bodies and all other stakeholders, this issue is of utmost interest for all market players (suppliers, generators, traders, etc.) but 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 ICT sector together, who will need to review and identify all the required improvements and further development in this area.

Mkt-3 <still under consideration>

There is a debate on the "standing" of the ESO's standards, similar as is the case for the New Approach directives (see http://www.newapproach.org/): presumption of conformity etc). This does not exist for smart grids.

7.2 Appendix 2 – Abbreviations and Acronyms

<List to be completed>

CHP	Combined Heat and Power	
DR	Demand-Response	
EV	Electrical Vehicle	
VPP	Virtual Power Plant	Cluster of distributed generation installations (such as microCHP, wind-turbines, photovoltaïc plant, small hydro, back-up gensets etc.) which are collectively run by a central control entity.

7.3 Appendix 3 – Bibliography

< to be added>

7.4 Appendix 4 – Core Editorial and Champion Teams compositions

<the list at this point lists the champions – the final text will contain the list of all involved contributors following a double-check with all champions >

Core Editorial Team

Ralph Sporer
Luc Van den Berghe
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Champions of dedicated sections:

5.1 Cross Cutting Issues
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5.1.2 Reference architecture Emmanuel Darmois
5.1.3 System Aspects Laurent Guise
5.1.4 Communication Willem Strabbing
5.1.5 Information Security Alfred Malina
5.1.6 Other cross-cutting issues Herve Rochereau

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5.2.4 Smart Metering David Johnson,

5.2.5 Industry Serge Volut;

5.2.6 Home and Building Automation Peter Kellendonk,

5.3 Market and Actors Tahir Kapetanovic;

7.5 Appendix 5 - Demand-Response

Demand-Response is one of the corner-stone of Smart Grid, then appears as an answer to many of the expected Smart Grid top-level services.

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 devices	DR is needed to shape loads at users side DR helps reaching quality criteria, and balancing 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 reaching quality criteria, and balancing 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 reaching quality criteria, and balancing reactive power
	7	operation schemes for voltage/current control	DR helps reaching quality criteria, and balancing reactive power
	8	Intermittent sources of generation to contribute to system security	DR helps reaching quality criteria, and balancing 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 increase 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 reaching quality criteria, and balancing reactive power
More direct involvement of consumers in their energy usage	12	Availability of individual continuity of supply and voltage quality indicators	

7.5.1 How to proceed to tackle DR standardisation ?

In front of the level of uncertainty attached to the setting-up of DR mechanism 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)

- Contributes to network security (high speed)
- Manage the EV charging issues, including the constraint of having the electricity supply contract following the charging spot location change due to the EV move.

Proposed steps :
Today's DR specifications are still too broad, and too business model dependant. Then standardisation should focus in a first stage to 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 shapping load in response to Demand Response Events, Electricity Price Indications or other system events (e.g. under frequency 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

Exchange Pricing indications	Communicate the Energy and service price indications to the interested parties
Manage DR contract	Handle the process which linkss 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

7.5.2 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 behavior.
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 mechanism, 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.
- Communicating/sharing the desired behavior within the provided flexibility, e.g. in terms of lowering, raising or shifting demand and/or supply.

Demand-Response is one of the corner-stone of Smart Grid, then appears as an answer to many of the expected Smart Grid top-level services.

7.6 Appendix 6 – Interoperability Standards

This appendix lists the available standards for the interfaces that are identified in the functional communication architecture of a Smart Grid shown in section 5.1.3.

7.6.1 Intra-Sectional Standards

7.6.1.1 WAN interface to Operations Subsystem

Formal (de-jure) communication standards
Related to external WAN's and LAN's:

- IEC 60870-5, *Telecontrol equipment and systems*
- IEC 60870-5-101, *Telecontrol equipment and systems - Part 5-101: Transmission protocols - Companion standard for basic telecontrol tasks*
- IEC 60870-5-103, *Telecontrol equipment and systems - Part 5-103: Transmission protocols - Companion standard for the informative interface of protection equipment"*
- IEC 60870-5-104, *Telecontrol equipment and systems - Part 5-104: Transmission protocols Network access for IEC 60870-5-101 using standard transport profiles*
- IEC 61850 series, *Communication networks and systems in substations*
- 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 LAN's:

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

7.6.1.2 Local interface between AMI and Home Automation

Formal (de-jure) communication standards

- EN 50090 series, Home and Building Electronic Systems (HBES, KNX)
- EN 50523-1, Household appliances interworking
- EN 14908 series (LON)
- EN ISO 16484 series, A Data Communication Protocol for Building Automation and Control Networks
- ISO/IEC 14543-3 series, , Information technology - Home Electronic System (HES) architecture
- ISO 16484-5, Buidling automation and control systems, part 5: data comm. prot.
- 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)
- ISO 16484-5/ ANSI-ASHRAE 135-2008, BACnet, A Data Communication Protocol for Building Automation and Control Networks
- ISO/IEC 15045, A Residential gateway model for Home Electronic System
- ISO/IEC 15067-3, Model of an energy management system for the Home Electronic System
- ISO/IEC 18012, Guidelines for Product Interoperability

7.6.1.3 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

7.6.1.4 WAN interface to Distributed Energy Resources

Formal (de-jure) communication standards

- IEC 61850-7-410 Ed. 1.0 English: Communication networks and systems for power utility automation - Part 7-410: Hydroelectric power plants - Communication for monitoring and control, 2007. IEC
- IEC 61850-7-420: Communication networks and systems for power utility automation - Part 7-420: Basic communication structure - Distributed energy resources logical nodes.
- IEC 61400-25 Communications for monitoring and control of wind power plants: Part 25-1 Overall description of principles and models
- IEC 61400-25 Communications for monitoring and control of wind power plants: Part 25-2 Information models
- IEC 61400-25 Communications for monitoring and control of wind power plants: Part 25-3 Information exchange models
- IEC 61400-25 Communications for monitoring and control of wind power plants: Part 25-4 Mapping to communication profiles (Mapping to XML based communication profile)
- IEC 61400-25 Communications for monitoring and control of wind power plants: Part 25-5 Conformance testing
- IEC 61400-25 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 CLC/TC 88

7.6.1.5 WAN interface to AMI subsystem & Head-End

Formal (de-jure) communication standards

- Metering protocols
  - EN 13757 series, Communication systems for meters and remote reading of meters (M-bus)
  - 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
  - IEC 61334, Distribution automation using distribution line carrier systems - Part 4 Sections 32, 511, 512, Part 5 Section 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

