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EU Commission Task Force for Smart Grids

Expert Group 1:
Functionalities of smart grids and smart meters

Final Deliverable

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1. SCOPE AND MISSION OF THE DOCUMENT

The tasks and scope of work of the Expert Group 1 (EG1) of the EC Task Force for Smart Grids (TF) are defined on the basis of the Mission and Vision and Work Programme documents that were presented at the second meeting of the TF Steering Committee on 16th December 2009.

According to that, the key deliverable of the EG1 is the ***services and functionalities of smart grids*** together with initiatives related to ***standardisation*** with regards to a future smart grid mandate. The EG1 deliverable could be used as an input to the European Standards Organisations (CEN/CENELEC/ETSI). The work, taking into account stakeholder inputs from the group, considers the following topics:

- Smart Grids concepts and definitions (chapter 3).
- Need for smarter transmission networks (chapters 4 and 5).
- High-level services from Smart Distribution Grids (chapter 6).
- Functionalities of Smart Distribution Grids (chapter 7).
- Functionalities of Smart Metering Systems, highlighting that smart metering is a pillar for building a number of smart grids functionalities and focusing on mandate M/441 (chapter 8).
- State of the art of demonstration projects and industry solutions already available related to the above services and functionalities (chapter 9).
- Reference to the wide set of existing standards, codes and guidelines, and related to smart grid services and functionalities and the international activities for mapping them (chapter 10).
- Main areas where further efforts are needed (chapter 11).
- Concluding remarks and recommendations for next steps (chapter 12).

2. INTRODUCTION

<u>High-level drivers for smart grids</u>

Smart grids have an essential role in the process of transforming the functionality of the present electricity transmission and distribution grids so that they are able to provide a user-oriented service, supporting the achievement of the 20/20/20 targets and guaranteeing high security, quality and economic efficiency of electricity supply in a market environment. Their development will be facilitated by the wide-scale deployment of electricity smart metering, as envisaged in 3rd Energy Package, Directive 2009/72/EC.

As electricity network infrastructures are investments with long-term returns, they require a stable framework. All consequences of such targets must be clearly assessed. The work of EG1 is a step to clarify how the targets will determine functionalities for smart grids.

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. Massive renewable integration and power energy storage technologies will have to be deployed. Energy efficiency will have to be a general driving vector, demand will become an active player within the electrical system and the increasing electrification of transport (E-mobility or Electric Vehicles) 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.

Renewable generation will increasingly affect electricity networks. In particular, large wind farms (possibly offshore) will be connected to transmission networks; in addition, many distributed generation units, mainly fed by renewable energy sources (photovoltaic, small wind, biomasses, CHP) will be hosted by distribution networks, both at MV and LV levels.

The whole electrical system will have to develop in the most efficient way to address the new challenges and needs of its users. The future scenarios are based on the development of a sustainable energy model where the carbon emissions will have to drastically decrease, with massive renewable energy integration.

<u>Main assumptions and principles adopted by Expert Group 1</u>

In this report EG1 assumes that:

- Services and functionalities defined by EG1 are focused on electricity networks. While EG1 recognises that some smart grid concepts are likely to be applicable to gas, heat and other networks, such extensions have not been taken into account in the report.
- Transmission networks are considered to be already in a process of increasing their "smartness". As further discussed in chapter 3, "smartness" is here intended as a path to an economically efficient, sustainable power system with low losses and high levels of quality and security of supply and safety. Therefore, chapters 4 and 5 of this document summarise the current European policy framework for transmission and highlights the new needs for smarter transmission networks, coordination requirements and potential changes coming from their interaction with distribution networks.
- The document will essentially focus on MV and LV distribution networks. DSOs must take into account expectations of all users and actors in order to increase efficiency in grid operation and planning.
- Some smart grid functionalities will depend also on certain of the additional functionalities provided by smart meters. Indeed the latter will allow the full capabilities of a smart grid system to be realised and the two projects may share the same telecommunications system. For this reason, close co-ordination with the work currently being done within the M/441 mandate will be essential.
- Area network facilities (home, building, commercial and industry) and smart devices are not within the scope of EG1; however the interface between the smart grid and these facilities (signals and data needed for e.g. demand response and load control) is in the scope. Attention is being paid to standardisation in this area in the M/441 mandate work overseen by the Smart Meters Co-ordination Group (SMCG)[1]. While it is thus not necessary for the Smart Grid TF to cover this aspect in detail, it must particularly consider the issue of communication protocols to be employed in smart grid and smart metering systems and ensure the necessary services are available.
- Smart grid functionalities and services must not impose any specific market model; different market models are assumed in this report to be treated on equal basis.
- The report does not evaluate the business model of each service. The current demonstration projects will help to assess the economics of each service and the societal

[1] SMCG is tasked with supporting M/441 standardisation work in the general area of smart metering.

and environmental benefits (e.g. energy saving, efficiency) by a better knowledge of the costs.

- The acceptability of new services involving customers is not yet fully known. The demonstration projects will also help to evaluate the customers' feedback and interest. This will help to determine the precise target of the services and the final business models for such services.
- Smart grids will also help network operators and national regulatory authorities to focus network investment in the most efficient way. However, considering the aging European infrastructure, smart grids will not remove the need for significant DSO investment in traditional network renewal in the next years, according to the age of the present network.

3. SMART GRIDS CONCEPT AND DEFINITIONS

A Smart Grid is an electricity network that can cost efficiently integrate the behaviour and actions of all users connected to it – generators, consumers and those that do both – in order to ensure economically efficient, sustainable power system with low losses and high levels of quality and security of supply and safety ([5] [2] based on [6]).

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 mainly the grid's capability to handle more complexity than today in an efficient and effective way. 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 and options for how they use their supply.
- Significantly reduce the environmental impact of the whole electricity supply system.
- Maintain or even improve the existing high levels of system reliability, quality and security of supply.
- Maintain and improve the existing services efficiently.
- Foster market integration towards European integrated market.

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 grid participants are categorised in this report as follows:

- Network operators: transmission and distribution system/network operators (DSOs/DNOs).
- Grid users: generators, consumers (including mobile consumers), storage owners.
- Other actors: suppliers, metering operators[3], ESCOs, aggregators, applications and services providers, power exchange platform operators.

In most EU Member States, DSOs combine several roles, including network operators, metering operators (including data collection) and application and services providers (data clearing).

[2] Square brackets contain references listed in chapter 13.

[3] Depending on the national market model, the metering operators may be distribution companies, suppliers or meter companies.

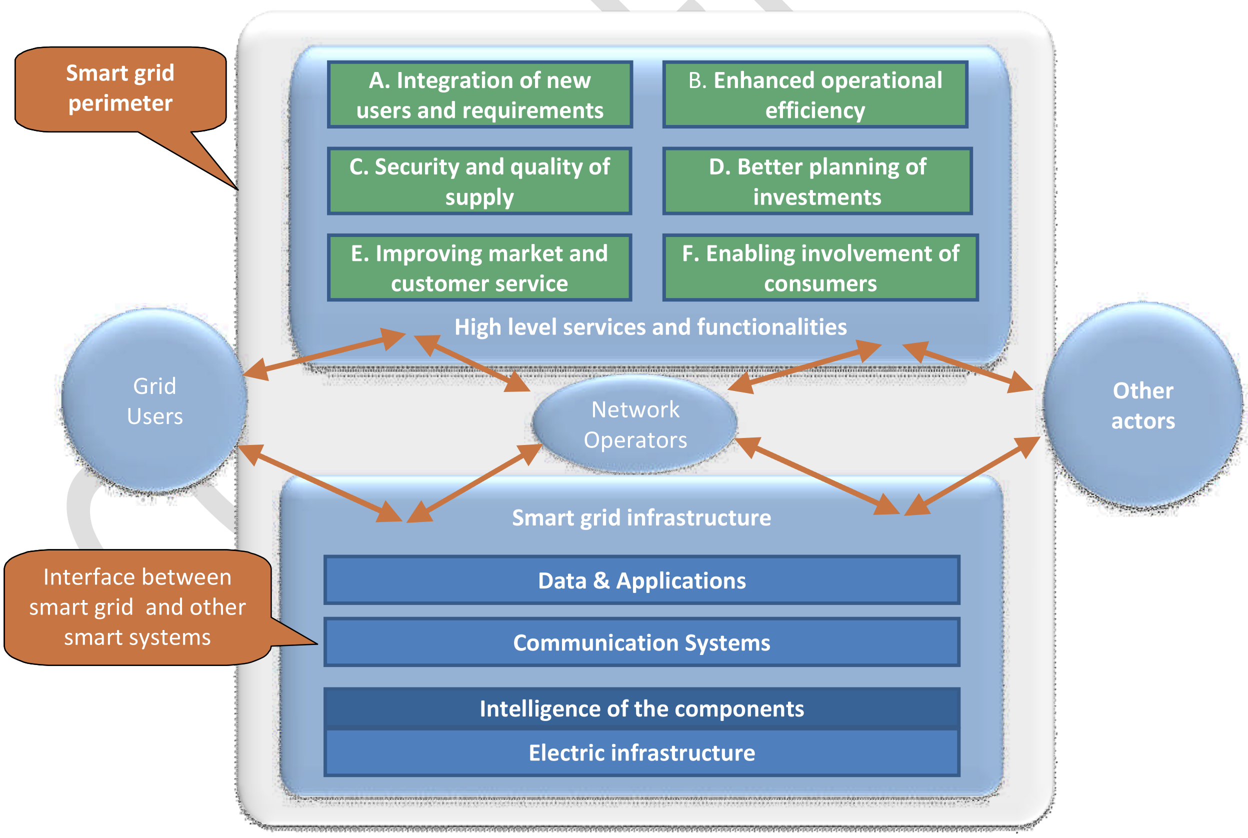
Conceptually, some smart grid participants provide services, based on a combination of functionalities, to other smart grid participants.

A smart grid service identifies, and can be commonly considered as, 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 a number of primary beneficiaries, recognising 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, which represent elementary bricks through which services can be implemented and delivered to beneficiaries. While some smart grids services are identified at this stage it is expected that new functionalities will be developed and may be deployed over time. The smart grids infrastructure shall provide enough flexibility for new functionalities to be deployed.

Chapters 6 and 7 develop a series of high-level services and functionalities that should be carefully taken into consideration for the deployment of smart grids. Deployment can be facilitated by the availability of standards, codes and guidelines (see chapter 11) covering the identified high-level services and functionalities.

The following drawing shows the inter actions between services and functionalities, actors and smart grids infrastructure.



4. OPTIMIZATION OF TRANSMISSION NETWORKS

Transmission network will have to be developed and enlarged, incorporating new technologies that give them the flexibility needed to accommodate new generation sources, their distributed nature and bi-directional flows. Interconnections, electricity corridors[4], the ability to control the power flows and storage systems will have to reach a mature stage before they can be put in place and so contribute to giving the system the necessary flexibility.

European energy policy sets out a clear path towards smarter transmission networks to achieve these objectives.

Directive 2009/72/EC identifies the responsibilities of transmission system operators (TSOs), including the submission to the regulatory authorities of a non-binding Community-wide 10-year network development plan, every two years. The Regulation (EC) 714/2009 mandate TSOs to cooperate at Community level through the ENTSO for Electricity. Among other tasks, the ENTSO for Electricity shall elaborate network codes for cross-border network issues and market integration issues related to 12 areas. As far as harmonisation and standardisation are concerned, these areas include data exchange rules and interoperability rules.

The technological innovation required is encouraged both by TSOs and by the regulatory authorities. Indeed, according to article 8 of the Regulation (EC) 714/2009, the ENTSO for Electricity shall adopt research plans and a yearly plan of research and development activities within the annual work programme[5]. Further, according to article 37.8 of the Directive 2009/72/EC, the regulatory authorities shall ensure that transmission and distribution system operators are granted appropriate incentive, over both the short and long term, to support the research activities related to increasing efficiency, fostering market integration and security of supply.

From the TSO perspective, research, development and demonstration activities related to smart grid solutions will allow the development and validation of advanced network technologies to improve system flexibility and security and delay future investments, prepare an investment plan for the network evolution in the long term, and enable the active participation of consumers and energy efficiency, within an innovative market place.

For the TSO perspective, the smart grid must consider the following effects and benefits:

- Increased transmission capacity of existing facilities based on close to real time system data.
- Improved real-time monitoring and controllability of the operational status of the system.
- Enhanced flexibility and controllability of power flows, also permitting increased transmission capacity.

[4] By Electricity corridor , EG1 means a set of electricity lines and facilities connecting regions or countries

[5] European Network of Transmission System Operators for Electricity published in March 2010 the first edition of its "Research and Development Plan", after a public consultation in the first months of 2010.

- Improvement of international coordination: in addition to the need for interconnection, the smart grid will foster the single European Market by designing e.g. cross-border balancing mechanisms and new options for congestion management.
- Mitigated the social and environmental impact of the transmission infrastructure.
- New methodologies and criteria for power system operation and planning, allowing the use of new technologies to be optimised and supporting cost-benefit analyses and impact assessments of new transmission infrastructures and smart grid solutions.
- Optimal integration of innovative transmission technologies within the existing transmission grid.

5. ENHANCED INTERACTION AND COORDINATION BETWEEN TRANSMISSION AND DISTRIBUTION

From the TSO perspective, strong coordination between transmission and distribution will be needed especially for issues concerning demand and operation but in general any distributed energy resource (small PV, EV, etc.), to ensure the suitable contribution of local resources to the global system security.

- Virtual Power Plants (VPP[6]): strong coordination is necessary on DG management (DERs and storage, the latter considered part of VPPs): for frequency control and system stability improvement (TSO), voltage control, better control the power flow, improving system security and network reliability (TSO & DSO). Utilisation of VPP is a resource to improve the power system control. VPP could be a source for the system operation (TSO & DSO).
- Demand Response: The integration of demand side management in TSO operations requires the development of specifications by TSOs for ensuring the successful contribution of active demand at system level, while DSOs (together with suppliers, energy service companies and consumers) will play a very relevant role in final implementation.
- Improved coordination in system security and emergency situations: defining common procedures, to designing more effective defence plans and managing the contribution of RES, DG and active demand during emergency situations throughout Europe, specifying the responsibilities of new actors towards the grid operators and the overall power system.

Smart grids will increase network flexibility by the development of additional intelligence (e.g.: temperature control of transformers, real time thermal monitoring of cables, etc*)* integrated within network equipments and will improve the existing communication systems. This will increase the current level of 'smartness' in the network, while optimising its operation and boosting its security.

Therefore it will be necessary to develop an adequate infrastructure for operation and control to provide scalable, adaptable and interoperable solutions.

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6 VPP: From the technical point of view it is an entity that provides location-specific services to the network operators by aggregating local DER. From the commercial point of view it offers services to the market or system operator. See also Annex A for more details.

6. HIGH LEVEL SERVICES OF SMART DISTRIBUTION GRIDS

<u>Smart grid services in the liberalised market</u>

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

A provider of a service is a participant that is responsible for such a service alone or in combination with other participants. Primary beneficiaries are participants that require or directly benefit from the services, recognising that the full benefits from these services are shared among a much wider group of participants.

<u>High-level services</u>

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 and storage) connected to the distribution network.

Provider: DSOs
Primary beneficiaries: Generators, consumers (including mobile consumers), storage owners.

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

Outcome: Optimise the operation of distribution assets and improve the efficiency of the network through enhanced automation, monitoring, protection and real time operation. 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: Consumers, generators, suppliers, DSOs.

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, aggregators, suppliers.
Primary beneficiaries: Generators, consumers, aggregators, DSOs, TSOs.

D. Enabling better planning of future network investment

Outcome: Collection and use of data to enable more accurate modeling of networks especially at LV level, also taking into account new grid users, 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: Consumers, generators, storage owners.

E. Improving market functioning and customer service

Outcome: Increase the performance and reliability of current market processes through improved data and data flows between market participants, and so enhance customer experience.

Provider: Suppliers (with applications and services providers), power exchange platform providers, DSOs, metering operators.
Primary beneficiaries: Consumers, suppliers, applications and services providers.

F. Enabling and encouraging stronger and more direct involvement of consumers in their energy usage and management

Outcome: Foster greater consumption awareness taking advantage of smart metering systems and 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, ability to integrate more intermittent generation.

Provider: Suppliers (with metering operators and DSOs), ESCOs.
Primary beneficiaries: Consumers, generators.

The only primary beneficiary which is present in all services is the consumer. Indeed, consumers will benefit:

- either because these services will contribute to the 20/20/20 targets
- or directly through improvement of quality of supply and other services

The hypothesis made here is that company efficiency and the benefit of the competitive market will be passed to consumers– at least partly - in the form of tariff or price optimisation, and is dependent on effective regulation and markets.

7. FUNCTIONALITIES OF SMART DISTRIBUTION GRIDS

As described in chapter 3, the delivery of smart grid services requires specific network functionalities. This chapter lists a series of functionalities grouped according to the high-level services identified in chapter 6. In some cases these functionalities could be broken down further into smaller sub-functionalities. However it is preferred to adopt this level of detail in order to:

- specify a limited number of items; and
- avoid the imposition of any specific market model with respect to other options, as a very detailed list could inhibit some business possibilities.

