STAKEHOLDERS' REQUIREMENTS ANALYSIS REPORT
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STAKEHOLDER' REQUIREMENTS ANALYSIS REPORT

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Authors	**Doina Dragomir (ASRO)** **Christoph Nölle (IWES)** **Speranta Stomff (ASRO)**		
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1 EXECUTIVE SUMMARY

This document is a deliverable of the European project "STARGRID – STandard Analysis supporting smart eneRgy GRID" on Seventh Framework Programme – FP7.

One of the general goals of the STARGRID project is to provide a mapping and analysis of current Smart Grid standardization activities, including industry developments, and recommendations for further actions, in order to sustain Smart Grid deployment. The analysis will be based on a set of stakeholder requirements and evaluation criteria for relevant documents, which are laid down in this report. Those have been identified through the study of existing documents such as different position papers issued by industry associations, through the participation to and the organization of industry workshops. The results will further be verified through a questionnaire that has been distributed to the stakeholders.

Furthermore, information for this document was deduced from various Smart Grid Standardization documents, namely from IEC SMB Smart Grid Strategic Group (IEC Roadmap [1]), CEN-CENELEC-ETSI Smart Grid Coordination Group (SG-CG) [2], [3], NIST [4], ENISA [5], ITU [6], IEEE [7] and from other European/international organisations involved in the standardisation work.

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GLOSSARY

AC - Alternating Current

AMI - Advance Metering Infrastructure

BEMS - Building Energy Management Service

CEMS – Customer Energy Management System

CPN - Customer Premises Network

DA - Distribution Automation

DC - Direct Current

DER - Distributed Energy Resources

DR –Demand Response

DSO – Distribution System Operator

EPRI - Electric Power Research Institute

EMS - Energy Management System

ESI - Energy Service Interface

EV – Electric Vehicle

GIS - Geographic Information System

HAN - Home Area Network

ICT - Information and Communication Technology

IEC -The International Electrotechnical Commission

ISO – The International Organization for Standardization

LAN - Local Area Network

NIST - National Institute of Standards and Technology

ODP - Open Distributed Processing

PEV - Plug-in Electric Vehicles

PLC - Power Line Communication

SCADA - Supervisory Control and Data Acquisition

SGAM - Smart Grid Architecture Model

SGCG – Smart Grid Coordination Group

SGIP – Smart Grid Interoperability Panel

TSO - Transmission System Operator

UHV - Ultra-High Voltage

1 INTRODUCTION

1.1 BACKGROUND

The Power System is more complex than many other systems, due to the fact that this consists of two large categories of complex systems: the energy domain on the one hand and the information and communication infrastructure on the other hand. These systems, including their components, have to work together in order to assure the highest level of performance and security. Moreover, all systems shall fulfil their functionalities in a "smarter" manner according to the high-level requirements imposed by smart grid stakeholders to maintain the continuity of operations within power system. Intelligent electronic devices and communication protocols have to be integrated into power systems, in order to facilitate the information management between all interfaces and assure the functional requirements and security.

Smart grid solutions are defined in international/regional/national publications (e.g. standards, technical reports, technical specifications, and other publications), company standards etc. and their operation is ruled by technical regulations such as grid codes. The international and European standards are the result of the work of technical committees in the international standardization organizations (International Electrotechnical Commission - IEC, International Standardization Organisation - ISO, International Telecommunication Union - ITU) and European standardization organizations (European Committee for Standardization - CEN, European Committee for Electrotechnical Standardization - CENELEC, European Telecommunications Standards Institute - ETSI), supported by the industry and research institutions.

Concerning the smart grid issues, technical committees involved through the European Commission Mandate M/490 – Smart Grid (CEN/CENELEC/ETSI) [8] have the task to prepare a suitable set of standards based on consensus of their members represented by relevant stakeholders. European standards represent means for the harmonious implementation of the international standards throughout Europe.

For the purpose of this project the available standards and drafts for smart grids (IEC, ISO, ITUT, IEEE) were identified and other industry initiatives were taken into consideration as well.

1.2 OBJECTIVES

The main goal of this document is to identify the smart grid stakeholders' requirements and the methodology and criteria for the evaluation of related standards. In practice, the information provided by this deliverable may be used as a guiding tool for the analysis process of a huge number of documents, such as technical regulations, company standards, European and international standards/drafts, research reports, and many other works related to industrial initiatives which provide smart grid solutions. In order to properly examine the large amount of documents, an appropriate methodology for the gathering process of smart grid stakeholders' requirements and the evaluation criteria for related documents have been defined.