3GPP

- TS 41.101, TS21.101, TS21.201, TS21.202

ETSI TISPAN

- ETSI TS 184 002 V1.1.1 "Identifiers (IDs) for NGN"
- ETSI TR 187 010 V2.1.1 Telecommunications and Internet converged Services and
- 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 Reference Points"
- ETSI TS 181 005 v3 "Service and Capability Requirements"
- ETSI TS 122 228 v.8.6.0 "IMS 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"

Integrated Service Digital Network (ISDN)

- EN 300 356-1 Version 4.2.1 Integrated Services Digital Network (ISDN);
- EN 300 403-1 Version 1.3.2 Integrated Services Digital Network (ISDN);
- ETSI EN 310 489-1: “Electromagnetic compatibility and radio spectrum matters (ERM);
- ETSI EN 300220-2 (v2.3.1): “Electromagnetic compatibility and Radio spectrum Matters (ERM);
- ETSI EN 300440-2 (v1.4.1): “Electromagnetic compatibility and Radio spectrum Matters (ERM);
- ETSI EN 300328 (v1.7.1): “Electromagnetic compatibility and Radio spectrum Matters (ERM);
- ETSI EN 302 065 (V1.2.1) (all parts):“Electromagnetic compatibility and Radio spectrum Matters (ERM);
- ETSI EN 302 500 (V1.2.1) (all parts): “Electromagnetic compatibility and Radio spectrum Matters

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

7.6.1.6 LAN/WAN interface to Generation Resources

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

- IEC 60870-5-101 and IEC 60870-5-104 for EMS/SCADA
- IEC 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
- IEC 61400-25 to access Wind Generation devices and controllers
- 57/1079/DC to access large-scale power production units (eg Thermal devices and controllers)

Since IEC 61850 covers various domains of the Smart Grid landscape, it is included in the section about 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 (eg Fleet Scheduling / Unit Operation or Performance Monitoring / Maintenance)
- Communication between Generation and Market applications (eg Fleet Scheduling / Energy Trading)
- Communication between Generation and External IT applications (eg 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.

7.6.2 Cross Sectional Standards

7.6.2.1 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 for 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 5.1.4.1: IEC TC 57 Seamless Integration reference Architecture - IEC TR 62357 provides an overview on the IEC TR 62357 Seamless Integration Architecture with a joint view on 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 schemes and payloads exists.

Data exchange of topological data: Apart from the XMI-based serialization for data exchange between EMS-related systems, topological information about the power grid can be serialized as RDF-triple graphs and be exchange between GIS, SCADA and OTS systems. Since RDF being a graph based format, it is less fragile than XML based tree structures and reasoning capabilities to find inconsistencies in the modeling 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 schemes, payloads and processes are defined in order to provide a good blueprint on highly standardizing the interfaces between those systems. Figure A2 provides an overview about the scope of those interfaces already being standardized and being capable of functioning as Distribution Automation interface.

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

CENELEC adopted standards (depicted light grey in

Figure 5.1.4.1: IEC TC 57 Seamless Integration reference Architecture - IEC TR 62357 **Error! Reference source not found.** are non adopted parts):

- EN 61970-1:2006 Ed. 1: Energy management system application program interface (EMS-API) - Part 1: Guidelines and general requirements
- CLC/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 61970-402:2008 Ed. 1.0: Energy management system application program interface (EMS-API) - Part 402: Component interface specification (CIS) - Common services
- EN 61970-403:2007 Energy management system application interface (EMS- API) - Part 403: Component Interface Specification (CIS) - Generic Data Access
- EN 61970-404:2007 Energy management system application program interface (EMS-API) - Part 404: High Speed Data Access (HSDA))
- EN 61970-405:2007 energy management system application program interface (EMS-API) - Part 405: Generic eventing and subscription (GES)
- EN 61970-407:2007 Energy management system application program interface (EMS-API) - Part 407: Time series data access (TSDA)
- 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 SG 3 recommended standards for operations in Smart Grid:

- IEC 61970-1 Ed. 1: Energy management system application program interface (EMS-API) - Part 1: Guidelines and general requirements IEC, 2005
- IEC 61970-2 Ed. 1.0: Energy management system application program interface (EMS-API) - Part 2: Glossary IEC, 2004
- IEC 61970-301: Energy management system application program interface (EMS-API) - Part 301: Common information model (CIM) base IEC, 2007
- IEC 61970-302 ED. 1.0: Energy management system application program inter- face (EMS-API) - Part 302: Common information model (CIM) financial, energy scheduling and reservations IEC, 2002
- IEC 61970-401 TS Ed.1: Energy management system application program interface (EMS-API) - Part 401: Component interface specification (CIS) framework IEC, 2005
- IEC 61970-402 Ed. 1.0: Energy management system application program interface (EMS-API) - Part 402: Component interface specification (CIS) - Common services IEC, 2006
- IEC 61970-403 Ed. 1.0: Energy management system application interface (EMS- API) - Part 403: Component Interface Specification (CIS) - Generic Data Access IEC, 2006
- IEC 61970-404 ed. 1: Energy management system application program interface (EMS-API) - Part 404: High Speed Data Access (HSDA)) IEC, 2007

- IEC 61970-405 Ed.1: energy management system application program interface (EMS-API) - Part 405: Generic eventing and subscription (GES) IEC, 2007
- IEC 61970-407 Ed. 1: Energy management system application program interface (EMS-API) - Part 407: Time series data access (TSDA) IEC, 2007
- IEC 61970-453 Ed. 1.0: energy management system application interface (EMS- API) - Part 453: CIM based graphics exchange IEC, 2007
- IEC 61970-501 Ed. 1: Energy management system application interface (EMS- API) - Part 501: Common information model resource description framework (CIM RDF) Schema IEC, 2006