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

1. Facilitate connections at all voltages/locations[7] for all existing and future devices with SG solutions through the availability of technical data and additional grid information to:
    - o simplify and reduce the cost of the connection process subject to maintaining network integrity/safety;
    - o facilitate an ‘open platform’ approach – close to ‘plug & play’;
    - o make connection options transparent;
    - o facilitate connection of new load types, particularly EV;
    - o ensure that the most efficient DER connection strategies can be pursued from a total system perspective;
2. Better use of the grid for users at all voltages/locations, including in particular renewable generators.
3. Registers of the technical capabilities [8] of connected users/devices with an improved network control system, to be used for network purposes (ancillary services).
4. Updated performance data 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>

5. Improved automated fault identification and optimal grid reconfiguration after faults reducing outage times:
    - o using dynamic protection and automation schemes with additional information where distributed generation is present;

[7] Technical constraints permitting and according to the price signal.

[8] Network users/devices, in order to actively participate/be managed in network’s operations and energy management, must be characterised by adequate technical capabilities. Considering the active control and demand-response of Distributed Energy Resources (i.e. generators, controllable loads and storage) some of the most relevant technical capabilities that have to be taken into account are:

- Active – reactive power capabilities.
- Dynamic response.
- Electric storage capacity in terms of energy and power.

For example, referring to the renewable generators participation in the network voltage regulation or power flows control, the generator reactive power capability curve and the other capabilities aforementioned, are technical constraints that have to be managed.

- strengthening Distribution Management Systems of distribution grids.

6. Enhanced monitoring and control of power flows and voltages.
7. Enhanced monitoring and observability of network components down to low voltage levels, potentially using the smart metering infrastructure.
8. 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).
9. Identification of technical and non technical losses through power flow analysis, network balances calculation and smart metering information.
10. Frequent information on actual active/reactive injections/withdrawals by generation and flexible consumption to system operator.

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

11. Solutions to allow grid users and aggregators to participate in an ancillary services market to enhance network operation.
12. Improved operation schemes for voltage/current control taking into account ancillary services.
13. Solutions to allow intermittent generation sources to contribute to system security through automation and control.
14. System security assessment and management of remedies, including actions against terrorist attacks, cyber threats, actions during emergencies, exceptional weather events and force majeure events.
15. Improved monitoring of safety particularly in public areas during network operations[9].
16. Solutions for demand response for system security purposes in required response times.

D. <u>Better planning of future network investment</u>

17. Better models of DG, storage, flexible loads (including EV), and the ancillary services provided by them for an improvement of infrastructure planning.
18. Improved asset management and replacement strategies by information on actual/forecasted network utilization.
19. Additional information on supply quality and consumption made available by smart metering infrastructure to support network investment planning.

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

20. Solutions for participation of all connected generators in the electricity market.
21. Solutions for participation of VPPs in the electricity market, including access to the register of technical capabilities of connected users/devices.
22. 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;
23. Grid solutions for EV recharging:

[9] e.g.: control of access to the equipment, detection of fault on overhead networks, protection of the contents of the buildings.

- o open platform grid infrastructure for EV recharge purposes accessible to all market players and customers.
- o smart control of the recharging process through load management functionalities of EV.

24. Improved industry systems for settlement, system balance, scheduling and forecasting and customer switching.
25. Grid support to intelligent home/facilities automation and smart devices by consumers.
26. Individual advance notice to grids users for planned interruptions.
27. Customer level reporting in event of interruptions (during, and after event).

F. <u>Enabling and encouraging stronger and more direct involvement of consumers in their energy usage and management</u>

28. Sufficient frequency of meter readings, measurement granularity for consumption /injection metering data (e.g. interval metering, active and reactive power, etc).
29. Remote management of meters.
30. Consumption/injection data and price signals via the meter, via a portal or other ways including home displays, as best suited to consumers and generators.
31. Improved provision of energy usage information, including levels of green energy available at relevant time intervals and supply contract carbon footprint.
32. Improved information on energy sources.
33. Individual continuity of supply and voltage quality indicators via meter, via portal or other ways including home displays.

Further aspects are of paramount importance in smart grids deployment:

- Possibility of easy updating and implementation of new technologies.
- System stability, system security, continuity of supply and voltage quality[10] must be safeguarded. In the framework of national legislations, performance based regulatory incentive schemes are recommended.
- The introduction of tailored contracts (curtailment, quality of supply[11]) between users or their suppliers and the network operator is an opportunity to meet the preferences of some users.
- The publication and transparency of actual/expected performance of the grid are a means to foster performance improvements and to inform grid users.
- The presentation to consumers of electricity prices and grid tariffs with appropriate frequency that complements smart grid functionalities and integrates/improves high-level service F.
- Starting levels of network conditions and smart grids functionalities are country-specific. This must be taken into account in order to allow a cost-efficient development and a medium/long term common pattern towards smart grids.
- Consumer safeguards will need to be ensured according to the 3rd package. In this smart but complex world, particular consideration must be given to the impact on low income and vulnerable consumers.

In general it can be observed that the functionalities of smart grids are today at different level of development: in addition to basic grid functionalities there will be supplementary functionalities and emerging functionalities. As the process towards smart grids deployment will be a continuous learning process, some aspects need further investigation, e.g. the use and

[10] For continuity of supply and voltage quality the European standard in force is EN 50160 ratified in March 2010.

[11] For tailored contracts, existing standards (e.g. EN 50160) should be taken into account

deployment of microgrid control to allow for local distributed intelligence in managing local network balances. The smart grid infrastructure shall provide enough flexibility for new functionalities and services to be deployed.

8. FUNCTIONALITIES OF SMART METERING

Overview

Smart metering is covered by a specific Mandate by the Commission to the European Standardization Organisations (ESOs), within the framework of the following Directives:

– 2006/32/EC Directive on energy end-use efficiency and energy services.
– “Third Energy Package“ with requirements for intelligent metering of electricity and gas.
– 2009/72/EC Directive for the Internal Electricity Market (replaces 2003/54/EC).
– 2009/73/EC Directive for the Internal Electricity Market (replaces 2003/55/EC).
– 2004/22/EC Measuring Instruments Directive.

The general objective of the mandate (M/441) is “To create European standards that will enable interoperability of utility meters (water, gas, electricity, heat) which can then improve the means by which customers’ awareness of actual consumption can be raised in order to allow timely adaptation in their demands”.
The work undertaken in response to that mandate considers the high-level smart metering functionalities which are additional to the traditional metrological functions of electricity and other meters.

Thus the major focus of the M/441 work is the provision of improved information and services to customers and enabling customers to better manage their consumption.

However, in addition, in relation to electricity metering, there is a particular objective to facilitate smart grid applications. In such uses, the meter acts as a remote sensor, providing information relevant to grid operators, especially in the case of low voltage grids (< 1000 Volt).

The scale of smart meter deployment and their data capabilities offer the prospect for vast amounts of detailed data to be gathered. However in this context, the meter is only one of the sensors or actuators in a smart grid - other data will also be available and used by grid management and control systems.

Smart grids thus encompass a much wider area than smart metering, but smart metering is an important first step towards a smart grid:

- Smart meters bring intelligence to the “last mile” between the grid and the final customer.
- Without this key element, the full potential of a smart grid will not be realised.

Smart metering data

No attempt at increasing energy efficiency either through consumption reduction or load shifting will be successful without final customer involvement. In order to unlock this potential direct feedback is essential.

Smart Metering is the means for direct communication to the customer, and two-way communication is a necessary prerequisite.

In relation to the data from smart meters, some will be relevant to suppliers and their services to customers e.g. the provision of detailed consumption information. Some data will be only of interest to grid operators and other data will be relevant to meter operators (who – depending on the national market model – are distribution companies, or suppliers or independent meter companies). Certain data may be relevant to more than one party.

The deployment of smart meters thus prompts decisions at national level about the requirements of the various market participants, the nature of data (individual or aggregated) and how dataflows should be managed. Decisions in this area will reflect national market structures and industry systems, but they will also affect the commercial and customer services that smart meters will enable.

Smart meter functionalities

The current work being undertaken in response to the M/441 mandate has identified six high-level additional functionalities. In terms of level, these functionalities correspond to the high-level services identified in this report for EG1.

1. Remote reading of metrological registers and provision of these values to designated market organisation(s)
   This includes export metering (i.e. the provision of consumption and injection data and on net flows exported)

2. Two-way communication between the metering system and designated market organisation(s)
   This includes data which permits e.g. monitoring of supply quality, outages, identification of possible meter malfunction, tamper & fraud detection and diagnostics. It will enable remote configuration of the meter or meter parameters. In addition it will enable the metering system to receive messages both standard and ad hoc, e.g. on planned interruptions or price changes.

3. Meter supporting advanced tariffing and payment systems
   In addition to supporting prepayment or other payment options, this will permit multiple registers within the metering system or recording of interval reads.

4. Meter allowing remote disablement & enablement of supply
   This can be used in case of incidents and to help manage maximum capacity. It is also an aspect of the prepayment options noted above.

5. Communicating with (and where appropriate directly controlling) individual devices in the home/building
   This can be used to permit remote load management applications and demand side management. In association with smart appliances, it can potentially be used by the

customer (remote control of his own equipment), by the supplier (as a service to the customer) or by the network operator.

6. <u>Meter providing information via portal / gateway to an in-home/building display or to auxiliary equipment</u>
   By means of an information display or pc, the customer is able to view his consumption information and for the latter to be linked to other information services.

This list shows that the smart metering infrastructure can also support the development of smart grids through many of the additional functionalities.
Accurate measurement through smart metering is essential to building a new set of functions to support the smart grid. Again, the support for advanced tarification and payment enable utilities to manage the grid in close contact with their customers, by using pricing signal to reduce peak loads. Remote disablement and enablement of power supply gives an additional tool to enhance system reliability in critical load situations.
Information through home portals and gateways, or direct communication to other devices in home empowers customers to make choices about energy consumption.
Data collected through smart metering systems, that include consumption profiles, outage data, distribution network status can be further used for smart grid strategic planning, asset management and improvement, through data analysis and forecasting.

Load and small scale generation control

Of particular concern to all participants including the customer is the potential for the smart meter to be the gateway by which the electricity supply can be controlled remotely – either the entire supply (through remote disablement or load/small scale generation limitation) or individual appliances (e.g. through signals sent to chips in the equipment to effect load limitation or time-shifting). There is likely to be considerable industry debate about how this area of functionality is to be provided and this will have implications for the commercial, technological, industry and regulatory structures within which such services will be made available.

Use cases

Starting with these smart metering functionalities, a number of high-level use cases are being developed to support the M/441 standardisation activity, recognising these can be further analysed into more detailed use cases as required.

Those high-level use cases (as currently defined) which are relevant to smart grids (in whole or in part) include:

- Monitor supply disruptions: provision of information on supply interruptions.
- Monitor diagnostics of electrical components: detection of inconsistent metering results.
- Monitor meter system status: routine communications checking.
- Remote configuration: parameters for local generation set by network operator.
- Customer display unit receiving messages from e.g. the network operator.
- Communication related to multiple-rate tariffs within the meter: setting of tariff schedules.
- Remote connection/disconnection: local disconnection when emergency load exceeded.
- Remote power limitation.
- Load management by network operator (or supplier) as agreed by customer.
- Load management made available by customer.
- Meter interface to home communications systems.

- Meter interface to sophisticated energy management systems.

The standardisation work being undertaken by M/441 therefore covers both the communications and metering requirements for the above purposes insofar as they affect the smart meters and associated infrastructure to be deployed.

In addition, the standardisation work will cover the information likely to be required by meter operators in the management of their meter population.

Smart grid services

Smart grid services / functionalities / use cases for the Smart Grid Task Force project are still in the course of development.

On the assumption that the services and functionalities in section 6 and 7 above are a reasonable indication, the main smart grid aspects already being addressed via M/441 are:

- Improving market functioning and customer service (in part), in particular supporting the widespread use of distributed generation.
- Enabling and encouraging stronger and more direct involvement of consumers in their energy usage and improving customer service

In particular, the following functions that are of paramount importance for the implementation of smart grids are anticipated in the work being undertaken under M/441.

- M/441 will address the capability of smart meters to support import/export metering: i.e. the metering of active energy withdrawn/injected and reactive inductive/capacitive energy, and the provision of consumption and injection data and on net flows exported.
- The standards developed under the mandate will support time of use and dynamic pricing and, information display (including Time Of Use registers and display of dynamic pricing information[12]).
- The availability for the consumer of consumption/injection and other data via the metering system or web portal (e.g.: towards an in-house display or energy management device) will facilitate the adoption of home automation.
- A fundamental M/441 functionality is two-way communication with the meter (with appropriate data encryption and security), e.g. for meter reading and remote management of the supply, including disconnection/connection, demand reduction and changing contractual parameters (contractual power, price scheme, etc)
- Relevant information e.g. on quality of supply will be able to be communicated via the communication systems envisaged to support smart metering.

EG1 believes that smart grids functionalities as developed in use cases will facilitate appropriate feedback mechanisms on customers' electricity consumption to facilitate their decisions.
Functionalities identified for smart grids and smart meters must not be limited by smart metering solutions which use data concentrators.

[12]Dynamic pricing information is a use case that requires deeper investigation as It implies a frequent (e.g.: hourly) communication between the central system and all (or a very high number of) smart meters and metrology aspects such as the use of interval metering for billing purposes.

9. STATE OF THE ART OF DEMONSTRATION PROJECTS AND AVAILABLE INDUSTRY SOLUTIONS

Many demonstration projects are currently in place, and some results are already available.
In this chapter the main projects are summarised and cross referenced with the high level services defined in the previous chapters.

9.1. European initiatives

More information is given in the Annex B of this document. This does not replace however the more detailed information on the different projects, available by the different projects partners, also though specific websites.

By analysing the available information, some conclusions can be drawn:

- Demonstration projects are available whose results will cover a broad range of smart grid functionalities.
- Solutions are available as building blocks to suit most of the smart grid functionalities; however they are still lacking harmonisation in a “system” view.
- Standards are available to cover many smart grid functionalities. Analyses are being performed by several bodies (see chapter 10) to understand any overlap and gaps in such standards.
- Smart metering is a reality under the mandate M/441. Notwithstanding the different scope, smart metering provides support to some smart grid functionalities.

<table>
<tr><th>High level services</th><th>RD&D Projects (see also Annex B for more details)</th><th>T&D industry comments</th></tr>
<tr><td>A. <u>Enabling the network to integrate users with new requirements</u>
.</td><td>EEGI RD&D projects (1)
“Mobi-E” project (Portugal) (2).
“Wind demonstration project” ESB (Ireland) (6)
Orkney project. Scottish & Southern (UK) (9)
DG DemoNetz (AT) (15)
emporA (AT) (17)
OPEN NODE (EU) (19)
Quantification criteria (22)</td><td rowspan="2">Most of European network were designed to support conventional energy flows, with predictable energy production. T&D Industry can provide upgrade path to fulfil the proposed requirement, however large scale deployment leads to some in-depth change in distribution networks in order to keep efficient network protection, voltage control, reduced losses, fault detection and network reconfiguration.
Many T&D projects already provided parts of the answer.
Today's solutions such as
• Replacement/refurbishment of Power Components
• WAMS/WACS & Upgrading Protection and Control Devices for Communication
• Installation of Power Quality Devices (Distribution Networks)
• Deployment of all types of HVDC
• Installation of FACTS (Transmission Networks)
can provide measurable benefits
Harmonised data modelling and communication services are a must to let all these actors exchanging efficiently meaningful information.</td></tr>
<tr><td>B. <u>Enhancing efficiency in day-to-day grid operation</u></td><td>EEGI RD&D projects (1)
UK projects (4)
“Wind demonstration project” ESB (Ireland) (6)
DG DemoNetz (AT) (15)
ISOLVES:PSSA-M (AT) (16)
MetaPV (EU) (18)
FENIX (EU) + zUQde (AT) (20)
Quantification criteria (22)</td></tr>
</table>

C. <u>Ensuring network security, system control and quality of supply</u>	EEGI RD&D projects (1) E-Energy ICT-based Energy System of the Future Project (Germany) (5) “Wind demonstration project “ESB (Ireland) (6) GROW-DERS (8) DG DemoNetz (AT) (15) MetaPV (EU) (18) FENIX (EU) + zUQde (AT) (20) Quantification criteria (22)	T&D Industry is already very active in this field thanks to the availability of new standard such as IEC 61850. However this same level of modelling and interoperability for “secondary networks” is not available yet. Neither it is to embrace condition monitoring applications. Harmonizing and Extending the scope of existing standard (IEC 61850 and CIM, mainly) to this domain (secondary network) and application (conditioned monitoring) will certainly leverage the spreading of such solutions. Standardised real-time interface between all these actors is a condition to reach the objective on a large scale. Cyber Security must be addressed in priority by standards T&D Industry can efficiently contribute to fulfil the requirement, by acting as a communication path between DER, end consumers and market. It would be even more efficient if the communication infrastructure enabling all these transactions can be shared by the communication infrastructure used for monitoring and controlling the distribution network.
D. <u>Better planning of future network investment</u>	EEGI RD&D projects (1) ISOLVES:PSSA-M (AT) (16) Quantification criteria (22)	
E. <u>Improving market functioning and customer service</u>	EEGI RD&D projects (1) EDP INOVGRID (Portugal) (3) ADDRESS project (EU) (10) EcoGrid (DK – EU) (21) Quantification criteria (22)	
F. <u>Enabling and encouraging stronger and more direct involvement of consumers in their energy usage and management</u>	EEGI RD&D projects (1) “Connected Home /empowering customer choice” ESB (Ireland) (7) DEHEMS (11): BeyWatch (12) Smart-A (13) Energy@Home (14) Quantification criteria (22) 3e Houses project (23)	

9.2. Smart grids programmes in some other countries outside EU

Japan

Japan is aiming at reducing CO_2 emissions by 25% compared with the level in 1990.
As for the "smart grid," the next-generation power distribution grid, Japanese administration will be supporting it financially as soon as possible.
Japan’s existing electricity network is already considered to be reliable, and so Japan's objective is more focused – to enable further introduction of renewable energy and create a new infrastructure for EVs and new services through the utilisation of smart meters and ICT network.