A further objective of this work is to provide input for the implementation of investigation tools (e.g. on-line questionnaires) to gather first-hand information by stakeholders, like standardisation related opinions, requirements and gaps to be filled in

2 APPROACH TO AN APPROPRIATE DOCUMENTATION FOR SMART GRID REQUIREMENTS

A further objective of this work is to provide input for the implementation of investigation tools (e.g. on-line questionnaires) to gather first-hand information by stakeholders, like standardisation related opinions, requirements and gaps to be filled in.

2.1 METHODOLOGY FOR IDENTIFICATION OF SMART GRID PRIORITIES

The methodology for the identification of smart grid priorities is based on the definition of smart grid relevant use cases. The use cases represent a systemic engineering tool for defining a system or portion of a system behaviour from users' perspective. The user's requirements may be derived from the relevant use cases that can be collected from various technical experts within power systems [12]. The users include the project engineers, executives, design engineers, system engineers etc. The use cases will serve as tools for the analysis of technical requirements, because they provide detailed scenarios which specify the necessary usages of a system by a user and show how a component, subsystem, or entire system should respond to a request originated somewhere else. The general objective of the work for building use cases is to collect all requirements of the concerned functionalities in a structured way, according to a scenario and technical architectures. For more information see the standard

ISO/IEC/IEEE 42010:2011 "Systems and software engineering — Architecture description"[9], which gives an overview on general rules to build any system architecture. Therefore, an architecture viewpoint includes information on techniques used to create, interpret or analyse a view governed by this viewpoint, such as:

- correspondence rules, criteria and methods for checking consistency and completeness;
- evaluation methods;
- patterns, methods, metrics, design rules or guidelines, best practices as well as different examples in order to aid in performing the analysis of the relevant documents.

An architecture description may include the following viewpoints, as needed:

a) The Enterprise viewpoint:

- the purpose, scope and policies for a complex system/subsystem with open distributed processing ;

- roles played by the system/subsystems;

- activities undertaken by the system/subsystems.

b) The Information viewpoint:

- the semantics of information and information processing in an ODP system.

c) The Computational viewpoint: a functional decomposition of the system into objects which interact at interfaces.

d) The Engineering viewpoint: the mechanisms and functions required to support distributed interaction between objects in the system.

e) The Technology viewpoint: the selection of standards for the system, their implementation and testing.

The methods used within the STARGRID project for gathering of Smart Grid stakeholders' requirements are:

- the analysis of relevant use cases identified by standardisation committees, Smart Grid projects and other actors;
- workshops and interviews addressed to the relevant stakeholders;
- questionnaire to be circulated to the smart grid stakeholders.