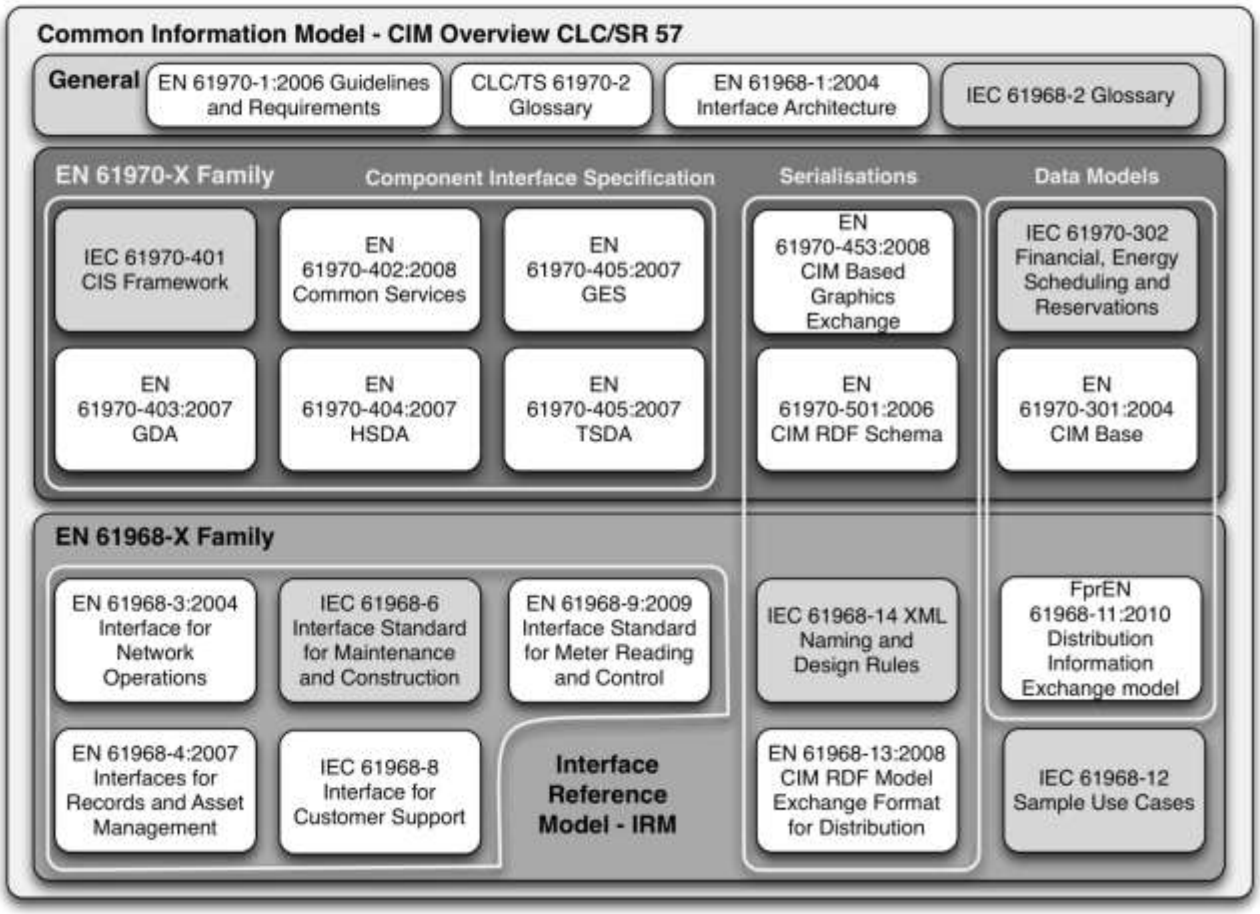


Figure A1: Overview on the CIM family – both EN 61968 and 61970

Most of those standards have also been recommended by the IEC SG 3 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.

7.6.2.2 IEC 61968 – Data models and system for distribution management and automation (secondary IT)

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

CENELEC adopted standards (depicted light grey in

Figure A2: Overview on the IEC 61968 IRM family are non adopted parts):

- 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 SG 3 and NIST recommended standards for DMS operation in Smart Grid:

- IEC 61968-1: Application integration at electric utilities - System interfaces for distribution management - Part 1: Interface architecture and general requirements IEC, 2007
- IEC 61968-2 Ed. 1.0: Application integration at electric utilities - System interfaces for distribution management - Part 2: Glossary IEC, 2003
- IEC 61968-3 Ed. 1: Application integration at electric utilities - System interfaces for distribution management - Part 3: Interface for network operations IEC, 2004
- IEC 61968-4 Ed. 1: Application integration at electric utilities - System interfaces for distribution management - Part 4: Interfaces for records and asset management IEC, 2007
- IEC 61968-6: Application integration at electric utilities - System interfaces for distribution management - Part 6: Interface Standard for Maintenance and Construction IEC, 2004
- IEC 61968-8: Application integration at electric utilities - System interfaces for distribution management - Part 8: Interface Standard for Customer Support IEC, 2008
- IEC 61968-9 Ed. 1.0: System Interfaces For Distribution Management - Part 9: Interface Standard for Meter Reading and Control IEC, 2007
- IEC 61968-11 and -12 Advance Copies: System Interfaces for Distribution Management IEC, 2007
- IEC 61968-13 Ed. 1.0: System Interfaces for distribution management - CIM RDF Model Exchange Format for Distribution IEC, 2006
- IEC 61968-14: System Interfaces for distribution management - XML Naming and Design Rules IEC, 2008