METI’s 2009 projects included a ‘Remote Island Smart Grid Project’ (micro-grid project), a ‘Smart Charge Project’ (with a focus on EV), and a ‘Smart House Project’ (an element of ‘Community Grid system’). In November 2009 a discussion forum was established, involving a wide range of stakeholders, to facilitate discussion through various relevant study groups.

China

The China market is a very important market for smart grid. The requirements there are for a stronger and smarter grid with massive investments focused on increasing capacity, reliability, efficiency and integration of renewable.

End of 2008, the Chinese government approved a US $586 billion stimulus plan focused on large-scale investment in low-income housing, water, rural infrastructure and electricity in China. A secondary effect of this stimulus plan is to increase investment in renewable energy and energy efficiency in China. This effort would include accelerating efforts to achieve the goal of reducing China's energy consumption per unit of GDP by a cumulative 20% by 2010. One very promising approach for China to build energy conservation into its infrastructure is the construction of a "smart grid."

China’s overall federal stimulus investments in smart grid projects will surpass the United States’ in 2010: the Chinese government will spend $7.3 billion dollars in the form of stimulus loans, grants and tax credits compared to $7.1 billion by the United States government.

Korea

South Korea aims to build the world's first nationwide smart grid system to reduce its emissions by monitoring energy use more carefully.

The grid, to be set up by 2030, is part of the country's $103bn initiative to increase its generation of green energy from the current 2.4 % of total power to 11 % in the next two decades. According to a government-led committee, South Korea could lower its greenhouse gas emissions by 40 million tonnes annually with a national smart grid.

The committee's findings estimate that smart grids would reduce overall energy use by 3 % and lower the peak load for electric power by about 6 %. The electricity savings would be equal to the output of seven 1GW nuclear power reactors.

The committee comprises government officials, company executives and representatives and researchers. It did not provide a cost estimate for the project. Consumers could reduce their electricity bills by an average of 15 % by charging their appliances and cars during off-peak hours, as indicated through the use of smart meters. State-run electricity monopoly Korea Electric Power Corp plans to set up a $65m smart grid pilot project in the country's southern Jeju Island by 2011. It would act as a test-bed for the nationwide initiative. The grid will incorporate two 10MW substation transformers and four power distribution lines located near an area with 3,000 households, commercial districts and green energy facilities that include a wind farm.

US

The US view is that the Smart Grid concept for the electric power grid integrates digital computing, and communication technologies and services, with the power-delivery infrastructure, supporting sophisticated new energy-related applications. Some example new Smart Grid-enabled applications include real-time consumer control over energy usage; increased reliance on solar and other clean or renewable energy sources; controls for large-scale energy storage; mobile billing for charging electric vehicles; security for critical infrastructure protection and for privacy, and more.

Obama administration economic stimulus funding, measured in the billions of dollars, has launched or accelerated Smart Grid technology initiatives that are developing and implementing the new concepts. In late October 2009, President Obama announced 100 Smart Grid Investment Grant Program awards totalling $3.4 billion. This federal investment leveraged an additional $4.7 billion in commitments from private companies, utilities, cities, and other partners that are forging ahead with plans to install Smart Grid technologies and enable an array of efficiency-maximizing and performance-optimising applications. At the end of 2009, the number of Smart Grid projects in the United States exceeded 130 projects spread across 44 states and two territories.

A recent forecast projects that the U.S. market for Smart Grid-related equipment, devices, information and communication technologies, and other hardware, software, and services will double between 2009 and 2014—to nearly $43 billion.

Key US Public/Private Strategic Activities: the National Institute of Standards and Technology (NIST) Smart Grid Initiatives (May-November 2009) and the NIST Smart Grid Interoperability Panel (November 2009 to Present)

US law, in the form of the 2007 Energy Independence and Security Act (EISA), assigned the National Institute of Standards and Technology, a division of the US Department of Commerce, to coordinate development of a framework of standards for Smart Grid. See their website at www.nist.gov/smartgrid . The concern was that the US's 3600 utilities (power companies), and the 50 state and 3 territorial Public Utility Commissions that regulate them, could follow many different paths in implementing Smart Grid. The result could be a collection of solutions that did not interoperate, limiting value and reducing the opportunity for implementing innovations nationwide. A framework of standards for implementation would help to reduce the implementation paths to a manageable number, increasing market sizes, stimulating innovation, and speeding deployment by lowering prices and increasing reuse.

From May 2009, NIST gathered industry experts from utilities (power companies) and the ITC industry, as well as from regulators, in three massive meetings in May, June and August. These experts analysed communications and information technology applications for the Smart Grid, proposed use cases and architectures for the SG information networks, and identified industry standards needed to implement these architectures. This work resulted in a report published in January, 2010, titled *NIST Framework and Roadmap for Smart Grid Interoperability Standards, Release 1.0* (see http://www.nist.gov/public_affairs/ releases/smartgrid_interoperability_final.pdf).

In November 2009, to carry this work forward, and to shift much of the responsibility for it to the private sector, NIST launched a public-private partnership, the Smart Grid Interoperability Panel (SGIP). Since then, almost 500 companies and other organizations have joined the SGIP, with 1,350 individuals from member organisations participating in the panel's technical activities. Membership is open to organizations based outside the US as well.

Chief among the SGIP's technical activities are the 16 Priority Action Programs. PAPs are chartered to address areas in which standards require development or revision to complete the Framework. The PAPs gather experts from industry segments related to their charters. For example, PAP #1 (Internet) and PAP #2 (Wireless) are cooperating to quantify SG network requirements, and then identifying standard Internet and radio technologies that meet these requirements. The SGIP work occurs openly, visible in a TWiki website, http://collaborate.nist.gov/twiki-sggrid/bin/view/SmartGrid/WebHome .

In addition to the PAPs, the SGIP also hosts working groups on special topics, including one on Smart Grid security for both critical infrastructure protection and privacy, the Cyber Security Coordination Task Group. This 300-person TG has produced a draft report, *DRAFT NISTIR 7628 Smart Grid Cyber Security Strategy and Requirements*, at http://collaborate.nist.gov/twiki-sggrid/pub/SmartGrid/NISTIR7628Feb2010/draft-nistir-7628_2nd-public-draft.pdf . Finally, the SGIP is launching two new standing committees, on Architecture and on Testing and Certification.

The goal is to complete most strategic and study work by late 2010 and then to move to implementation of a US national, interoperable Smart Grid.

10. INTERNATIONAL INITIATIVES RELATED TO SMART GRID STANDARDISATION: STATE OF THE ART

At present there are many activities running in parallel which are related to the field of smart grid standardisation. Since these activities are relevant to the same subject, there is inevitably some overlapping and duplication of activity and opportunities for learning from the work of others.
Among these initiatives are:

- Smart Grids European Technology Platform
- M 441 Smart metering mandate
- OPEN meter project
- NIST Smart Grid mandate
- IEC Smart grid (SMB Strategic Group)
- IEEE Smart grid initiatives

10.1. SG ETP

The European Technology Platform is engaged *"to foster and support the deployment of SmartGrids in Europe advising and providing coordination to the various SmartGrids Forum stakeholders (European Commission, TSO, DSO, Energy System and Component vendors, Energy Research Centres, Smart Metering Industry, Energy Consumers, Utilities Telecom Providers, Grid Regulators) among projects and parallel related initiatives, to facilitate the smooth and efficient running of the European Technology Platform SmartGrids ensuring its strategic relevance and its consistency with EU policy*.
To link with relevant technology platforms dealing with energy matters that have an impact both at the generation and the demand side, on the future of the grid.
To provide relevant input to the EU initiatives such as SET-plan and its European Industrial Initiatives."

Work began in 2005. Its aim was to formulate and promote a vision for the development of European electricity networks looking towards 2020 and beyond.
In April 2006 the Advisory Council of the European Technology Platform (ETP) for Europe's Electricity Networks of the Future presented its Vision document for Smart Grids.
In the Strategic Research Agenda, published in 2007 it described the main areas to be investigated, technical and non-technical, in the short-medium term in Europe.
At the end of 2008, the first draft of this Strategic Deployment Document (SDD) was released. Today this document is formally finalised, and describes the priorities for the deployment of innovation in the electricity networks and the benefits that such innovation will deliver for all stakeholders. It also gives a timeline for deployment.

10.2. Smart Metering Mandate (M/441)

Smart metering is covered by a specific Mandate by the European Commission (M/441 Standardisation Mandate to the European Standards Organisations - ESOs). It is described in chapter 8 above and its results will ensure EU-level standards are available for a number of the core services to be provided by smart grids.

To this mandate are also linked standards relevant to home automation. In details these are CENELEC EN 50090 series to prepare necessary performance requirements and necessary hardware and software interfaces for all aspects of home and building electronics.

10.3. OPEN meter project

OPEN meter is a project supported by the European Commission's DG Research"[13], within the EU's Seventh Framework Programme. It has the main objective to specify a comprehensive set of open and public standards for advanced metering infrastructure (AMI), supporting electricity, gas, water and heat metering, based on the agreement of all the relevant stakeholders in this area, and taking into account the real conditions of the utility networks so as to allow for full implementation.

The scope of the project is to address knowledge gaps for the adoption of open standards for smart multi-metering equipments. All relevant aspects – regulatory, environmental, smart metering functions, communication media, protocols, and data formats – are considered within the project.

The result of the project will be a set of draft standards, based on already existing and accepted standards wherever possible. Existing standards will be complemented with new standards, based on innovative solutions developed within the project, to form the new body of smart metering standards. The resulting draft standards will be fed into the European and international standardization process. The project is closely coordinating with the Mandate M/441 initiative. This project officially started on 1st January 2009 and will be accomplished in 30 months, by 30th June 2011.

10.4. NIST Smart Grid Mandate

In 2009 the American Recovery and Reinvestment Act (the Stimulus Bill) directed National Institute of Standards and Technology to address Smart Grid. NIST had had a mandate under the Energy Independence and Security Act of 2007 (EISA).
It foresees a three phase approach:

- Identification of applicable standards / specifications.
- Resolution of "gaps".
- Creation of a conformance regime.

The number of selected standard is significant:

- Twenty-five standards / specifications selected.
- Fifty standards for "further study".
- Fifteen, (to be sixteen), "Priority Action Plans".

NIST focuses on the following issues:

- Demand Response and Consumer Energy Efficiency.
- Wide-Area Situational Awareness.
- Energy Storage.
- Electric Transportation.

[13] "Open" is an acronym for Open Public Extended Network

- Advanced Metering Infrastructure.
- Distribution Grid Management.
- Cyber Security.
- Network Communications.
- On January 25, 2010 NIST published the Framework and Roadmap for Smart Grid Interoperability Standards, Release 1.0: a conceptual reference model to facilitate design of an architecture;
- An initial set of 75 standards;
- Priorities for additional standards;
- Action plans for standards-setting;
- An initial cyber security strategy

10.5. IEC Smart grid initiative

A special group of the International Electro technical Commission IEC, namely Strategic Group 3 (SG3) was started in 2009.
The selected approach to standardisation foresees five phases:

- Identification of the individual parts and applications of the Smart Grid system.
- Definition of new requirements based on the above description.
- Mapping of existing standards to the requirements.
- Identification of gaps.
- Recommendations for IEC actions. (Filling the gaps / managing a standard framework).

The number of listed standards for consideration reached the impressive number of more than 100.

IEC SG3 focuses on:

- Interoperability.
- Transmission.
- Distribution.
- Metering.
- Connecting the consumers.
- Cyber Security.

The following investigation points are being addressed:

- Communication.
- Security.
- HVDC/FACTS.
- Blackout Prevention/EMS.
- Advanced Distribution Management.
- Distribution Automation.

- Smart Substation Automation.
- Distributed Energy Resources.
- Advanced Meter Infrastructure.
- Demand Response and Load Management.
- Smart Home and Building Automation.
- Electric Storage.
- Electric transportation.
- Condition Monitoring.
- General Topics: EMC, LV Installation, Object Identification, PPC, Engineering / Planning, Use Cases.

In the framework of harmonising standards and avoiding duplication of work, a significant initiative is the proposal by IEC SG3 to put in place a formal liaison between NIST SGIP and SMB SG3.

First conclusions can be summarized by the following key issue: to enforce use of concepts/methods from the horizontal committees:

- IEC 61850 and CIM suite of solutions across the entire portfolio framework.
- IEC 61850 (existing and extended) will be used for all communications to field equipment and systems,
- IEC 61970 and IEC 61968 will be used within control centres for managing information exchanges among enterprise systems.

10.6. IEEE Smart Grid

The IEEE is engaged in a number of smart grid initiatives globally.
IEEE P2030 is an IEEE project developing a "Draft Guide for Smart Grid Interoperability of Energy Technology and Information Technology Operation with the Electric Power System (EPS), and End-Use Applications and Loads"
The IEEE-SA P2030 guide will provide a knowledge framework for understanding and defining smart grid interoperability of the electric power system with end use applications, setting the stage for future standards related to the smart grid.

10.7. IETF Smart Energy activities

In addition to the IP protocol suite at large, the IETF created a set of activities pertaining to sensor technologies: 6Lowpan, roll. These activities are aiming at bringing the Internet Protocol to sensor and M2M devices needed to build a monitoring infrastructure for the Smart Grid. The IETF work is moving up the layers to introduce an HTTP equivalent for sensor devices (CoAP protocol). Recently the IETF created the smart grid directorate aiming at steering the different Smart Energy activities within the IETF

10.8. 3GPP and ETSI work on M2M

Both ETSI and 3GPP are working on M2M Technology which is believed to be a major building block for the Smart Grid as a means to deploy a wide scale monitoring and control infrastructure. ETSI M2M work aims at providing an architecture that allows the management of the sensor and M2M networks and the deployment of new services on top:

- Data collection and storage
- Communication mediation
- Lifecycle management (incl. software and firmware upgrade)
- Security

In addition ETSI M2M is specifying a set of enablers that will facilitate the deployment of the Smart Grid service layer such as compensation and billing or transaction management. These enablers will be exposed towards Applications through a set of specified and open interfaces.

On the 3GPP side work has been ongoing on the optimising of access and core network infrastructure to allow cost efficient delivery of M2M services. This work is aiming at increasing the scalability and cost effectiveness of the network taking into account fundamental characteristics of M2M communications such as:

- Stationary devices
- Small amount but frequent data transmission
- Different charging models,

ETSI is one of the organisational partners of 3GPP. In addition all 3GPP standards are transposed into ETSI standards once approved.

11. STANDARDISATION: RECOMMENDATIONS AND PRIORITIES FOR A STRATEGY TOWARDS SMART GRIDS DEPLOYMENT

EG1 believes that the scope of smart grids is large; thus the risk is that too many bodies work on this issue and that the priorities will not be precisely defined.

The challenge of smart grids deployment will require changes to existing standards, industry rules and processes. These changes are responsibilities of numerous bodies and levels according to Member States arrangements.

Road map

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

The road map 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 harmonisation of models and standards is highly desirable Technical standards have to be defined clearly and fast; if not the desired effect will not occur in the expected time frame. Due to this reason it is necessary to prioritise some key issues and define "fast track" solutions for the core set of standards (see below).

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

Standardisation methodology

Concerning standardisation, EG1 recommends a top-down approach in order to organise the priorities as proposed below:

1st level: Harmonise the Smart Grid use cases according to roles of each actor in Member States

- mandate one group to host and harmonise Smart Grid use cases in order to support that standardisation bodies are working on the same understanding;
- define one formalisation method of use cases;
- describe a common set of cross-cutting requirements into the standards to facilitate exchange of confidential and authentic information.