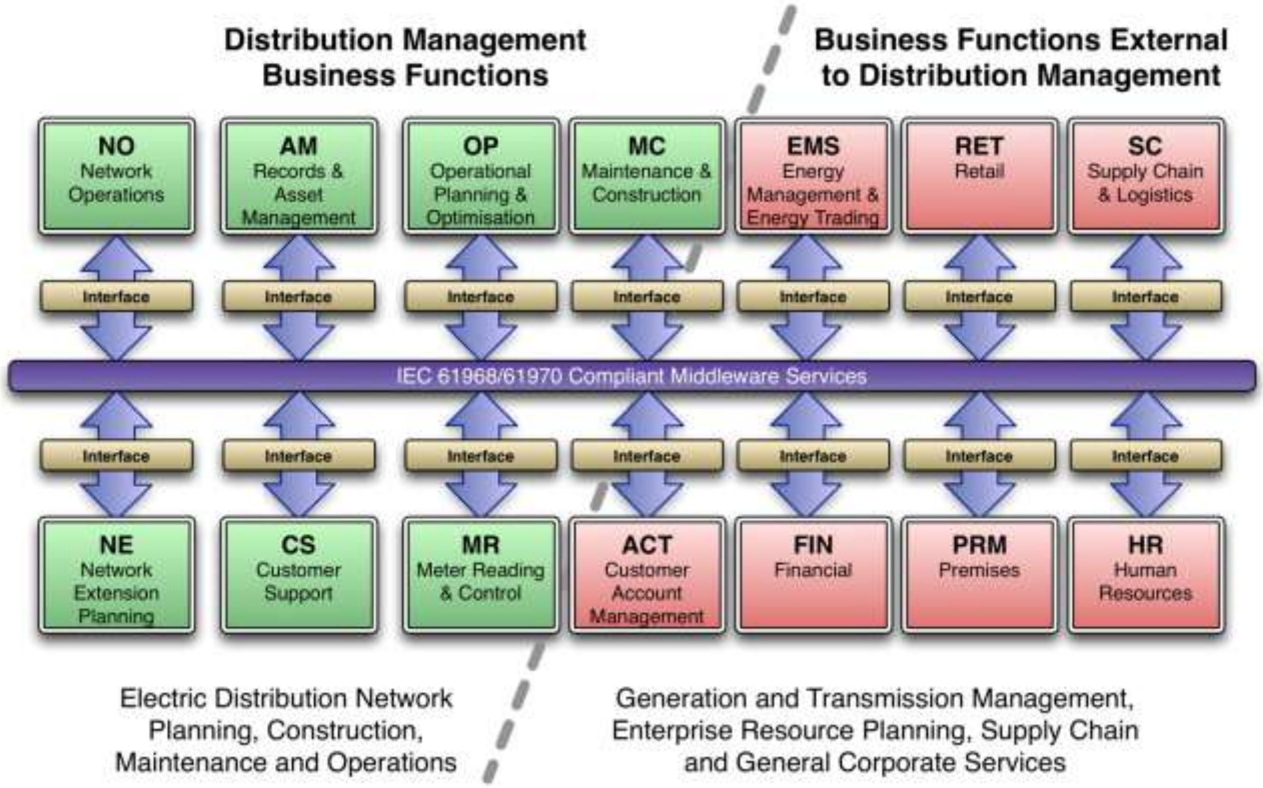


Figure A2: Overview on the IEC 61968 IRM family

7.6.2.3 IEC/EN 61850 – Substation Automation

IEC/EN 61850 is much more than just a communication standards but deals also with configuration, engineering testing for interoperability and data modelling in substations Figure A3: Overview on the EN 61850 family alongside related standards provides an overview on how the different parts interact wihle Figure A4: logical overview on 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 having a different model paradigm than the CIM, providing a tree-like structured 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 just introduces an new technical communication layer.