2nd level: Harmonise Smart Grid data modelling and description language

- common data modelling and description language will allow machine-to-machine understanding;
- an intermediate target could be to get formal and validated translation rules from one machine to another (including wording, semantic and grammar).

3rd level: Harmonise communication protocols

- if protocols are well structured[14], applications can be written in a way they are independent from the protocol:
  - one first step could be to harmonize an abstract definition of communication services;
  - a second step could be to validate mapping of this abstract communication services set on selected communication layers;

Standardisation area

[14] Well structured protocols should avoid that different constraints lead to different solutions.

An indicative list of possible items to address is shown below. Items are grouped according to the high level services identified in chapter 6.

A. Enabling the network to integrate users with new requirements

- Physical and electrical connections for generators and consumers;
- Physical and electrical connections for electrical vehicles;
- Physical and electrical connections for heat pumps;
- Physical and electrical connections for storage;
- Communication protocols for generators protection relays;
- Technical data and other grid information for the choice of optimal connection points;
- Service level interface specification for e.g. electrical vehicle, pumps, generators, etc

B. Enhanced efficiency in day-to-day grid operation

- Communication protocols for protection relays.
- Communication protocols for HV/MV Substation automation.
- Communication protocols for RTUs in HV/MV substations.
- Communication protocols for RTUs in MV/LV substations.
- Common and standardised quality indicators (e.g.: SAIDI, SAIFI, MAIFI weighted on LV consumers) with appropriate grouping rules for interruptions recording.
- Guidelines for maintenance and standardised indicators for unavailability of electrical elements.
- Guidelines for information to consumers about interruption restoration time.
- Guidelines for losses calculation.

C. Ensuring network security, system control and quality of supply

- Standardized data models for load flow analysis, short circuit analysis, selectivity analysis, distance protection, reliability analysis, etc.
- Communication protocols for dispatching and balancing services.
- Communication protocols for storage.
- Guidelines for generation forecasting.
- Grid codes for ancillary services, system balance, scheduling.
- Grid codes for interoperability rules.
- Grid codes and other codes for data exchange rules and settlement.
- Metering codes (part of the grid code focused on metering).
- Guidelines for improving monitoring of safety in public areas.
- Grid codes and defence plans.
- Grid codes for operational procedures during emergencies.
- Guidelines for cyber security.

D. Better planning of future network investment

- Standardised data models for planning.
- Telecommunication systems.

E. Improving market functioning and customer service

– Standards for communication with EV and loading stations.
– Procedures and interfaces for demand response/load control programmes.
– Procedures for switching.

F. Enabling and encouraging stronger and more direct involvement of consumers in their energy usage and management

– Communication protocols for smart metering systems, including interfaces towards home/building area networks (at all OSI levels, included data encryption, through each communication way - smart metering systems, other gateways, portal).

Common aspects for communication

Some common aspects can be highlighted, as of particular relevance in the area of smart grids communication :

- Standards for deploying a monitoring infrastructure (sensor and monitoring devices) as a means to manage and increase the reliability of the grid. These include communication mediation, gateway management, sensor life cycle management, data collection and storage, etc.

- Standards to optimise wireless and wire line telecommunication infrastructures for the delivery of M2M services including the monitoring infrastructure.

- Standards for ensuring quality of service (QoS) requirements on the communication networks are met in terms of delay, jitter and bandwidth. QoS is required by certain grid process such as teleprotection, failure detection, etc.

- Standards aiming at the exposure of service enablers towards Smart Grid Applications. These shall provide simple interfaces as a means to expedite the development and deployment of new applications making use of the Smart Grid service enablers.

- Standards aiming at specifying a set of service enablers for the Smart Grid to be used by Applications. These will include service enablers that facilitate electricity markets and other applications. Examples of such service enablers include compensation and billing, transaction management, etc.

Some priorities in the relevant standards to allow Smart Grids deployment

A huge set of standards relevant to Smart Grid is already available from different organisations; some of these standards are identified as core for any present and future implementation of Smart Grid.

Here below the standards identified as having core relevance are listed, other standards with high relevance also follow.

The complete list can be found in Annex C that includes all the standards of the families mentioned below, as well as other standards with relevance identified as low.

Standards identified as having Core relevance:

- IEC 62357 - Reference Architecture – SOA
- IEC 61970 - Common Information Model
- IEC 61850 - Substation Automation
- IEC 61968 - Distribution Management
- IEC 61970 - Energy management system application program interface (EMSAPI)
- IEC 62351 - Security
- IEC TR 62357 - Power system control and associated communications –Reference
- architecture for object models, services and protocols
- IEC 60870-5 Telecontrol

Standards identified as having High Relevance:

- IEC 60870-6 TASE2
- IEC/TR 61334 DLMS Distribution Line Message Specification
- IEC 61400 – Wind Turbines
- IEC 61850-7-410 Hydro Power
- IEC 61851 Electrical vehicle charging
- IEC 62051-54 and IEC 62058-59 Metering
- IEC 62056 COSEM

The main focus of activities in development are AMI (including standards of the families IEC 62051-62059; IEC/TR 61334); DER (e.g. IEC 61850-7-410: -420) and EV (e.g. IEC 61851). There are also areas that have not been traditionally matter for standardisation such as market and service systems.

The above analysis does not constitute a gap analysis; however it is indicative of the scope of work required and identifies new challenges for standardisation. This is then a key area to be developed with the cooperation of the relevant organisations.

Standards referring to data safety, data handling and data protection are considered in the EG2 report.

A key issue : Interoperability

A smart grid, and within that smart metering, 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, these components will need to be linked together. In this context, interoperability becomes of major importance, not least in the interest of ensuring greater competition.

Interoperability can be defined as the ability of a system or a product to work well with other systems or products. While there are many ways to achieve interoperability, one common way is via interface standards. A good example of this is the set of standards developed for the World Wide Web, including TCP/IP, HTTP and HTML, by which information is seamlessly exchanged over the Internet between devices of all sorts and brands, for the benefit of users and businesses.

Interoperability can be achieved through standardisation of communications in terms of interfaces, signals, messages and workflows. This does not mean unifying all data protocols or applications to a single technology but defining them in a detailed and unambiguous manner and agreeing on the usage and interpretation of standards in such a way as to ensure interoperability between systems and devices.

The introduction of smart grids and smart meters clearly requires the specification of an evolving interoperable framework to support secure communications both upstream and downstream of the meter as defined in the SMCG M/441 report.

Interoperability between devices and equipment is key, as the introduction of smart grids and smart metering should not create a barrier to competition or unnecessary cost.

- Upstream communications must be supported from the meter to the designated market organisation(s). In a smart power system, relevant information will be required to flow to a number of different actors for the requisite functionalities to be achieved

  At an individual level, remote meter reading will be able to be accomplished irrespective of the meter's type or kind, as long as it is a smart meter supporting standard telecommunication interfaces to be specified and agreed upon. What is then important is that the customer is able to choose a new supplier and continue to receive essential smart metering services without the need for the meter {at least) to be changed. Similarly there is a need to ensure that the customer is able to enjoy a comparable level of service after moving house.

- Downstream communications from the meter into the home are also needed in order to provide services for consumers through in-home displays or any other home automation device. This highlights the need for high level security and safety relevant to the distribution network. Interoperability shall consider compatibility between smart appliances, display and metering system. Switching energy supplier should normally not imply change of smart appliances.

There are numerous definitions of interoperability which could be adopted. For the purposes of this report, it is not envisaged necessary to go beyond a level of interoperability which is sufficient to meet the above objectives and which ensures that processes are seamless from the perspective of network operators, grid users and customers.

To facilitate economies of scale in the market, consideration should be given to relevant communications standards in use (or considered for use) elsewhere in Europe as well as to international developments in the standardisation market.

Some other guiding principles :

- Because of the large scope, of the size of the work, of the numerous bodies involved, it is necessary to :
  - Reuse existing standards and learn from existing initiatives

    - Several initiatives are already underway for developing the Smart Grid. The work being done by the relevant organizations, as described in chapter 10 to drive standards gap analysis and standards areas have to be taken into account.
    - In addition existing standards developments need to be fully taken into account
  - Adhere and seek the development of international standards: so as to help reduce product and investments costs.
  - Ensure and maximize collaboration and coordination among the different stakeholder organisations: Smart Grid work is clearly very wide in scope. Its development needs also a wide range of expertise. Ensuring a coherent set of standards will mandate a strong collaboration spirit both in the development of the roadmap as well as during the standards development process.

- Backward compatibility with the existing home installations should be taken into account.

- Streamline and speed-up the development of European requirements for Smart Grids: several activities are in place to standardise the Smart Grid. Ensuring a timely effective coordination and standards eco-system is urgently needed so that European requirements can be included in ongoing standards developments.

- Standardise applications enablers, but not applications: while some smart grid services are known, it is not possible to think of all possible services on top of the Smart Grid. In order to promote innovation, standardisation should focus on service enablers and avoid specification of technical solutions.

12. CONCLUSIONS AND FURTHER RECOMMENDATIONS

1. **EG1 identified the services that Smart Grids are expected to deliver** to different network users. The agreement of all stakeholders on that core is a priority. After validation by the Steering Committee, the **communication and the standardisation process** by DG ENER must be organised.

2. **Services and functionalities defined in the report represent the basis that smart grids are expected to offer to all electrical network users in Europe** over time. The implementation of the services allowed by functionalities must be deployed according to the present situation of each Member State, using a ranking method including a cost / benefit analysis for each implementation.

3. To this purpose **EG1 recommends that the level of deployment is assessed at National level**, taking also into account the initial status of networks and their "smartness". For each functionality defined by EG1, this assessment at national level should be based on criteria and indicators developed and recommended by EG3.

4. Furthermore EG1 believes that the process towards **smart grids deployment will be a continuous learning process,** therefore a transparent oversight of demonstration projects is fundamental to assess the current and future status of deployment for each functionality listed by EG1. This oversight should take advantage of project indicators, cost-benefit assessments and dissemination of results.

5. **Smart metering systems are a key factor** for including residential customers in the energy efficiency improvement process. However, **without such a programme, some Smart Grids functionalities can still be implemented,** for example for distributed generation connection, electric vehicle charging infrastructure, network monitoring and network automation.

6. Functionalities for smart metering systems as defined in **mandate M/441** include the necessary requirements for implementation of services on smart grids. **An update of this mandate is not necessary.**

7. **Transmission and distribution network operators** have their own programmes for implementing smart grids. However, **they must increase the level of coordination between them**: VPP management, demand response program, security of supply and emergency process are key issues for a successful coordination.

8. The **acceptability of new services by the customers** is a main concern, all opportunities for evaluating customers' interest must be used, specially involving them in **demonstration projects** planned or in progress in different Member States. This acceptability will be facilitated by a clear **confidentiality policy** concerning customers' data.

9. As smart grids and their benefits still represent broadly misunderstood concepts by most of end consumers, and as many initiatives related to smart grids or smart metering have created concerns and questions towards the usefulness and relevance of such developments, EG1 would recommend encouraging member states **to address communication and education of member states citizens and to develop a smart grid communication roadmaps** to:
    - o familiarise citizens with the EU 20/20/20 targets and the motivations behind those targets, in particular environmental motivations
    - o familiarise citizens with the operational and economic aspects of energy systems and how different technologies can positively impact energy use to achieve stated objectives
    - o familiarise citizens with the meaning of smart grids and how those will support different initiatives to make our energy supply systems and energy use more efficient, including the contribution of smart metering
    - o addressing identified concerns related to safety, security, privacy that many consumers may have expressed as well as the economic impact on their anticipated bills
    - o familiarising citizens with the proposed roadmap

10. **Demand response programmes** will represent a main part of energy efficiency approaches. **All types of customers must be involved in this process: industrial, commercial and residential** consumers. The focus of smart metering programs on residential users must not induce the demand response programme to be limited to houses and flats consumption.

11. As smart grids will increase the role of telecommunications in the electric system, **cyber security will become a major concern** and the dialogue between equipments outside and inside public network must be structured to exclude any possibility for external

equipment or actors to jeopardize the electric system entering into the electrical telecommunications system.

12. Particular care must be given to **defining the level of performance of the telecommunication infrastructure for smart grids** and smart metering systems, in relation to the real time level expected, its cost and its interest. The standardisation actors must define some reference levels corresponding to two or three performance levels for the whole system. Some uniformity between European actors is expected, especially to help the interaction between Transmission and Distribution.

13. Further aspects are of paramount importance in smart grids deployment:
    - Possibility of easy updating and implementation of new technologies.
    - System stability, system security, continuity of supply and voltage quality[15] must be safeguarded. In the framework of the national legislations, performance based incentive regulatory schemes are recommended.
    - The introduction of tailored contracts (curtailment, quality of supply) between the users or their suppliers and the network operator is an opportunity to meet the preferences of some users.
    - The publication and transparency of actual/expected performance of the grid are a means to foster performance improvements and to inform grid users.
    - While some smart grid services are known at this stage it is expected that new services will be developed and deployed over time. The smart grid infrastructure shall provide enough flexibility for new services to be deployed.

Specific recommendations on **standardization issues** are highlighted:

14. EG1 believes that the scope of smart grids is large, thus the risk is that too many bodies work on this issue and that the priorities will not be precisely defined. It is necessary to **ensure and maximize collaboration and coordination among the different stakeholder organisations.** The different domains (Energy Market, Transmission and Distribution, DER, E-Mobility) need to define common interfaces through telecommunication and service standardised and interoperable architectures.

15. According to this a harmonisation of models and standards is necessary. Technical standards have to be defined clearly and quickly; due to this reason it is necessary to prioritize some key issues and define “fast track” solutions for the core set of standards.

16. Models, 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.

17. Standardisation work is necessary for an efficient and fast smart grid implementation, but considering that the impact of smart grid is not only technical, but more on the services and the process linked to, **the involvement of all actors working on codes, rules and global regulation is quite important.**

[15] For continuity of supply and voltage quality the European standard in force is EN50160 ratified in March 2010.

18. **Interoperability between systems is an expectation from all the industrial actors**. Standardisation actors must take that requirement into account. However they must be careful not to restrict innovation and competition by an excessive level of requirements.

19. The **standardisation of the interface between the wide area network and the HAN is a key issue**, including protocols, messages and workflow. This interface will be the gateway between electrical system and home equipments. To facilitate the development of new functionalities in these equipments, the interface must be precisely defined via M/441 in order to fulfil the service performance level required by end users and in-house appliance manufacturers.

20. Concerning **standardisation methodology, EG1 recommends a top-down approach** in order to organise the priorities:
    - 1st level: Harmonise the Smart Grid use cases to roles of each actor in Member States
    - 2nd level: Harmonise Smart Grid data modelling and description language
    - 3rd level: Harmonise communication protocols

    The reuse of existing standards is a priority.

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ANNEX A – LIST OF ABBREVIATIONS AND DEFINITIONS

List of abbreviations

Term	Definition
3GPP	Third Generation Partnership Project
AMI	Advanced Metering Infrastructure
CEN	European Committee for Standardization Comité Européen de Normalisation
CENELEC	European Committee for Electrotechnical Standardization Comité Européen de Normalisation ÉLECtrotechnique
CHP	Combined Heat and Power
CIM	Common Information Model
CoAP	Constrained Application Protocol
COSEM	COmpanion Specification for Energy Metering
DER(s)	Distributed Energy Resource(s)
DG	Distributed Generation
DG ENER	Directorate General Energy
DLMS	Distribution Line Message Specification
DNO(s)	Distribution network operator(s)
DSO(s)	Distribution system operator(s)
EC	European Commission
EEGI	European Electricity Grid Initiative
EG1	Expert Group 1 (of the Task Force)
EG2	Expert Group 2 (of the Task Force)
EG3	Expert Group 3 (of the Task Force)
EIA DOE	Energy Information Administration (US) Department of Energy
EISA	(US) Energy Independence and Security Act
EMC	Electromagnetic compatibility
EMS	Energy management system
EN	European Norm
ENTSO for Electricity	European Network of Transmission System Operators for Electricity
EPRI	Electric Power Research Institute
ERGEG	European Regulators Group for Electricity and Gas
ESCO(s)	Energy Service COmpany(ies)
ESO(s)	European standardisation organisation(s)
ETP	European Technology Platform
ETSI	European Telecommunications Standards Institute
EU	European Union
EV(s)	Electric vehicle(s)
FACTS	Flexible alternating current transmission systems
FERC	US Federal Energy Regulatory Commission
HAN	Home Area Network

Term	Definition
HTML	HyperText Markup Language
HTTP	Hyper Text Transfer Protocol
HV	High Voltage
HVDC	High Voltage Direct Current
ICT	Information & communication technology
IEC	International Electrotechnical Commission
IEEE	The world’s largest professional association for the advancement of technology - former Institute of Electrical and Electronic Engineers
IETF	Internet Engineering Task Force
IP	Internet Protocol
IT	Information technology
LV	Low Voltage
M2M	Machine to Machine
MAIFI	Momentary average interruption frequency index
MV	Medium Voltage
NIST	National Institute of Standards and Technology
OSI	Open Systems Interconnection
PPC	Product Properties and Classification
PV	Photovoltaic
R&D	Research and development
RES	Renewable energy sources
RTU	Remote Terminal Unit
SAIDI	System average interruption duration index
SAIFI	System average interruption frequency index
SET-Plan	Strategic Energy Technology Plan
SG3	(IEC) Strategic Group on Smart Grid
SGIP	Smart Grid Interoperability Panel
SMB	(IEC) Standardization Management Board
SOA	Service-Oriented Architecture
T&D	Transmission and distribution
TCP	Transmission Control Protocol
TF	Task Force
TR	Technical Report
TSO(s)	Transmission system operator(s)
VPP(s)	Virtual Power Plant(s)

Definitions

Aggregator (with dispatching service functions of DER)
Market participant purchasing/selling electricity products on behalf on two or more consumers/generators/DERs.