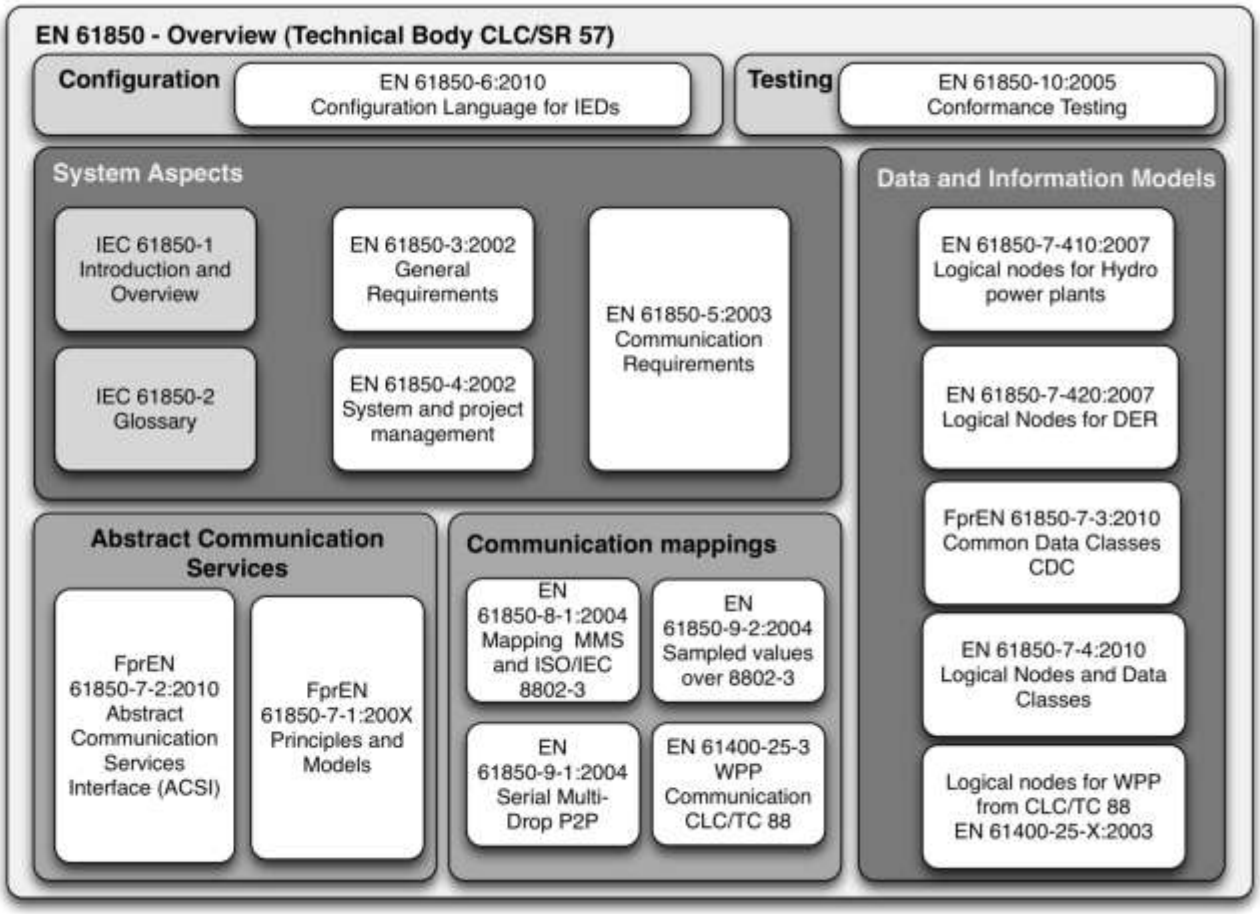


Figure A3: Overview on the EN 61850 family alongside related standards

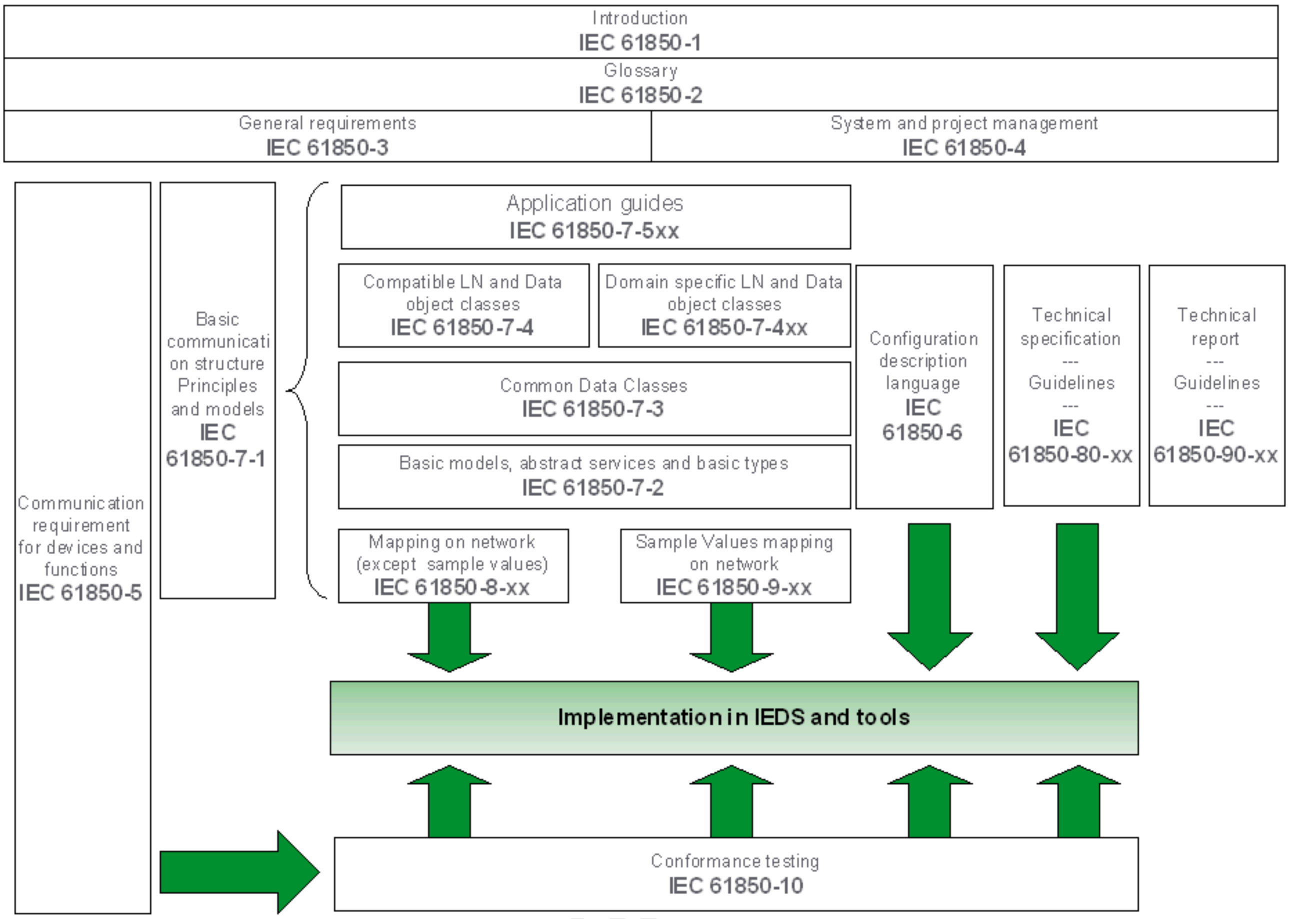


Figure A4: logical overview on IEC 61850 from edition 2 upcoming

The IEC SG 3 and the NIST Framework recommend the following parts :

- IEC/TR 61850-1 Ed. 1.0 English: Communication networks and systems in substations - Part 1: Introduction and overview, 2003.
- IEC/TS 61850-2 Ed. 1.0 English: Communication networks and systems in substations - Part 2: Glossary, 2003.
- IEC 61850-3 Ed. 1.0 Bilingual: Communication networks and systems in substations - Part 3: General requirements, 2002.
- IEC 61850-4 Ed. 1.0 Bilingual: Communication networks and systems in substations - Part 4: System and project management, 2002.
- IEC 61850-5 Ed. 1.0 English: Communication networks and systems in substations - Part 5: Communication requirements for functions and device models, 2003.
- IEC 61850-6 Ed. 1.0 English: Communication networks and systems in substations - Part 6: Configuration description language for communication in electrical substations related to IEDs, 2004.
- IEC 61850-7-1 Ed. 1.0 English: Communication networks and systems in substations - Part 7-1: Basic communication structure for substation and feeder equipment - Principles and models, 2003.
- IEC 61850-7-2 Ed. 1.0 English: Communication networks and systems in substations - Part 7-2: Basic communication structure for substation and feeder equipment – Abstract communication service interface (ACSI), 2003.
- IEC 61850-7-3 Ed. 1.0 English: Communication networks and systems in substations - Part 7-3: Basic communication structure for substation and feeder equipment - Common data classes, 2003.

- IEC 61850-7-4 Ed. 1.0 English: Communication networks and systems in substations - Part 7-4: Basic communication structure for substation and feeder equipment - Compatible logical node classes and data classes, 2003.
- IEC 61850-8-1 Ed. 1.0 English: 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, 2004.
- IEC 61850-9-1 Ed. 1.0 English: Communication networks and systems in substations - Part 9-1: Specific Communication Service Mapping (SCSM) - Sampled values over serial unidirectional multidrop point to point link, 2003.
- IEC 61850-9-2 Ed. 1.0 English: Communication networks and systems in substations - Part 9-2: Specific Communication Service Mapping (SCSM) - Sampled values over ISO/IEC 8802-3, 2004.
- IEC 61850-10 Ed. 1.0 English: Communication networks and systems in substations - Part 10: Conformance testing, 2005.
- IEC 61850-80-1 TS Ed. 1.0 E APUB: 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, 2008.
- IEC 61850-90-1 TR Ed. 1.0 E ACDV: Communication networks and systems for power utility automation - Part 90-1: Use of IEC 61850 for the communication between substations, 2008.

CENELEC has adopted the following parts (Also depicted in

Figure 5.1.4.1: IEC TC 57 Seamless Integration reference Architecture - IEC TR 62357)