AMI - Advanced Metering Infrastructure [9]

Infrastructure which allows two way communications between the Head-End data collection system and the meter(s) and other in-house devices. This infrastructure enables alternative ways of data collection and implementation of mechanisms for remote control of in-house devices. It consists of systems, communication devices and communication networks.

Ancillary services (from FERC order 888-A, April 1996)
Those services that are necessary to support the transmission of capacity and energy from resources to loads while maintaining reliable operation of the Transmission Service Provider's transmission system in accordance with good utility practice. FERC Order 888 identified the following six ancillary services to be included in an open access transmission tariff:

- Scheduling, System Control and Dispatch Service;
- Reactive Supply and Voltage Control from Generation Sources Service;
- Regulation and Frequency Response Service;
- Energy Imbalance Service;
- Operating Reserve - Spinning Reserve Service;
- Operating Reserve - Supplemental Reserve Service.

FERC Order 888 does not preclude the transmission provider from offering voluntarily to provide other interconnected operations services to the transmission customer along with the supply of basic transmission service and ancillary services.
During the consultation process towards Order 888, NERC proposed interconnected operations services were 12 as follows:

- system control and dispatch services;
- accounting;
- regulation service;
- energy imbalance service;
- frequency response service;
- backup supply service;
- operating reserve service: spinning reserve and supplemental reserve services;
- real power loss service;
- reactive supply (from generation resources) and voltage control service;
- restoration service;
- facilities use;
- reactive supply (from transmission resources).

Application and service provider
Provider of applications and services in the Information and Communication Technology world.

CoAP = Constrained Application Protocol (Source IETF).
A specialized transfer protocol for use with constrained networks and nodes for machine-to-machine applications such as smart energy and building automation.

Demand Response (by FERC)
Changes in electric usage by end-use customers from their normal consumption patterns in response to changes in the price of electricity over time, or to incentive payments designed to induce lower electricity use at times of high wholesale market prices or when system reliability is jeopardized.

Demand Side Management (from EIA DOE)
The planning, implementation, and monitoring of utility activities designed to encourage consumers to modify patterns of electricity usage, including the timing and level of electricity

demand. It refers to only energy and load-shape modifying activities that are undertaken in response to utility-administered programs. It does not refer to energy and load-shaped changes arising from the normal operation of the marketplace or from government-mandated energy-efficiency standards. Demand Side Management covers the complete range of load-shape objectives, including strategic conservation and load management, as well as strategic load growth.

DNO - Distribution Network Operator [9]
Organization responsible for managing the electricity network supplying the grid users premises.

DSO
Distribution System Operator: organization owning distribution assets and acting as DNO.

ESCO – Energy Service Company
Market participant offering new contract based products to consumers based on their individual usage pattern of energy (e.g. related to demand response, energy efficiency, etc.)

Metering operator [9]
Entity which offers services on a contractual basis to provide, install and maintain metering equipment related to a supply. The contract may be with the customer, the supplier or the DNO/DSO. The meter may be rented to, or owned by, the customer.

Microgrids (from More Microgrids Project)
Interconnection of small, modular generation to low voltage distribution systems forms a new type of power system, the Microgrid. Microgrids can be connected to the main power network or be operated islanded, in a coordinated, controlled way.

Power exchange platform operator
Operator that provides a market place for trading in physical and financial contracts within defined country or region.

Smart meter [9]
Meter with extra functionality allows the meter to collect usage data and transmit this data back to the via the AMI. Load control and tariff management are also examples of possible extra functionality. The Smart Meter has provisions for a consumer interface that enables the consumer to monitor energy usage .

Smart metering system
System including AMI, smart meters, data concentrators, central system and other devices/systems/interfaces suitable to exchange metering information among all market participants.

Virtual Power Plant – VPP (Source - EU Project FENIX)[16]
A Virtual Power Plant (VPP) aggregates the capacity of many diverse Distributed Energy Resources (DER), it creates a single operating profile from a composite of the parameters characterizing each DER and can incorporate the impact of the network on aggregate DER output. There are two types of VPP, the Commercial VPP (CVPP) and the Technical VPP (TVPP).

[16] See also the definition of aggregator.

Commercial VPP (Source - EU Project FENIX)
A CVPP has an aggregated profile and output which represents the cost and operating characteristics for the DER portfolio. The impact of the distribution network is not considered in the aggregated CVPP profile.
Services/functions from a CVPP include trading in the wholesale energy market, balancing of trading portfolios and provision of services (through submission of bids and offers) to the system operator. The operator of a CVPP can be any third party aggregator or a Balancing Responsible Party (BRP) with market access; e.g. an energy supplier.

Technical VPP (Source - EU Project FENIX)
The TVPP consists of DER´s placed in the same distribution network region. The TVPP includes the real-time influence of the local network on DER aggregated profile as well as representing the cost and operating characteristics of the portfolio.
Services and functions from a TVPP include local system management for Distribution System Operator (DSO), as well as providing Transmission System Operator (TSO) system balancing and ancillary services. The operator of a TVPP requires detailed information on the local network.

ANNEX B - RESEARCH PROJECTS IN THE FIELD OF SMART GRIDS

(1) EEGI Research, Development and Demonstration (RD&D) projects:

The European Electricity Grid Initiative (EEGI) has proposed a 9-year European research, development and demonstration (RD&D) programme, initiated by electricity transmission and distribution network operators, to accelerate innovation and the development of the electricity networks of the future in Europe. The initiative has been launched as a European Industrial Initiative at the SET Plan conference in Madrid on the 3rd of June 2010.

The cost of the entire program is estimated at 2 B€ covering the expected participation of regulated networks, market players, research centres and universities. It does not cover the costs of deploying the solutions across Europe. A detailed implementation plan is also provided, covering priority projects that should start urgently, in the period 2010-2012. The investment in the priority projects is estimated at 1 B€ to cover their full duration.

The proposed RD&D programme focuses on system innovation rather than on technology innovation, and addresses the challenge of integrating new technologies under real life working conditions and validating the results. The demonstrations of new developments will allow evaluating their benefits, estimating their costs, and preparing scaling up and replication for an accelerated take-up by all network operators.

A set of functional projects has been defined, covering the main functionalities of the Smart Grids that need to be developed and tested to prepare for the deployment of Smart Grids at European level. Each functional project includes a description of the demonstration and/or research activities needed to reach specific functional goals.

The proposed approach takes into account the diversity of existing network architectures, operations and national regulations which constrain network performances all over EU27.

The functional needs described can be served by one or more competing technology-based solutions to meet the same needs. This is why the corresponding RD&D projects have been expressed in functional terms leaving the room to competing RD&D proposals to deliver the required knowledge. Program management at European level will ensure that an appropriate number of projects are launched to cover different local conditions and competitive solutions and to meet the needs of each set of requirements in the functional projects.

I.- Projects dealing with joint TSO-DSO issues over the period 2010-2018:

1.- Increased observability of the electric system for more efficient network interactions
- Use of metering data to deliver DG footprints
- Use of simulation models in substations to identify the state of the system
- Data exchange between TSOs and DSOs to better manage imbalances
- Validation of the SMART GRID data exchange conceptual model for current operations

2.- The integration of Demand Side Management in TSO operations
- The TSO planning tools at pan-European level integrate local active demand data
- Demand Response programs are implemented on a wider scale

3.- Further integration of decentralised generation and storage

- Aggregation of loads and distributed generation to manage imbalances and to provide ancillary services to the system
- System services are provided by DER units at DSO level (voltage control and reactive compensation)
- Coordinated congestion management between TSOs and DSOs

4.- Improved defence and restoration plans

- Validation of the SMART GRID data exchange conceptual model for emergency operations

II.- Projects on DSOs' issues over the period 2010-2018:

1.- Active Demand Response

- Peak shaving and energy saving with a full range of incentives encompassing:
  - Real-time price signals
  - Application of time-of-use tariffs
  - Possibility of visualizing and controlling their own power consumption using the latest technology

2.- Energy efficiency coming from network integration of Smart Buildings

- Promoting energy efficiency by integrating energy management systems, home appliances and the Home Automation Network within the local electricity distribution network

3.- Metering infrastructure

- Finding common, open standard solutions for Identifying and overcoming regulatory, technological and economic barriers
- Proposing solutions that can enable a full roll-out of smart metering systems in Europe at more affordable costs
- Expanding the number of clients that will be metered with the same technology

4.- Smart Metering data processing

- Evaluating new business cases when using metering data
- Metering as an enabler for the integration of future renewable energy sources (RES)

5.- DSO integration of small renewables

- Proposing new network design criteria which extend network hosting capacity while still leading to secure operations and high power quality
- Proposing improved connection criteria
- Addressing grid protection issues with specifications towards manufacturers

6.- System integration of mid-size renewables

- Designing and demonstrating new solutions for medium-scale integration
- Increasing the grid hosting capacity for intermittent renewable energy sources
- Validating active, real-time network management for large-scale integrated management of distributed generation

7.- Integration of storage technologies in network management

- Contributing to active, real-time, large-scale integration of storage in conjunction with renewable energy sources and electric vehicles

- Storage integration to obtain a flattening of the load curve and increased power quality
- New knowledge on which storage solution appears the most effective and efficient at a system level

8.- Infrastructure to host electric vehicles

- Proposals to implement an extended electricity recharge infrastructure in order to both enable the easy, secure and flexible recharging of EV and PHEV and boost and foster EV-PHEV penetration in Europe
- Regulatory recommendations to support EV/PHEV penetration
- Tariff scheme to act as an enabler and incentive to promote nightly recharging when energy costs are lower
- Business models related to EV recharging (Energy Suppliers will benefit from the project by extending their offers and including EV energy special contracts)
- Impacts on the grid, testable via a clustered and enlarged set of EV cars recharging simultaneously

9.- Improved planning, monitoring and control of LV networks

- Mass-production of low-cost devices that allow proper monitoring of the LV network
- European standards for such monitoring and control
- More efficient network architectures leading to more effective outage management, load control, load modelling and data exchanges
- Network regulatory schemes based on reliability and quality of power supply

10.- Automation and control of MV network

- MV Advanced network control functions to allow for self-healing grids
- Mobility Tools
- Targeted, preventive maintenance

11.- Methods and system support

- Revamping programs of IT solutions over the MV and LV life cycles, based on policy definition and implementation of the upgrades using new asset management approaches
- Targeted preventive maintenance (power and IT systems)
- Improving the development of renewables in MV and LV networks
- Improvement renewables forecasting

12.- Integrated communication solutions

- Promoting the IP standard in the industry (product and application supplier for electricity network, including supervision and control solution providers)
- Maximising efficiency of electricity infrastructure operations
- Enabling new services requiring broadband and real time interaction between grid components
- Enabling information exchange between DSOs and TSOs, so improving Electric System security and reliability
- Achieving sustainability of IT solutions (including cyber security and life time management)

(2) “Mobi-E” project (Portugal)

Project promoted by the Portuguese government for facilitating the introduction of electric vehicles. Twenty one Portuguese cities are involved in "Mobi-E" and the short-term goal is the installation of 320 recharging stations by end-2010 and to have active 1 300 recharging stations at the end of 2011. A consortium of Portuguese companies is organised under the "Mobi-E" initiative **involving EDP**, several industrial and consultant companies and research centres.

(3) EDP INOVGRID (Portugal)

It is a first pilot demonstration trial, already under implementation. It has the objective of connecting, during 2009, 500 customers in 4 different geographical areas of Portugal and 50 000 customers during 2010. The cost of this pilot demonstration trial (15 M€) was accepted by the Portuguese NRA and incorporated at the actual regulatory period tariffs.

(4) UK projects

A number of smart grid projects are already being pursued under existing incentive arrangements – the Innovation Funding Incentive and Registered Power Zones. Projects employing dynamic line ratings, intelligent generator constraint management and advanced voltage control are already operational.

(5) E-Energy Project (Germany)

"E-Energy: ICT-based Energy System of the Future" is a new part of the technology policy of the Federal Government. "E-Energy" stands for the comprehensive digital interconnection and computer-based control and monitoring of the entire energy supply system. The primary goal of E-Energy is to create E-Energy model regions that demonstrate how the tremendous potential for optimisation presented by information and communication technologies (ICT) can best be tapped to achieve greater efficiency, supply security and environmental compatibility (cornerstones of energy and climate policy) in power supply, and how, in turn, new jobs and markets can be developed. What is particularly innovative about this project is that integrative ICT system concepts, which optimise the efficiency, supply security and environmental compatibility of the entire electricity supply system all along the chain - from generation and transport to distribution and consumption – are developed and tested in real-time in regional E-Energy model projects.
To force the pace on the innovative development needed and to broaden the impact of the results, the E-Energy programme focused on the following three aspects:
1. Creation of an E-Energy marketplace that facilitates electronic legal transactions and business dealings between all market participants;
2. Digital interconnection and computerisation of the technical systems and components, and the process control and maintenance activities based on these systems and components, such that the largely independent monitoring, analysis, control and regulation of the overall technical system is ensured;
3. Online linking of the electronic energy marketplace and overall technical system so that real time digital interaction of business and technology operations is guaranteed.
An E-Energy technology competition was held and **six model projects** were declared the winners. They each pursue an integral system approach, covering all energy-relevant economic activities both at market and technical operating levels. The programme will run for a 4-year term and mobilises, together with the equity capital of the participating companies, some €140 million for the **development of six E-Energy model regions:**
- eTelligence, model region of Cuxhaven,
Subject: Intelligence for energy, markets and power grids

- E-DeMa, Ruhr area model region
Subject: decentralised integrated energy systems on the way towards the E-Energy marketplace of the future
- MeRegio,
Subject: Minimum Emission Region
- Mannheim model city
Subject: Model city of Mannheim in the model region of Rhein-Neckar
- RegModHarz
Subject: Regenerative model region of Harz
- Smart Watts, model region Aachen
Subject: Greater efficiency and consumer benefit with the Internet of Energy

By 2012, the selected model regions are to develop their promising proposals up to the stage at which they are ready for market launching and to test their marketability in everyday application

(6) "Wind demonstration project" ESB (Ireland)

- Exploration of Voltage / Var control on Distribution connected wind farms
- Use of voltage regulators to limit voltage rise
- Single transformer cluster stations for wind farms

Green circuits:
- Self Healing Networks
- Losses Reduction
    - Voltage Upgrading i.e. 20kV Conversion
    - Dynamic re-configuration of networks to minimise losses
    - Re-conductoring
    - Amorphous core transformers
    - Installation of Capacitor banks
    - Lower average supply voltage using line drop compensation

(7) "Connected Home/empowering customer choice" ESB (Ireland)

Objective is 'to ascertain the potential for smart meter technology to effect measurable change in consumer behaviour'. 6400 statistically representative customers: One year profile data per customer (at least 6 actual months) for benchmark period

(8) GROW-DERS: Grid reliability and operability with distributed generation using transportable storage.

Project coordinated by KEMA. Main companies involved Iberdrola, MVV Energie among others. Goal: to demonstrate the technical and economical possibilities of existing electricity storage technologies.

(9) Orkney project. Scottish & Southern (UK)

Goal: how to connect renewable energy quickly and economically to constrained networks.

(10) ADDRESS project: Active Distribution network with full integration of Demand and distributed energy RESourceS

ADDRESS is a large-scale Integrated Project co-founded by the European Commission under the 7th Framework Programme.
its target is to enable the Active Demand in the context of the smart grids of the future, or in other words, the active participation of small and commercial consumers in power system markets and provision of services to the different power system participants.
It is carried out by a Consortium of 25 partners from 11 European countries. Enel Distribuzione (Italy) is the Coordinator.