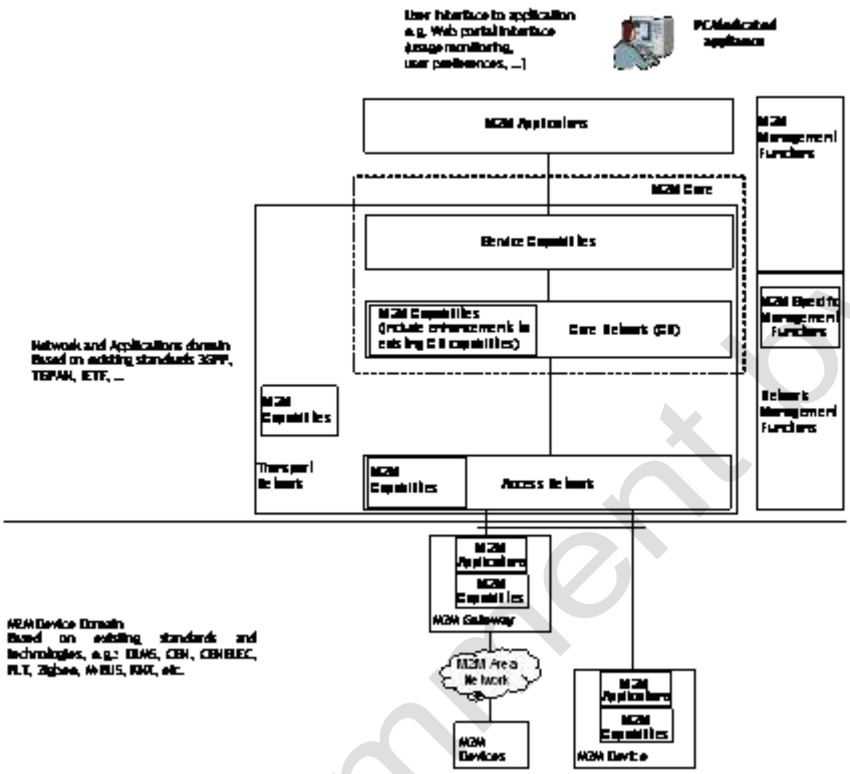
- EN 61850-3:2002 Communication networks and systems in substations - Part 3: General requirements
- EN 61850-4:2002 Communication networks and systems in substations - Part 4: System and project management
- EN 61850-5:2003 Communication networks and systems in substations - Part 5: Communication requirements for functions and device models,
- E 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 beginning of 2011.

Apart from the pure substation communication, models for DER (EN 61850-7-420) and WPP (CLC/TC 88 EN 61400-25-X) exist.

7.6.2.4 Data transport technologies

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.



7.7 Appendix 7A : References related to EMC/Power Quality in the range 2-150 kHz

IEC/EN 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 SC77A/CLC TC 210)

IEC/EN 61334-3-1 : Distribution automation using distribution line carrier systems –Part 3-1: Mains signalling requirements – Frequency bands and output levels (IEC TC 57/CLC 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 on 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)

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)

IEC/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 SC77A/CLC 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 IEC 61000-4-6.

IEC/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 SC77A/CLC TC 210)

Current scope limited to 9 kHz

IEC/EN 61000-4-6 : Electromagnetic compatibility (EMC) - Part 4-6: Testing and measurement techniques - Immunity to conducted disturbances, induced by radio-frequency fields (IEC SC77B/CLC TC 210)

Scope : above 150 kHz

IEC/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 SC77A/CLC 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)

IEC/EN 61000-2-12 : EMC - Environment – Compatibility levels for low-frequency conducted disturbances and signalling in public medium-voltage power supply systems (IEC SC77A/CLC 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/ CLC 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/ CLC 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.

IEC/EN 61000-6-1, Electromagnetic compatibility (EMC) – Generic standards – Immunity for residential, commercial and light-industrial environments (IEC TC77/CLC TC 210)

No requirement between 2 and 150 kHz

IEC/EN 61000-6-2, Electromagnetic compatibility (EMC) – Generic standards – Immunity for industrial environments (IEC TC77/CLC TC 210)

No requirement between 2 and 150 kHz

IEC/EN 61000-6-3, Electromagnetic compatibility (EMC) – Generic Standards – Emission standard for residential, commercial and light-industrial environments (CISPR/CLC TC 210)

No requirement between 2 and 150 kHz

IEC/EN 61000-6-4, Electromagnetic compatibility (EMC) – Generic Standards – Emission standard for industrial environments (CISPR/CLC TC 210)

No requirement between 2 and 150 kHz

CISPR/I/330/NP : Electromagnetic Compatibility of Multimedia equipment Immunity Requirements (CISPR/CLC 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.

SC205A/sec0260/R : Study Report on Electromagnetic interference between electrical equipment/systems in the frequency range below 150 kHz.

7.8 Appendix 7B: Standards related to Low Frequency EMC or Power Quality

EN 50160 : Voltage characteristics of electricity supplied by public electricity networks (CLC TC 8X)

IEC TR 62510 : Standardising the characteristics of electricity (IEC TC8)

IEC/EN 61000-2-2 : EMC - Environment . Compatibility levels for low frequency conducted disturbances and signalling in public low-voltage power supply systems (IEC SC77A/ CLC TC 210)

IEC/EN 61000-2-12 : EMC - Environment – Compatibility levels for low-frequency conducted disturbances and signalling in public medium-voltage power supply systems (IEC SC77A/CLC 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 SC77A)

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 SC77A)

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 SC77A)

Draft IEC TR 61000-3-14 : EMC - Assessment of emission limits for the connection of disturbing installations to LV power systems (IEC SC77A)

Draft IEC TR 61000-3-15 : EMC - Limits - Assessment of low frequency electromagnetic immunity and emission requirements for dispersed generation systems in LV network (SC77A)

IEC/EN 61000-4-30 : EMC - Testing and measurement techniques – Power quality measurement methods (IEC SC77A/ CLC 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 TC8)

IEC TR 61000-2-5(77/382/CD): Electromagnetic compatibility (EMC) – Part 2-5: Environment – Classification of electromagnetic environments

7.9 Appendix 8 - Generation

7.9.1 From high level services to use cases

Generation is involved in many high-level Smart Grid services as described in the matrix below.

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 devices	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 to network ancillary services: power flow and voltage control

Top-level services	N°	Main SG applications	Typical Generation application
	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	Idem 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 to 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 to the (active) Energy Market
	11	Participation of VPPs and aggregators in the electricity market	VPP can participate to 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 to islanding mode

7.9.2 Existing standards and gaps

<u>Standards : Interface to the Grid and Grid operation</u>

Uses Cases	Existing	Gaps	priority
All	IEC 61850[21] IEC 61400-25 IEC 61968-61970[22] IEC 60870-5 series IEC 62351	G1 : Harmonized glossary, semantic & modeling between back-office applications (CIM) and field applications (61850) G3 :Efficient and consistent communication means compatible with narrow bandwidth / intermittent communications G4 : Extended data modeling standard (part of IEC 61850) to have more complete description of generation elements (nuclear, hydro, DER, …), G5 : Extended data modeling 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)*	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 cluster (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

<u>Standards : Interface to the Energy market</u>

Uses Cases	Existing	Gaps	priority
All	IEC 62056	G7: Harmonization between DLMS/COSEM data model and IEC 61850/CIM	1
Make the Power generator dispatchable *(Enable the generator to participate to the energy market, including ancillary services)*		G8 : Extended field data modeling standard (part of IEC 61850) to support Demand-Response schema G9 : Extended field data modeling 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 to 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

1. ______________________

[21] 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,

22 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,

7.10 Appendix 9A - Transmission High Level Services : Details / Explanations

<u>a. Enabling the network to integrate grid users with new requirement.</u>

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 – uses cases:

- Facilitate connections at high voltages, in all locations for RES (including offshore 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 are 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 host 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 yet defined by national standard, also called grid code.

The necessity of grid code arose with the new context of market liberalisation 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 national experience and with some differences between countries.

Grid connection requirements are yet predominantly defined by specific national legislation and/or Grid Codes and by bilateral contracts between network operators and grid users. Now harmonisation is required by the 3rd 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 addresses 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 grid 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 yet 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 a need now for harmonised responses from system users across synchronous areas, to avoid or at least minimise the impact of widespread faults, in order to maintain security of supply and in line with the objectives of European policy.

The objective is hence to establish an appropriate minimum degree of standardisation 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 – uses 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 Phase Measurement Units (PMU) technologies-develop real time application.

Explanations:

The mission of Transmission grid is the transfer of electrical power from generation sources to the distribution areas, in 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 grid.

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, the Transmission has to face, this observability must be hugely enlarged.

An optimal representation and visualization as well as decision-supporting tools must be developed in order to support the operator of such complex systems. The massive amount of data must be transmitted, synchronized, analysed and represented in a way to safeguard the system integrity of the overall transmission net.

The combination of distributed generation with intermittent sources, long lines between generators and loads, and an increase in interconnections illustrate the new situation and emphasize the change for the observability challenge.

In order to maintain adequacy, security and quality levels, the new situation requires to know the state of the electrical system, more enlarged, with more accurately and quickly data than in the past, in order to precisely and timely identify critical contingencies, as well as to dispose as soon as possible the power network protection in case of systems faults or restoration in case of black-outs.

This enlargement concerns all the stakeholders of the electricity chain, from generation until end-users and through Transmission operators. Information exchange may be necessary across large geographical areas and across traditional systems operation boundaries.

The needs for a wider observability of the transmission grid are indicated below.

Enlargement between TSOs
More closely cooperation between European TSOs are encouraged by European legislation in order to develop methods and to take actions to improve system security of the European transmission grid, more and more meshed.

IT platforms for data exchange and performing 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 face their missions, TSOs need to ensure the suitable contribution of local resources to the global system security.

Virtual Power Plant (VPP) concept has emerged for a better management of distributed generation installations. VPP provides location-specific services to the network operators by aggregating local Distributed Energy Resources (DER).

Therefore VPPs appear as a new contributor in Transmission system with specific characteristics for the observability : frequency, voltage, power flow controls.

Enlargement with clusters of customers
Smart Grid initiative will encourage “end-users” for a more active participation in the electricity market.

As for DER, cluster of consumers should be introduced in order to optimize the management of the useful information. Nevertheless, new contributors will appear with an impact in the management of the global transmission grid.

To achieve this challenge, relevant information should be communicated to stakeholders and therefore the observability of Transmission system should be improved.

Optimising Grid operation and usage
In order to face the new challenges in a cost efficient way, TSOs need to improve the use of existing infrastructure.

Condition monitoring of components of a substation or of lines, provides technical information, useful for optimized loading and help 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 the observability is not limited to the hardware domain but also include the software aspect, and especially the data model for the 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-efficient way possible.
- Optimize the use of the present infrastructure.

Provider: Generators, DSOs, TSOs.

Primary beneficiaries: consumers.

Functionalities – uses cases:

- Monitor the contribution of the intermittent generation sources to the system security.
- Improve the methods and the knowledge on the real load capacity of assets in order to withstand load change without the replacement of assets.
- Implement new scheduling algorithms and decision tools (user interface, remedial action scenarios) at the control center level.
- Improve models for condition monitoring,
- Ensure the suitable contribution of local resources to the global system security.
- Consumer flexibility in ancillary services.

Explanations:
As the production of intermittent energy sources is not time-synchronized with the consumption, the management of the electricity supply-demand balance would be more complex with the development of new renewable energy sources.

Nevertheless, the development of RES must not jeopardise the security of supply of the whole system. Therefore contributions from grid users are expected, including also intermittent sources, in order to provide the useful ancillary services, key issue for the security of supply.

In relation with the development of RES, new investments in the Transmission grid are obviously required for the grid access. But the introduction of large scale renewable energy source and also the development of interconnections have indeed 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 a better knowledge on the real load capacity of assets should avoid some replacements.

Aging equipment, dispersed generation as well as load increase might lead to highly utilized equipment during peak load conditions. If the upgrade of the power grid should be reduced to a minimum, new ways of operating power systems have be found and established. New methods, mainly based on the efforts of modern information and communication techniques, to operate power systems, 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, capacity margins and, therefore, costs will be able to be optimised.

<ins>d. Planning of the future network.</ins>

Outcome: - Relevant architecture for 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 a 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 – uses cases:

- Enhance flexibility and controllability of power flows,
- Identify solutions for the 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 offshore wind farms.
- Improve asset management, maintenance and replacement strategies in order to take into account the requirement of new solutions.
- Adapt network simulation tools to new constraints (renewable integration, DC networks,…).
- Adapt the network for a 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 equipments 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.

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-efficient way possible.
Nevertheless, the architecture and the design of the transmission grid should change to take account for new constraints in a more efficient way.

The new constraints concern technical aspect (longer distance for connections, off-shore connections, ….), environmental aspect (high sensibility to environmental issues) and also system aspect (flexibility and controllability of load flows).
Nevertheless, the traditional challenges of Transmission grid are still valid for the future.

- Ensuring network operational security,
- Providing an optimal amount of network capacity,
- Minimising transmission losses,
- Minimising demand for ancillaries services,
- Guaranteeing satisfactory quality of electricity supply.

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.

Solutions exist yet :

- 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 grid.
- Phase shifting transformers,
- ….

But the deployment of the new solutions needs a 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 grid should grow for technical and economical reasons.
Nevertheless, DC technology is quite new in 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.

<u>e. Improving market functioning and customer service.</u>

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.

Primary beneficiaries: Customers, suppliers, networks operators.

Functionalities – uses 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 ancillaries services issue.

<u>f. Enabling and encouraging direct involvement of consumers in the energy usage.</u>

Outcome: Facilitate the active participation of all actors to the electricity market, through demand response signals and a more effective management of the 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 – uses 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 signal for grid users in order to avoid constraints in the grid.