(11) DEHEMS:

A mix of European local authorities, private business and universities is to develop and test a *Digital Energy Home Energy Management System* (**DEHEMS**) for the home market in the frame of FP7. DEHEMS aims at bringing the current intelligent meters in an ‘energy performance model’ looking at how energy is used to enable new policies in carbon allowances and support increased localized generation and distribution of energy. It will bring together sensor data on household heat loss and appliance performance and monitor energy usage to give real time information on emissions and energy performance of appliances and services. www.dehems.eu

(12) BeyWatch

BeyWatch is a 30-month research project supported by the European Commission (DG Information Society and Media) aiming at *ICT tools for environmental management and energy efficiency*. BeyWatch will develop an energy-aware and user-centric solution, able to provide intelligent energy monitoring/control and power demand balancing at home/building & neighbourhood level. Website: http://www.beywatch.eu/
Participants: EDF, Sigma Orionis, GL, Gorenje, Telefonica, Fagor, Universita degli studi di Palermo, Synelixis

(13) Smart-A

The Smart-A project, *Smart domestic Appliances in Sustainable Energy Systems,* focuses on assessing the potential for load-shifting by household appliances and analysing possible synergies with local sustainable energy generation as well as the requirements of regional load management. Website: http://www.smart-a.org/
Participants: University of Bonn, Germany; Enervision GmbH, Germany
Imperial College, United Kingdom; Inter-University Research Centre, Austria; The European Association for the Promotion of Cogeneration,
(COGEN Europe), Belgium; EnBW Energie Baden-Württemberg AG, Germany; University of Manchester, United Kingdom.
CECED Member: Miele & Cie. KG, Germany.

(14) Energy@Home (Italy)

This project builds on the capability of a smart grid to deliver energy data such as price through an home gateway to smart appliances; these can give to the customer a suggestion and assistance on how to improve the energy management of the house, or can automatically react taking into consideration all the in-house energy requirements.
Partners: Enel Distribuzione, Telecom Italia, Electrolux, Indesit Company

(15) Project chain DG DemoNet: Active distribution network operation with a high share of distributed generation (Austria)

The main project target is to integrate a maximum of decentralised generation units based on renewable energy resources into the electric distribution network without reinforcement of the network.
In the predecessor projects DG DemoNet-Concept and BAVIS voltage control concepts for medium voltage networks with a high share of distributed generation were developed in numerical simulation environments, based on real network data, as well as their economic and technical efficiency was evaluated compared to a reference scenario. Based on this experience, DG DemoNet-Validation analyses, if the promising results from the simulations are also valid under real network conditions and if the developed concepts are effective.
In the present project DG DemoNet-Validation voltage control concepts will be implemented in reality in the analysed grid sections in Vorarlberg and Salzburg by using test platforms. This will allow validating the simulation results from the former projects.

The detailed results of the project are:

- Development of a technical solution (ICT & ET) that complies with the requirements of the developed control concepts.
- Examination of the general applicability of the results.
- Compilation of an operational concept
- Analysis of the long-term cost savings, compared to traditional network planning concepts

(16) ISOLVES:PSSA-M: Innovative Solutions to Optimise Low Voltage Electricity Systems: Power Snap-Shot Analysis by Meters (Austria)

The objective of the project ISOLVES:PSSA-M is to define and develop the required technical foundations to enable an increasing number of distributed energy feed-in opportunities in low voltage networks. For this purpose a method is developed to take an instantaneous image of the network, the so-called "Power Snap-Shot Analysis by Meters" (PSSA-M), and is applied together with the smart meters to be adapted in the framework of the project.
The basic idea behind this method is to simultaneously display measurement values – caused by a trigger state - which represent an instantaneous image of the whole local network (voltage parameters, asset load, etc.). The following possibilities offered by an analysis of the instantaneous image of physical parameters in a low voltage network will be used: load flow and load distribution, critical voltage states, error location, etc. In order to make use of synergies (avoid installation of additional measurement devices, together with high investment and operational costs) the project requires the adaptation of smart meters as measurement devices.

By analysing the obtained measurement data of up to 100 different low voltage networks (including those with urban and rural structures) the potential for implementing a smart grid approach for an active network operation in low voltage networks can be evaluated.
Results from this analysis contribute to investigate and to model low voltage networks more precisely which leads to an essential improvement of network planning and network operation in distribution networks. The final considerations deducted bring considerable improvement to the field of network planning, especially in the area of new generation and demand installations, and it will contribute to guarantee the power quality for end users.

(17) emporA - E-Mobile Power Austria (Austria)

The emporA project brings together Austria's leading businesses from the automobile industry, infrastructure technology, energy supply and science sectors in order to integrate sub-systems, which are either new or currently in development, within innovative complete systems for electric mobility in a user-oriented and international coordinated way.

Objectives of the project (in relation to Smart Grids)

- Forecast and online estimation of distributed renewable generation and e-car demand
- Control of generation / e-car charging to keep the power balance - VPP
- Data concentration (per balance responsible party) at public / fleet car parks
- Control of e-car charging to keep the network balance / voltage band
- Develop for existing DMS system an advanced distribution voltage control application
- Interface for DSO at public / fleet car parks network node level
- Data concentration (per network node) at public / fleet car parks
- Automation system concepts for concentrated e-cars (e.g. in parking houses)

(18) Meta PV project: Metamorphosis of Power Distribution: System Services from Photovoltaics (EU)

MetaPV demonstrates the provision of electrical benefits from photovoltaics (PV) on a large scale. Additional benefits for active grid support from PV will be demonstrated at two sites: a residential/urban area of 128 households with 4 kWp each, and an industrial zone of 31 PV systems with 200 kWp each. The enhanced control capacities to be implemented into PV inverters and demonstrated are active voltage control, fault ride-through capability, autonomous grid operation, and interaction of distribution system control with PV systems. A detailed technical and economic assessment of the additional services from PV is carried out. The role of PV in an area fully supplied by renewable sources is to be assessed.

Main Objectives of the project are:

- Development of the necessary elements for enabling active grid support from PV, namely:
  - enhanced control capacities implemented into PV inverters,
  - adapted grid control strategies and infrastructure including means of communication where required,
  - an efficient use of distributed storage
- Demonstration of additional benefits from PV in a Belgium distribution system, namely:
  - power quality improvement,
  - increased security of power supply.

(19) Open Architecture for Secondary Nodes of the Electricity SmartGrid (EU)

The OpenNode project is focussing on inner parts of the distribution grid, namely the smart **Secondary Substation Nodes (SSN)** as substantial component to monitor and control the distribution grid status. Based on Information and Communication Technology (ICT) three challenges will be addressed by a network of embedded devices – the SSNs – capable of communicate to each other and contribute to the efficient exploitation of the energy resources.

OpenNode project is focussing on research and development of (1) an **open secondary substation node** which is seen as an essential control component of the future smart distribution grid, (2) a **Middleware to couple the SSN operation** with the Utilities systems for grid and utility operation and (3) a **modular communication architecture** based on standardised communication protocols to grant the flexibility required by the stakeholder diversification and to cope with massively distributed embedded systems in the distribution grid. Developments will be guided by an initial analysis of requirements and definition of the overall architecture and interfaces together with the detailed description of the use cases leading to the technical demonstrations with two functional prototypes of a Secondary Substation Node.

(20) FENIX - Flexible Electricity Networks to Integrate the eXpected "energy revolution" (EU) + zUQde (Austria)

The goal of the FENIX project was to enable Distributed Energy Resources (DER) to make the EU electricity supply system cost efficient, secure and sustainable through aggregation into Large Scale Virtual Power Plant (LSVPP). Two demonstrations had been successful.

Received results:

- Maximum integration / maximum benefit of Decentralized Generation (Medium Voltage range)
- DSO validates (and if necessary, constrains) the DER power offer schedules
- Sell aggregated DER power to the energy market
- Provide aggregated tertiary reserve to TSO reserve market
- Provide reactive power regulation capability of DER in MV range as service for DSO (e.g. to keep line voltages)

Within the research and demonstration project zUQde the results of the FENIX project will be transferred from an offline into an online (full – active) DMS / DSE application version at an medium voltage branch, within an distribution grid of Salzburg Netz AG.

(21) EcoGrid EU project: A Smart Grid prototype for the Future
The EcoGrid EU vision:
- To implement high dissemination of multiple renewable energy resources to meet the EU 20-20-20 goals
- To create a new and fine meshed electric system based on bidirectional grid, distributed consumption and generation with real-time control and market prices
- To enhance consumer and local producers (prosumers) to participate in the operation of the electric system through a real-time market, energy storage and savings
- To deploy a full scale demonstration in a real grid with participation of the DSO, industrial partners and Community.

(22) Università degli Studi di Genova – T&D Europe

Study on Criteria for the Quantification of how modern T&D-systems help accomplish the EU 20/20/20 targets

The study is aimed at providing criteria on the evaluation on how the future Transmission and Distribution (T&D) infrastructures (Smart Grids process) contribute to accomplish the "EU 20-20-20 targets", in terms of efficiency increase (+ 20% within 2020), CO_2 reduction (– 20% within 2020) and a wider employ of renewable energy resources (+ 20% within 2020).

In particular, the developed methodology allows to quantify the possible environmental benefits as well as the power quality improvement provided by the application of modern T&D products and systems on the power grids to be renovated/upgraded.

Such methodology seems to be at present the only available in state-of-the-art scientific literature and is based on the identification of suitable "performance (technical) indices" to be used to rank the benefits brought by the different grid upgrading measures and on the definition of suitable "test networks". The criteria applied on the reference test networks can be deployed as benchmarks to perform the evaluation, via the introduced indices, of whatever future grid improvement.

Methodology outcomes will be therefore quantities like the saved kilowatt hours, the non-emitted CO_2 Mtons and the evaluation of the increment in renewables penetration due to the modernization of power grids with interventions like:

- replacement/refurbishment of power components;
- increased use of WAMS/WACS;
- upgrading protection and control devices for communication;
- increase of voltage level;
- installation of power quality devices;
- increased use of compensation devices;
- adoption of new technologies and systems for power transmission (all types of HVDC).

(23) 3e-HOUSES project

3e-HOUSES project deals with the integration of the most established ICT technologies in social housing in order to provide an innovative service for **energy efficiency**.

- Real time monitoring of the energy consumption
- Integration of renewable energies
- Creating the resources to lower energy consumption

ANNEX C – Some relevant standards

This Annex highlights EU, International and Defacto standards identified in the IEC, NIST and ESMIG reports and relevant to smart grid and smart metering applications[17].

European Standards

Electricity Metering (CENELEC)	**Description**
EN 50470-1:2006	Electricity metering equipment (a.c.) – Part 1: General requirements, tests and test conditions – Metering equipment (class indexes A, B and C)
EN 50470-2:2006	Electricity metering equipment (a.c.) – Part 2: Particular requirements – Electromechanical meters for active energy (class indexes A and B)
EN 50470-3:2006	Electricity metering equipment (a.c.) – Part 3: Particular requirements – Static meters for active energy (class indexes A, B and C)
EN 61334-3-21:1996	Distribution automation using distribution line carrier systems -- Part 3: Mains signaling requirements -- Section 21: MV phase-to-phase isolated capacitive coupling device
EN 61334-3-22:2001	Distribution automation using distribution line carrier systems -- Part 3-22: Mains signaling requirements - MV phase-to-earth and screen-to-earth intrusive coupling devices
EN 61334-4-1:1996	Distribution automation using distribution line carrier systems -- Part 4: Data communication protocols -- Section 1: Reference model of the communication system
EN 61334-4-33:1998	Distribution automation using distribution line carrier systems -- Part 4-33: Data communication protocols - Data link layer - Connection oriented protocol
EN 61334-4-42:1996	Distribution automation using distribution line carrier systems -- Part 4: Data communication protocols -- Section 42: Application protocols - Application layer
EN 61334-4-32:1996	Distribution automation using distribution line carrier systems -- Part 4: Data communication protocols -- Section 32: Data link layer - Logical link control (LLC)
EN 61334-4-41:1996	Distribution automation using distribution line carrier systems -- Part 4: Data communication protocols -- Section 41: Application protocols - Distribution line message specification
EN 61334-4-61:1998	Distribution automation using distribution line carrier systems -- Part 4-61: Data communication protocols - Network layer - Connectionless protocol
EN 61334-4-511:2000	Distribution automation using distribution line carrier systems -- Part 4-511: Data communication protocols - Systems management - CIASE protocol
EN 61334-4-512:2002	Distribution automation using distribution line carrier systems -- Part 4-512: Data communication protocols - System management using profile 61334-5-1 - Management Information Base (MIB)
EN 61334-5-1:2001	Distribution automation using distribution line carrier systems -- Part 5-1: Lower layer profiles - The spread frequency shift keying (S-FSK) profile

[17] This list has been provided by EG2.

Electricity Metering (CENELEC)	Description
EN 61334-6:2000	Distribution automation using distribution line carrier systems -- Part 6: A-XDR encoding rule
EN 62052-11	Electricity metering equipment (AC) – General requirements, tests and test conditions – Part 11: Metering equipment
EN 62052-21	Electricity metering equipment (AC) – General requirements, tests and test conditions – Part 21: Tariff and load control equipment
EN 62053-11	Electricity metering equipment (a.c.) – Particular requirements – Part 11: Electromechanical meters for active energy (classes 0,5,1 and 2)
EN 62053-21	Electricity metering equipment (a.c.) – Particular requirements – Part 21: Static meters for active energy (classes 1 and 2)
EN 62053-22	Electricity metering equipment (a.c.) – Particular requirements – Part 22: Static meters for active energy (classes 0,2 S and 0,5 S)
EN 62053-23	Electricity metering equipment (a.c.) – Particular requirements – Part 23: Static meters for reactive energy (classes 2 and 3)
EN 62053-31	Electricity metering equipment (a.c.) – Particular requirements – Part 31: Pulse output devices for electromechanical and electronic meters (two wires only)
EN 62053-52	Electricity metering equipment (a.c.) – Particular requirements – Part 52: Symbols
EN 62053-61	Electricity metering equipment (a.c.) – Particular requirements – Part 61: Power consumption and voltage requirement
EN 62054-11	Electricity metering (a.c.) – Tariff and load control – Part 11: Particular requirements for electronic ripple control receivers
EN 62054-21	Electricity metering (a.c.) – Tariff and load control – Part 21: Particular requirements for time switches
EN 62055-31	Electricity metering – Payment systems – Part 31: Particular requirements – Static payment meters for active energy (classes 1 and 2)
EN 62056-21	Electricity metering – Data exchange for meter reading, tariff and load control – Part 21: Direct local data exchange
EN 62056-31	Electricity metering – Data exchange for meter reading, tariff and load control – Part 31: Use of local area network on twisted pair with carrier signalling
EN 62056-42	Electricity metering – Data exchange for meter reading, tariff and load control – Part 42: Physical layer services and procedures for connection-oriented asynchronous data exchange
EN 62056-46+am1	Electricity metering – Data exchange for meter reading, tariff and load control – Part 46: Data link layer using HDLC protocol
EN 62056-47	Electricity metering – Data exchange for meter reading, tariff and load control – Part 47: COSEM transport layers for IPv4 networks
EN 62056-53	Electricity metering – Data exchange for meter reading, tariff and load control – Part 53: COSEM application layer
EN 62056-61	Electricity metering – Data exchange for meter reading, tariff and load control – Part 61:Object identification system (OBIS)
EN 62056-62	Electricity metering – Data exchange for meter reading, tariff and load control – Part 62:Interface classes
FprEN 62058-11	Electricity metering equipment (AC) – Acceptance inspection – Part 11:General acceptance inspection methods

Electricity Metering (CENELEC)	Description
FprEN 62058-21	Electricity metering equipment (AC) – Acceptance inspection – Part 21:Particular requirements for electromechanical meters for active energy (classes 0,5,1 and 2)
FprEN 62058-31	Electricity metering equipment (AC) – Acceptance inspection – Part 31:Particular requirements for static meters for active energy (classes 0,2 S, 0,5 S, 1 and 2)
EN 62059-31-1	Electricity metering equipment – Dependability – Part 31-1: Accelerated reliability testing – Elevated temperature and humidity
FprEN 62059-32-1:2008	Electricity metering equipment - Dependability -- Part 32-1: Durability - Testing of the stability of metrological characteristics by applying elevated temperature
EN 62059-41	Electricity metering equipment – Dependability – Part 41: Reliability prediction
prEN 62059-51	Electricity metering equipment - Dependability -- Part 51: Software aspects of dependability
FprEN 61968-9:2008	Application integration at electric utilities - System interfaces for distribution management -- Part 9: Interface standard for meter reading and control
Communications	
EN 13321-1 Part 1	Developed by CEN. Open data communication in building automation, controls and building management - Home and building electronic system: Product and system requirements
EN 13321-1 Part 2	Developed by CEN. Open data communication in building automation, controls and building management - Home and building electronic system:KNXnet/IP Communication
EN 13757-1:2003 Part 1	Developed by CEN. Communication system for meters and remote reading of meters. Include such communication systems as M-Bus and PLC. Part 1: Data exchange includes Obis and DLMS/COSEM)
EN 13757-2:2004 Part 2	Developed by CEN. Communication system for meters and remote reading of meters. Include such communication systems as M-Bus and PLC. Part2: Physical and link layer.
EN 13757-3:2004 Part 3	Developed by CEN. Communication system for meters and remote reading of meters. Include such communication systems as M-Bus and PLC. Part 3: Dedicated application layer.
EN 13757-4:2005 Part 4	Developed by CEN. Communication system for meters and remote reading of meters. Include such communication systems as M-Bus and PLC. Part 4: Wireless meter read-out (electricity meters are not covered by this standard, as the standardization of remote readout of electricity meters is a task for IEC/CENELEC.
EN 13757-5:2008 Part 5	Developed by CEN. Communication system for meters and remote reading of meters. Include such communication systems as M-Bus and PLC. Part 5: Wireless relay.
EN 13757-6 Part 6	Developed by CEN. Communication system for meters and remote reading of meters. Include such communication systems as M-Bus and PLC. Part 6: Local Bus.
EN 50090-2-1:1994	Home and Building Electronic Systems (HBES) -- Part 2-1: System overview - Architecture

Electricity Metering (CENELEC)	Description
EN 50090-2-2:1996	Home and Building Electronic Systems (HBES) -- Part 2-2: System overview - General technical requirements
EN 50090-2-2:1996/A1:2002	Home and Building Electronic Systems (HBES) -- Part 2-2: System overview - General technical requirements
EN 50090-2-2:1996/A2:2007	Home and Building Electronic Systems (HBES) -- Part 2-2: System overview - General technical requirements
EN 50090-2-3:2005	Home and Building Electronic Systems (HBES) -- Part 2-3: System overview - General functional safety requirements for products intended to be integrated in HBES
EN 50090-3-1:1994	Home and Building Electronic Systems (HBES) -- Part 3-1: Aspects of application - Introduction to the application structure
EN 50090-3-2:2004	Home and Building Electronic Systems (HBES) -- Part 3-2: Aspects of application - User process for HBES Class 1
EN 50090-3-3:200X	Home and Building Electronic Systems (HBES) -- Part 3-3: Aspects of application - HBES Interworking model and common HBES data types
EN 50090-4-1:2004	Home and Building Electronic Systems (HBES) -- Part 4-1: Media independent layers - Application layer for HBES Class 1
EN 50090-4-2:2004	Home and Building Electronic Systems (HBES) -- Part 4-2: Media independent layers - Transport layer, network layer and general parts of data link layer for HBES Class 1
EN 50090-4-3:2007	Home and Building Electronic Systems (HBES) -- Part 4-3: Media independent layers - Communication over IP
EN 50090-5-1:2005	Home and Building Electronic Systems (HBES) -- Part 5-1: Media and media dependent layers - Power line for HBES Class 1
EN 50090-5-2:2004	Home and Building Electronic Systems (HBES) -- Part 5-2: Media and media dependent layers - Network based on HBES Class 1, Twisted Pair
EN 50090-5-3:2006	Home and Building Electronic Systems (HBES) -- Part 5-3: Media and media dependent layers - Radio frequency
CLC/prTS 50090-6-4	Home and Building Electronic Systems (HBES) -- Part 6-4: Interfaces - Residential gateway model for a home and building electronic system
EN 50090-7-1:2004	Home and Building Electronic Systems (HBES) -- Part 7-1: System management - Management procedures
EN 50090-8:2000	Home and Building Electronic Systems (HBES) -- Part 8: Conformity assessment of products
EN 50090-9-1:2004	Home and Building Electronic Systems (HBES) -- Part 9-1: Installation requirements - Generic cabling for HBES Class 1 Twisted Pair
CLC/TR 50090-9-2:2007	Home and Building Electronic Systems (HBES) -- Part 9-2: Installation requirements - Inspection and testing of HBES installation
EN 60870-2-1:1996	Telecontrol equipment and systems -- Part 2: Operating conditions -- Section 1: Power supply and electromagnetic compatibility
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 60870-5-1:1993	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

Electricity Metering (CENELEC)	Description
EN 60870-5-3:1992	Telecontrol equipment and systems -- Part 5: Transmission protocols - Section 3: General structure of application data
EN 60870-5-4:1993	Telecontrol equipment and systems -- Part 5: Transmission protocols - Section 4: Definition and coding of application information elements
EN 60870-5-5:1995	Telecontrol equipment and systems -- Part 5: Transmission protocols - Section 5: Basic application functions
FprEN 60870-5-6:2008	Telecontrol equipment and systems -- Part 5-6: Guidelines for conformance testing for the IEC 60870-5 companion standards
EN 60870-5-101:2003	Telecontrol equipment and systems -- Part 5-101: Transmission protocols - Companion standard for basic telecontrol tasks
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 60870-5-103:1998	Telecontrol equipment and systems -- Part 5-103: Transmission protocols - Companion standard for the informative interface of protection equipment
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 60870-6-2:1995	Telecontrol equipment and systems -- Part 6: Telecontrol protocols compatible with ISO standards and ITU-T recommendations -- Section 2: Use of basic standards (OSI layers 1-4)
EN 60870-6-501:1996	Telecontrol equipment and systems -- Part 6: Telecontrol protocols compatible with ISO standards and ITU-T recommendations -- Section 501: TASE.1 Service definitions
EN 60870-6-502:1996	Telecontrol equipment and systems -- Part 6: Telecontrol protocols compatible with ISO standards and ITU-T recommendations -- Section 502: TASE.1 Protocol definitions
EN 60870-6-503:2002	Telecontrol equipment and systems -- Part 6-503: Telecontrol protocols compatible with ISO standards and ITU-T recommendations - TASE.2 Services and protocol
EN 60870-6-601:1995	Telecontrol equipment and systems -- Part 6: Telecontrol protocols compatible with ISO standards and ITU-T recommendations -- Section 601: Functional Profile for providing the Connection-Oriented Transport Service in End System connected via permanent access to a Packet Switched Data Network
EN 60870-6-701:1998	Telecontrol equipment and systems -- Part 6-701: Telecontrol protocols compatible with ISO standards and ITU-T recommendations - Functional profile for providing the TASE.1 application service in end systems
EN 60870-6-702:1998	Telecontrol equipment and systems -- Part 6-702: Telecontrol protocols compatible with ISO standards and ITU-T recommendations - Functional profile for providing the TASE.2 application service in end systems
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 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

Electricity Metering (CENELEC)	Description
EN 61850-5:2003	Communication networks and systems in substations -- Part 5: Communication requirements for functions and device models
EN 61850-6:2004	Communication networks and systems in substations -- Part 6: Configuration description language for communication in electrical substations related to IEDs
FprEN 61850-6:200X	Communication networks and systems for power utility automation -- Part 6: Configuration description language for communication in electrical substations related to IEDs
FprEN 61850-7-1:2008	Communication networks and systems for power utility automation -- Part 7-1: Basic communication structure - Principles and models
EN 61850-7-1:2003	Communication networks and systems in substations -- Part 7-1: Basic communication structure for substation and feeder equipment - Principles and models
FprEN 61850-7-2:2008	Communication networks and systems for power utility automation -- Part 7-2: Basic information and communication structure - Abstract communication service interface (ACSI)
EN 61850-7-2:2003	Communication networks and systems in substations -- Part 7-2: Basic communication structure for substation and feeder equipment - Abstract communication service interface (ACSI)
FprEN 61850-7-3:2008	Communication networks and systems for power utility automation -- Part 7-3: Basic communication structure - Common data classes
EN 61850-7-3:2003	Communication networks and systems in substations -- Part 7-3: Basic communication structure for substation and feeder equipment - Common data classes
FprEN 61850-7-4:2008	Communication networks and systems for power utility automation -- Part 7-4: Basic communication structure - Compatible logical node classes and data classes
EN 61850-7-4:2003	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 61850-7-410:2007	Communication networks and systems for power utility automation -- Part 7-410: Hydroelectric power plants - Communication for monitoring and control
FprEN 61850-7-420:2008	Communication networks and systems for power utility automation -- Part 7-420: Basic communication structure - Distributed energy resources logical nodes
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 61850-9-1:2003	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

Electricity Metering (CENELEC)	Description
CLC/prTS 61850-80-1	Communication networks and systems for power utility automation - Part 80-1: Guideline to exchanging information from a CDC-based data model using IEC 60870-5-101 or IEC 60870-5-104
Interface	
EN 61970-1:2007	Energy management system application program interface (EMS-API) Part 1: Guidelines and General Requirements
CLC/TS 61970-2:2005	Energy management system application program interface (EMS-API) - Part 2: Glossary
FprEN 61970-301:2009	Energy management system application program interface (EMS-API) Part 301: Common information model (CIM) base
EN 61970-402:2008	Energy management system application program interface (EMS-API) Part 402: Common services
EN 61970-403:2008	Energy management system application program interface (EMS-API) Part 403: 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 program interface (EMS-API) Part 453: CIM based graphics exchange
EN 61970-501:2006	Energy management system application program interface (EMS-API) Part 501: Common information model resource description framework (CIM RDF) schema
EN 61968-1:2004	Application integration at electric utilities - system interfaces for distribution management Part 1: Interface architecture and general requirements
EN 61968-3:2004	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
FprEN 61968-9:2008	Application integration at electric utilities - System interfaces for distribution management -- Part 9: Interface standard for meter reading and control
EN 61968-13:2008	Application integration at electric utilities - System interfaces for distribution management - Part 13: CIM RDF Model exchange format for distribution

International

Electricity Metering (IEC)	Description
IEC/TR 62051	Electricity metering – glossary of terms
IEC/TR 62051-1	Electricity metering – data exchange for meter reading, tariff and load control
IEC/TR 61334-1-1 (1995-11)	Distribution automation using distribution line carrier systems - Part 1: General considerations - Section 1: Distribution automation system architecture

Electricity Metering (IEC)	Description
IEC/TR 61334-1-2 (1997-12)	Distribution automation using distribution line carrier systems - Part 1-2: General considerations - Guide for specification
IEC/TR 61334-1-4 (1995-11)	Distribution automation using distribution line carrier systems - Part 1: General considerations - Section 4: Identification of data transmission parameters concerning medium and low-voltage distribution mains
IEC 61334-3-1 (1998-11)	Distribution automation using distribution line carrier systems - Part 3-1: Mains signalling requirements - Frequency bands and output levels
IEC 61334-3-21 (1996-03)	Distribution automation using distribution line carrier systems - Part 3: Mains signalling requirements - Section 21: MV phase-to-phase isolated capacitive coupling device
IEC 61334-3-22 (2001-01)	Distribution automation using distribution line carrier systems - Part 3-22: Mains signalling requirements - MV phase-to-earth and screen-to-earth intrusive coupling devices
IEC 61334-4-1 (1996-07)	Distribution automation using distribution line carrier systems - Part 4: Data communication protocols - Section 1: Reference model of the communication system
IEC 61334-4-32 (1996-09)	Distribution automation using distribution line carrier systems - Part 4: Data communication protocols - Section 32: Data link layer - Logical link control (LLC)
IEC 61334-4-33 (1998-07)	Distribution automation using distribution line carrier systems - Part 4-33: Data communication protocols - Data link layer - Connection oriented protocol
IEC 61334-4-41 (1996-08)	Distribution automation using distribution line carrier systems - Part 4: Data communication protocols - Section 41: Application protocol - Distribution line message specification
IEC 61334-4-42 (1996-10)	Distribution automation using distribution line carrier systems - Part 4: Data communication protocols - Section 42: Application protocols - Application layer
IEC 61334-4-61 (1998-07)	Distribution automation using distribution line carrier systems - Part 4-61: Data communication protocols - Network layer - Connectionless protocol
IEC 61334-4-511 (2000-04)	Distribution automation using distribution line carrier systems - Part 4-511: Data communication protocols - Systems management - CIASE protocol
IEC 61334-4-512 (2001-10)	Distribution automation using distribution line carrier systems - Part 4-512: Data communication protocols - System management using profile 61334-5-1 - Management Information Base (MIB)
IEC 61334-5-1 (2001-05)	Distribution automation using distribution line carrier systems - Part 5-1: Lower layer profiles - The spread frequency shift keying (S-FSK) profile
IEC/TS 61334-5-2 (1998-05)	Distribution automation using distribution line carrier systems - Part 5-2: Lower layer profiles - Frequency shift keying (FSK) profile
IEC/TS 61334-5-3 (2001-01)	Distribution automation using distribution line carrier systems - Part 5-3: Lower-layer profiles - Spread spectrum adaptive wideband (SS-AW) profile
IEC/TS 61334-5-4 (2001-06)	Distribution automation using distribution line carrier systems - Part 5-4: Lower layer profiles - Multi-carrier modulation (MCM) profile
IEC/TS 61334-5-5 (2001-09)	Distribution automation using distribution line carrier systems - Part 5-5: Lower layer profiles - Spread spectrum - fast frequency hopping (SS-FFH) profile
IEC 61334-6 (2000-06)	Distribution automation using distribution line carrier systems - Part 6: A-XDR encoding rule
IEC 61698	
IEC 62052-11	Electricity metering equipment (AC) – General requirements, tests and test conditions – Part 11: Metering equipment
IEC 62052-21	Electricity metering equipment (AC) – General requirements, tests and test conditions – Part 21: Tariff and load control equipment
IEC 62053-11	Electricity metering equipment (a.c.) – Particular requirements – Part 11: Electromechanical meters for active energy (classes 0,5,1 and 2)
IEC 62053-21	Electricity metering equipment (a.c.) – Particular requirements – Part 21: Static meters for active energy (classes 1 and 2)
IEC 62053-22	Electricity metering equipment (a.c.) – Particular requirements – Part 22: Static meters for active energy (classes 0,2 S and 0,5 S)
IEC 62053-23	Electricity metering equipment (a.c.) – Particular requirements – Part 23: Static meters for reactive energy (classes 2 and 3)
IEC 62053-31	Electricity metering equipment (a.c.) – Particular requirements – Part 31: Pulse output devices for electromechanical and electronic meters (two wires only)
IEC 62053-52	Electricity metering equipment (a.c.) – Particular requirements – Part 52: Symbols
IEC 62053-61	Electricity metering equipment (a.c.) – Particular requirements – Part 61: Power consumption and voltage requirement
IEC 62054-11	Electricity metering (a.c.) – Tariff and load control – Part 11: Particular requirements for electronic ripple control receivers

Electricity Metering (IEC)	Description
IEC 62054-21	Electricity metering (a.c.) – Tariff and load control – Part 21: Particular requirements for time switches
IEC 62055-21	Electricity metering – Payment systems – Part 21:Framework for standardization
IEC 62055-31	Electricity metering – Payment systems – Part 31: Particular requirements – Static payment meters for active energy (classes 1 and 2)
IEC 62055-41	Electricity metering – Payment systems – Part 41: Standard transfer specification (STS) – Application layer protocol for one-way token carrier systems
IEC 62055-51	Electricity metering – Payment systems – Part 51: Standard transfer specification (STS) – Physical layer protocol for one-way numeric and magnetic card token carriers
IEC 62055-52	Electricity metering – Payment systems – Part 52: Standard transfer specification (STS) – Physical layer protocol for a two-way virtual token carrier for direct local connection
IEC 62056-21	Electricity metering – Data exchange for meter reading, tariff and load control – Part 21: Direct local data exchange
IEC 62056-31	Electricity metering – Data exchange for meter reading, tariff and load control – Part 31: Use of local area network on twisted pair with carrier signalling
IEC/TS 62056-41	Electricity metering – Data exchange for meter reading, tariff and load control – Part 41: Data exchange using wide area networks: Public switched telephone network (PSTN) with LINK + protocol
IEC 62056-42	Electricity metering – Data exchange for meter reading, tariff and load control – Part 42: Physical layer services and procedures for connection-oriented asynchronous data exchange
IEC 62056-46+am1	Electricity metering – Data exchange for meter reading, tariff and load control – Part 46: Data link layer using HDLC protocol
IEC 62056-47	Electricity metering – Data exchange for meter reading, tariff and load control – Part 47: COSEM transport layers for IPv4 networks
IEC/TS 62056-51	Electricity metering – Data exchange for meter reading, tariff and load control – Part 51: Application layer protocols
IEC/TS 62056-52	Electricity metering – Data exchange for meter reading, tariff and load control – Part 52: Communication protocols management distribution line message specification (DLMS) server
IEC 62056-53	Electricity metering – Data exchange for meter reading, tariff and load control – Part 53: COSEM application layer
IEC 62056-61	Electricity metering – Data exchange for meter reading, tariff and load control – Part 61:Object identification system (OBIS)
IEC 62056-62	Electricity metering – Data exchange for meter reading, tariff and load control – Part 62:Interface classes
IEC 62058-11	Electricity metering equipment (AC) – Acceptance inspection – Part 11:General acceptance inspection methods
IEC 62058-21	Electricity metering equipment (AC) – Acceptance inspection – Part 21:Particular requirements for electromechanical meters for active energy (classes 0,5,1 and 2)
IEC 62058-31	Electricity metering equipment (AC) – Acceptance inspection – Part 31:Particular requirements for static meters for active energy (classes 0,2 S, 0,5 S, 1 and 2)
IEC/TR 62059-11	Electricity metering equipment – Dependability – Part 11: General concepts
IEC/TR 62059-21	Electricity metering equipment – Dependability – Part 21: Collection of meter dependability data from the field
IEC/TR 62059-31	Electricity metering equipment – Dependability – Part 31-1: Accelerated reliability testing – Elevated temperature and humidity
IEC/TR 62059-41	Electricity metering equipment – Dependability – Part 41: Reliability prediction
IEC 61968-9 Ed. 1.0	System Interfaces For Distribution Management - Part 9: Interface Standard for Meter Reading and Control
Communications	