Explanations:

With the 20-20-20 goals, changes in customer's behaviour are expected. Customers should be encouraged to modify their load profile according the constraints present in the electricity market.

In complement to the transmission development, Smart Grid should provide a solution to improve the management of the transmission load flow, by involving the consumers. Based on signals sent to the consumers, transformed in "prosumers", the increase of peak load could be at least reduced.

Moreover, the "operational security" or reserve providing by DER for ancillary services of transmission grid could also involved in the "pro-sumers" category.

In order to achieve this change of behaviour, TSOs should contribute to provide relevant information, data or signal to the grid users. Aggregators, like DSOs, should be an useful interface between distributed consumers and TSOs.

7.11 Appendix 9B – Transmission domain - 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.*
- IEC 60870-6 TASE-2,
- IEC 61400-25, *Communication for monitoring and control of wind power plants,*
- IEC 61850 *Communication networks and systems in substations.*
- IEC 61970 *Energy management system application.*
- IEC 61968 *Information model for DMS,*
- IEC 62357, *Power system control and associated communications – Reference architecture for object models, services and protocols.*

In equipment domain :

- IEC 61869 and IEC 60044-x *Instrument transformers*.
- IEC 62271-3 *High-voltage switchgear and controlgear – part 3 Digital interface based on IEC 61850.*

c. Grid security of supply and optimization

- IEC 60076-7, *Loading guide for oil-immersed power transformers.*
- IEC 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 of TSOs addressing the security of supply issue (for instance for 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

For on new technologies applicable to Transmission:

- IEC 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.*

- IEC 60700-1, Ed.1.2, *Thyristor valves for high voltage direct current (HVDC) power transmission – Part 1 : Electrical testing.*
- IEC 61954, Ed.1.1, *Power electronics for electrical transmission and distribution systems – Testing of thyristor valves for static VAR compensators*.
- IEC 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.*
- IEC 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 communication.*

To be completed.

f. Prosumers

To be completed after checking the list of other topics.

7.12 Appendix 9C – Transmission domain

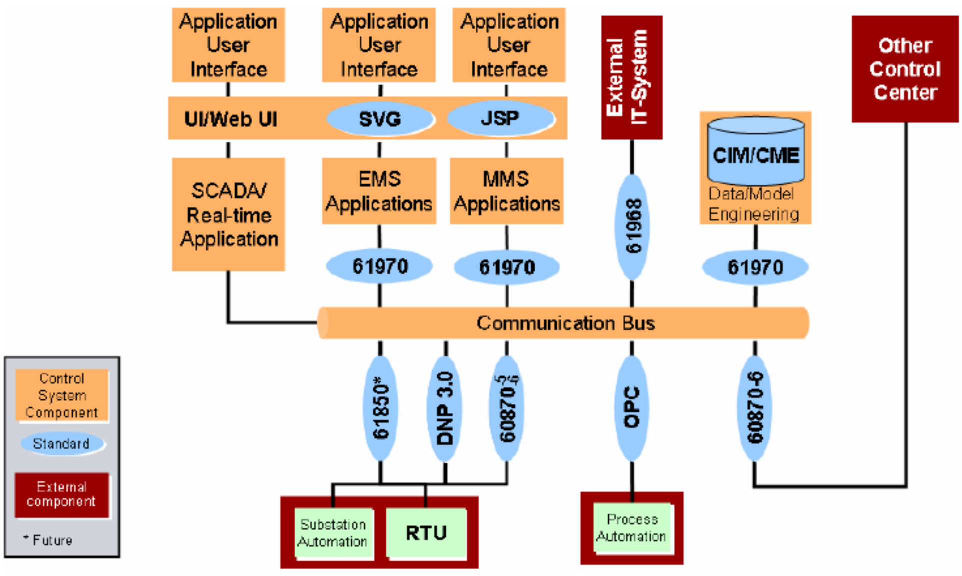


Figure 6 – Overview of advanced EMS architecture

The IEC 62357 Reference Architecture gives an overview (figure above) on the useful standards in the domain of interoperability for power utility.

7.13 Appendix 10 - Distribution High Level Services : Details / Explanations

a. <u>Enabling the network to integrate users with new requirements</u>

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 EV;
- 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. <u>Enhancing efficiency in day-to-day grid operation</u>

Outcome: Optimise 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 optimised asset maintenance activities based on detailed operational information.

Provider: DSOs, metering operators

Primary beneficiaries: DSOs, consumers.

Functionalities – use cases:

- Improved automated fault identification and optimal grid reconfiguration after faults reducing outage times:
  - using dynamic protection and automation schemes with additional information in presence of distributed generation;
  - strengthening Distribution Management Systems of distribution grids.
- Enhance monitoring and control of power flows and voltages.
- Enhance monitoring and observability of grids down to low voltage levels, even 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 information on actual active/reactive injection/withdrawals by generation and flexible consumption among DSOs and TSO.

c. <u>Ensuring network security, system control and quality of supply</u>

Outcome: Foster system security through an intelligent and more effective control of distributed energy resources, ancillary back-up reserves and other ancillary services. Maximise the capability of the network to manage intermittent generation, without adversely affecting 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 into account ancillary services.
- 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. <u>Enabling better planning of future network investment</u>

Outcome: Collection and use of data to enable more accurate modelling at LV level in order to optimise 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 DG, 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/forecasted network utilization.
- Additional information on grid quality performance and consumption made available by smart metering infrastructure to support network investment planning.

e. <u>Improving market functioning and customer service</u>

Outcome: Increase the performance and reliability of current and incoming new market processes related to e.g. billing, change of supplier and change of tenancy, through improved data and dataflows 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 EV.
- 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 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 to 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 signal 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.

7.14 Appendix 11 – Home and building automation

Extract of Standards, which defines profiles/services or functions in Home and Building Automation

Area	**Norm**	**Organisation**
HBES *(KNX)*	EN 50090 (CENELEC), VDE 0829-x (DKE), ISO/IEC 14543-3-x (ISO/IEC)	DKE 716 CENELEC TC 205 ISO/IEC JTC 1
BACS *(KNX)*	EN 13321	CEN
BACS *(LON)*	EN ISO 14908	ISO; CEN
HBES/ BACS *(neutral)*	EN 50491	CEN/CENELEC JWG TC247/TC205
BACnet	EN ISO 16484	ISO, CEN/TC247
UPnP	ISO/IEC 29341	ISO/IEC
Zigbee	IEEE 802.15.4	IEEE
Bluetooth	IEEE 802.15.1	IEEE