Electricity Metering (IEC)	Description
EN/ISO 14908-1	Open data communication in building automation, controls and building management - Building network protocol - Part 1: Protocol stack
EN /ISO 14908-2	Open Data Communication in Building Automation, Controls and Building Management -- Control Network Protocol -- Part 2: Twisted Pair Communication
EN /ISO 14908-3	Open data communication in building automation, controls and building management. Control network protocol. Part 3: Power line channel specification
EN /ISO 14908-4	Open Data Communication in Building Automation, Controls and Building Management -- Control Network Protocol -- Part 4: IP Communication
IEEE 802	Standards for Local Area Network and Metropolitan Area Network. The most widely used standards are: Ethernet, Token Ring, Wireless LAN, Wireless PAN (Personal Area Network), Wireless MAN, Bridging and Virtual Bridged LANs.
IEEE 802.1	Overview & Architecture.
IEEE 802.2	Standard defining Logical Link Control (LLC), which is the upper portion of the data link layer of the OSI Model.
IEEE 802.3	Standards defining the physical layer, and the media access control (MAC) sublayer of the data link layer, of wired Ethernet. This is generally a LAN technology with some WAN applications. Physical connections are made between nodes and/or infrastructure devices (hubs, switches, routers) by various types of copper or fiber cable.
IEEE 802.4	The IEEE 802.4 standard defines a bus physical topology which uses a token message to grant the right to access the physical network media. Group has been disbanded
IEEE 802.5	CSMA/CD Access method (Lists provisions for Ethernet technology - widely used in such countries as Netherlands, Belgium, Bulgaria, Lithuania, etc.)
IEEE 802.11	Token Ring Access Method
IEEE 802.15	Wireless Personal Area Network (Lists provisions for Zigbee, PhyNet, Sensinode technology).
IEEE 802.15.1:2005	Wireless Personal Area Network standard based on the Bluetooth v1.2 specifications.
IEEE 802.15.2:2003	Addresses the issue of coexistence of wireless personal area networks (WPAN) with other wireless devices operating in unlicensed frequency bands such as wireless local area networks (WLAN).
IEEE 802.15.3:2003	MAC and PHY standard for high-rate (11 to 55 Mbit/s) WPANs.
IEEE 802.15.4:2006	A standard which specifies the physical layer and media access control for low-rate wireless personal area networks (LR-WPANs). ZigBee
IEEE 802.15.5	Mesh Networking of Wireless Personal Area Networks (WPANs)
IEEE 802.15.6	This task group is focusing on BAN or Body Area Network Technologies. The goal is a low-power and low-frequency short-range wireless standard.[3]
IEEE 802.16	Broadband Wireless Metropolitan Area Networks
IEEE 802.17	Resilent Packet Rings access method and physical layer specifications
IEC/TR 60870-1-1 Ed. 1.0	Telecontrol equipment and systems. Part 1: General considerations. Section One: General principles
IEC 60870-1-2 Ed. 1.0	Telecontrol equipment and systems. Part 1: General considerations. Section Two: Guide for specifications
IEC/TR 60870-1-3 Ed. 2.0	Telecontrol equipment and systems - Part 1: General considerations - Section 3: Glossary
IEC/TR 60870-1-4 Ed. 1.0	Telecontrol equipment and systems - Part 1: General considerations - Section 4: Basic aspects of telecontrol data transmission and organization of standards IEC 870-5 and IEC 870-6

Electricity Metering (IEC)	Description
IEC/TR 60870-1-5 Ed. 1.0	Telecontrol equipment and systems - Part 1-5: General considerations - Influence of modem transmission procedures with scramblers on the data integrity of transmission systems using the protocol IEC 60870-5
IEC 60870-2-1 Ed. 2.0	Telecontrol equipment and systems - Part 2: Operating conditions - Section 1: Power supply and electromagnetic compatibility
IEC 60870-2-2 Ed. 1.0	Telecontrol equipment and systems - Part 2: Operating conditions - Section 2: Environmental conditions (climatic, mechanical and other non electrical influences)
IEC 60870-3 Ed. 1.0	Telecontrol equipment and systems. Part 3: Interfaces (electrical characteristics)
IEC 60870-4 Ed. 1.0	Telecontrol equipment and systems. Part 4: Performance requirements
IEC 60870-5-1 Ed. 1.0	Telecontrol equipment and systems. Part 5: Transmission protocols - Section One: Transmission frame formats
IEC 60870-5-2 Ed. 1.0	Telecontrol equipment and systems - Part 5: Transmission protocols - Section 2: Link transmission procedures
IEC 60870-5-3 Ed. 1.0	Telecontrol equipment and systems - Part 5: Transmission protocols - Section 3: General structure of application data
IEC 60870-5-4 Ed. 1.0	Telecontrol equipment and systems - Part 5: Transmission protocols - Section 4: Definition and coding of application information elements
IEC 60870-5-5 Ed. 1.0	Telecontrol equipment and systems - Part 5: Transmission protocols - Section 5: Basic application functions
IEC 60870-5-6 Ed. 1.0	Telecontrol equipment and systems - Part 5-6: Guidelines for conformance testing for the IEC 60870-5 companion standards
IEC 60870-5-101 Ed. 2.0	Telecontrol equipment and systems - Part 5-101: Transmission protocols - Companion standard for basic telecontrol tasks
IEC 60870-5-102 Ed. 1.0	Telecontrol equipment and systems - Part 5: Transmission protocols - Section 102: Companion standard for the transmission of integrated totals in electric power systems
IEC 60870-5-103 Ed. 1.0	Telecontrol equipment and systems - Part 5-103: Transmission protocols - Companion standard for the informative interface of protection equipment
IEC 60870-5-104 Ed. 2.0	Telecontrol equipment and systems - Part 5-104: Transmission protocols - Network access for IEC 60870-5-101 using standard transport profiles
IEC/TS 60870-5-601	Telecontrol equipment and systems - Part 5-601: Conformance test cases for the IEC 60870-5-101 companion standard
IEC/TS 60870-5-604 Ed. 1.0	Telecontrol equipment and systems - Part 5-604: Conformance test cases for the IEC 60870-5-104 companion standard
IEC/TR 60870-6-1 Ed. 1.0	Telecontrol equipment and systems - Part 6: Telecontrol protocols compatible with ISO standards and ITU-T recommendations - Section 1: Application context and organization of standards
IEC 60870-6-2 Ed. 1.0	Telecontrol equipment and systems - Part 6: Telecontrol protocols compatible with ISO standards and ITU-T recommendations - Section 2: Use of basic standards (OSI layers 1-4)
IEC 60870-6-501 Ed. 1.0	Telecontrol equipment and systems - Part 6: Telecontrol protocols compatible with ISO standards and ITU-T recommendations - Section 501: TASE.1 Service definitions
IEC 60870-6-502 Ed. 1.0	Telecontrol equipment and systems - Part 6: Telecontrol protocols compatible with ISO standards and ITU-T recommendations - Section 502: TASE.1 Protocol definitions
IEC 60870-6-503 Ed. 2.0	Telecontrol equipment and systems - Part 6-503: Telecontrol protocols compatible with ISO standards and ITU-T recommendations - TASE.2 Services

Electricity Metering (IEC)	Description
	and protocol
IEC/TS 60870-6-504 Ed. 1.0	Telecontrol equipment and systems - Part 6-504: Telecontrol protocols compatible with ISO standards and ITU-T recommendations - TASE.1 User conventions
IEC/TR 60870-6-505 Consol. Ed. 1.1 (incl. am1)	Telecontrol equipment and systems - Part 6-505: Telecontrol protocols compatible with ISO standards and ITU-T recommendations - TASE.2 User guide
IEC/TR 60870-6-505-am1 Ed. 1.0	Amendment 1 - Telecontrol equipment and systems - Part 6-505: Telecontrol protocols compatible with ISO standards and ITU-T recommendations - Tase.2 User guide
IEC 60870-6-601 Ed. 1.0	Telecontrol equipment and systems - Part 6: Telecontrol protocol s compatible with ISO standards and ITU-T recommendations - Sect ion 601: Functional profile for providing the connection-oriente d transport service in an end system connected via permanent acc ess to a packet switched data network
IEC/TS 60870-6-602 Ed. 1.0	Telecontrol equipment and systems - Part 6-602: Telecontrol protocols compatible with ISO standards and ITU-T recommendations - TASE transport profiles
IEC 60870-6-701 Ed. 1.0	Telecontrol equipment and systems - Part 6-701: Telecontrol protocols compatible with ISO standards and ITU-T recommendations - Functional profile for providing the TASE.1 application service in end systems
IEC 60870-6-702 Ed. 1.0	Telecontrol equipment and systems - Part 6-702: Telecontrol protocols compatible with ISO standards and ITU-T recommendations - Functional profile for providing the TASE.2 application service in end systems
IEC 60870-6-802 Consol. Ed. 2.1 (incl. am1)	Telecontrol equipment and systems - Part 6-802: Telecontrol protocols compatible with ISO standards and ITU-T recommendations - TASE.2 Object models
IEC 60870-6-802-am1 Ed. 2.0	Amendment 1 - Telecontrol equipment and systems - Part 6-802: Telecontrol protocols compatible with ISO standards and ITU-T recommendations - TASE.2 Object models
IEC/TR 61850-1 Ed. 1.0	Communication networks and systems in substations - Part 1: Introduction and overview
IEC/TS 61850-2 Ed. 1.0	Communication networks and systems in substations - Part 2: Glossary
IEC 61850-3 Ed. 1.0	Communication networks and systems in substations - Part 3: General requirements
IEC 61850-4 Ed. 1.0	Communication networks and systems in substations - Part 4: System and project management
IEC 61850-5 Ed. 1.0	Communication networks and systems in substations - Part 5: Communication requirements for functions and device models
IEC 61850-6 Ed. 1.0	Communication networks and systems in substations - Part 6: Configuration description language for communication in electrical substations related to IEDs
IEC 61850-7-1 Ed. 1.0	Communication networks and systems in substations - Part 7-1: Basic communication structure for substation and feeder equipment - Principles and models
IEC 61850-7-2 Ed. 1.0	Communication networks and systems in substations - Part 7-2: Basic communication structure for substation and feeder equipment - Abstract communication service interface (ACSI)
IEC 61850-7-3 Ed. 1.0	Communication networks and systems in substations - Part 7-3: Basic communication structure for substation and feeder equipment - Common data classes
IEC 61850-7-4 Ed. 1.0	Communication networks and systems in substations - Part 7-4: Basic communication structure for substation and feeder equipment - Compatible logical node classes and data classes

Electricity Metering (IEC)	Description
IEC 61850-7-410 Ed. 1.0	Communication networks and systems for power utility automation - Part 7-410: Hydroelectric power plants - Communication for monitoring and control
IEC 61850-8-1 Ed. 1.0	Communication networks and systems in substations - Part 8-1: Specific Communication Service Mapping (SCSM) - Mappings to MMS (ISO 9506-1 and ISO 9506-2) and to ISO/IEC 8802-3
IEC 61850-9-1 Ed. 1.0	Communication networks and systems in substations - Part 9-1: Specific Communication Service Mapping (SCSM) - Sampled values over serial unidirectional multidrop point to point link
IEC 61850-9-2 Ed. 1.0	Communication networks and systems in substations - Part 9-2: Specific Communication Service Mapping (SCSM) - Sampled values over ISO/IEC 8802-3
IEC 61850-10 Ed. 1.0	Communication networks and systems in substations - Part 10: Conformance testing
IEC/TS 61850-80-1 Ed. 1.0	Communication networks and systems for power utility automation - Part 80-1: Guideline to exchanging information from a CDC-based data model using IEC 60870-5-101 or IEC 60870-5-104
ISO/IEC 14543-2-1	Information technology - Home electronic system (HES) architecture - Part 2-1: Introduction and device modularity - **(NOTE: ISO/IEC 14543 aligns with European Standards EN13321-1/2 & EN 50090)**
ISO/IEC 14543-3-1	Information technology - Home electronic system (HES) architecture - Part 3-1: Communication layers - Application layer for network based control of HES Class 1
ISO/IEC 14543-3-2	Information technology - Home electronic system (HES) architecture - Part 3-2: Communication layers - Transport, network and general parts of data link layer for network based control of HES Class 1
ISO/IEC 14543-3-3	Information technology - Home electronic system (HES) architecture - Part 3-3: User process for network based control of HES Class 1
ISO/IEC 14543-3-4	Information technology - Home electronic system (HES) architecture - Part 3-4: System management - Management procedures for network based control of HES Class 1
ISO/IEC 14543-3-5	Information technology - Home electronic system (HES) architecture - Part 3-5: Media and media dependent layers - Powerline for network based control of HES Class 1
ISO/IEC 14543-3-6	Information technology - Home electronic system (HES) architecture - Part 3-6: Media and media dependent layers - Twisted pair for network based control of HES Class 1
ISO/IEC 14543-3-7	Information technology - Home electronic system (HES) architecture - Part 3-7: Media and media dependent layers - Radio frequency for network based control of HES Class 1
ISO/IEC 14543-4-1	Information technology - Home electronic system (HES) architecture - Part 4-1: Communication layers - Application layer for network enhanced control devices of HES Class 1
ISO/IEC 14543-4-2	Information technology - Home electronic system (HES) architecture - Part 4-2: Communication layers - Transport, network and general parts of data link layer for network enhanced control devices of HES Class 1
Interface	
IEC 61970-1	Energy management system application program interface (EMS-API) Part 1: Guidelines and General Requirements
IEC/TS 61970-2	Energy management system application program interface (EMS-API) - Part 2: Glossary

Electricity Metering (IEC)	**Description**
IEC 61970-301	Energy management system application program interface (EMS-API) Part 301: Common information model (CIM) base
IEC 61970-302	Energy management system application program interface (EMS-API) - Part 302: Common information model (CIM) financial, energy scheduling and reservations
IEC/TS 61970-401:2005	Energy management system application program interface (EMS-API) - Part 401: Component interface specification (CIS) framework
IEC 61970-402	Energy management system application program interface (EMS-API) Part 402: Common services
IEC 61970-403	Energy management system application program interface (EMS-API) Part 403: Generic data access
IEC 61970-404	Energy management system application program interface (EMS-API) Part 404: High speed data access (HSDA)
IEC 61970-405	Energy management system application program interface (EMS-API) Part 405: Generic eventing and subscription (GES)
IEC 61970-407	Energy management system application program interface (EMS-API) Part 407: Time series data access (TSDA)
IEC 61970-453	Energy management system application program interface (EMS-API) Part 453: CIM based graphics exchange
IEC 61970-501	Energy management system application program interface (EMS-API) Part 501: Common information model resource description framework (CIM RDF) schema
IEC 61968-1	Application integration at electric utilities - system interfaces for distribution management Part 1: Interface architecture and general requirements
IEC/TS 61968-2	Application integration at electric utilities - System interfaces for distribution management - Part 2: Glossary
IEC 61968-3	Application integration at electric utilities - system interfaces for distribution management Part 3: Interface for network operations
IEC 61968-4	Application integration at electric utilities - system interfaces for distribution management Part 4: Interfaces for records and asset management
IEC 61968-13	Application integration at electric utilities - System interfaces for distribution management - Part 13: CIM RDF Model exchange format for distribution
Data exchange security	
IEC/TS 62351-1:2007	Power systems management and associated information exchange - Data and communications security - Part 1: Communication network and system security - Introduction to security issues
IEC/TS 62351-2	Application integration at electric utilities - System interfaces for distribution management - Part 2: Glossary
IEC/TS 62351-3:2007	Power systems management and associated information exchange - Data and communications security - Part 3: Communication network and system security - Profiles including TCP/IP
IEC/TS 62351-4:2007	Power systems management and associated information exchange - Data and communications security - Part 4: Profiles including MMS
IEC/TS 62351-6:2007	Power systems management and associated information exchange - Data and communications security - Part 6: Security for IEC 61850

Other Defacto standards, TRs, FDIS, CDs

Standard	**Description**

Standard	Description
ZigBee Smart Energy Profile	HAN protocol based on IEEE 802.15.4 MAC and PHY.
PCI - DSS	Code of practice for payment card Industry for the holding of Credit and Debit Card details and persona data.

Other IEC standards and activity

Standard	Description
IEC 61400 - 21	Power quality for grid connected wind turbines.
IEC 61400 - 27	Generic electrical simulation models for wind power.
WG AHG 4	Intelligrid methodology for developing requirements for energy system
TC 08 - MT1	Maintenance of EN/IEC 60038, IEC 60059, IEC 60196