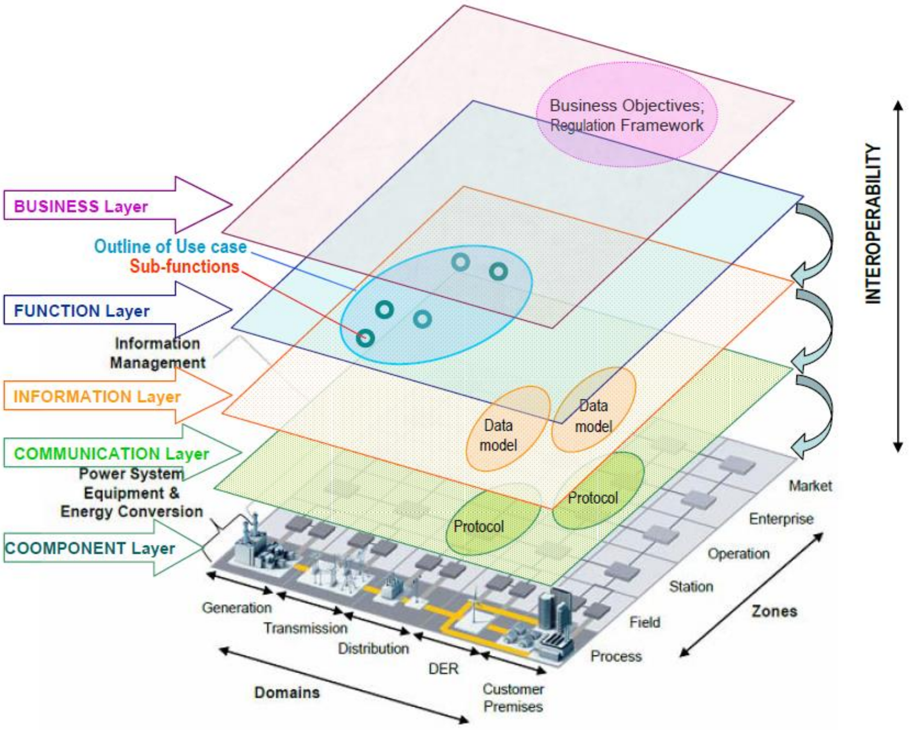

Figure 1: Smart Grid Architecture Model (SGAM)

(Initial sources: [3], [8] - SG-CG/M490/C)

In general, the management of power systems distinguishes between the electrical process (Energy domain experts) and the information (ICT domain experts) infrastructure. Each domain encompasses "Smart Grid actors" and "applications". The information gathered using the above mentioned methods shall be compared and selected, keeping in mind the roles of various actors in the energy industry. The roles of the energy industry actors are those related to the transmission operation (TSO is a stakeholder), distribution operation (DSO is a stakeholder), centralised/local operation, distributed energy resources connection and operation, energy market operations (the meter operator is a stakeholder, but its role may depend on the national regulations, e.g. in some cases it may coincide with the DSO), customer services, network management (taking into account only the technical considerations), and various others [10].

The mapping of the use cases proposed by Smart Grid Reference Architecture (SGAM) (WG Reference Architecture, SG-CG/RA) was deemed a key input for supporting the use cases' analysis. In compliance with the

mentioned SGAM, the Smart Grid "domains" (i.e. Bulk Generation, Transmission, Distribution, DER, Customer) refer to the operation aspects and the "zones" (i.e. Process, Field, Station, Operation, Enterprise, Market) refer to hierarchical system aspects of each domain. The third vertical dimension of the SGAM refers to the interoperability aspects (regarding the components, the communication, the information exchange, the internal functions to the use case and the business). To guarantee the interoperability, suitable standards are needed.

Taking into consideration the information exchanged throughout the layers within Smart Grid reference architecture, the steps of development for any use case are the following, starting from the investigation of the FUNCTION layer:

- The identification of the domains and zones affected by the use case;
- The use case boundaries in the Smart Grid reference architecture;
- The distribution of the sub-functions or services of the use case to appropriate location in the "Smart Grid" plan.

The above investigation steps are repeated for the next layers from top to bottom, i.e.: INFORMATION, COMMUNICATION and COMPONENT.

The final step is the check of the consistency of all layers (there are no gaps) and of the connection of all entities.

The use cases analysis can be seen as part of a methodology to improve the collaboration among the various key stakeholder communities and sectors (e.g. utilities, ICT providers, manufacturers, smart metering, home automation, etc.) and within the technical standardization committees. The process of extracting functional and non-functional requirements from use cases is described in detail in [12]. This method applies to concrete projects and allowed the project team to extract very specific requirements of the involved stakeholders. So far, the national standards bodies and countless stakeholders agreed on the fact that the use case methodology given in IEC PAS 62559, IntelliGrid methodology for developing requirements for energy systems, prepared by IEC/TC8/AHG4, represents the most effective way for the description of smart grids. In this context, the use case template for the energy systems are already suggested in an IEC coming standard (Committee Draft [13]) with contributions by the subgroup "Methods & Tools" of IEC/TC 8/AHG 4, which has been disbanded and replaced by two working groups: IEC TC8/WG5 "Methodology and Tools" and WG6 "Generic Smart Grid Requirements. Based on the collected data from the existing use cases at European level through the mandate M/490, a detailed description and a global consolidation between different domains shall be realised.

As said, the information provided by documented use cases (either generic or specialised use cases) will be used to gather the input data for the analysis process of technical specifications, specific rules from industry, technical regulations and standards in order to identify possible problems (gaps, overlaps, wrong priorities, criticalities, etc.) as output data for preparing and reviewing concerned publications. Grouping several use cases together into use case clusters, these latter being generic use cases or Smart Grid systems, someone may arrive to what we call system-specific requirements, which generalise and subsume the specific use case requirements. In this analysis we can consider the following Smart Grid requirements:

1) Generic requirements;

2) System-specific requirements;

3) Use Case-specific requirements.

STARGRID is mostly concerned with the system-specific requirements, since they are both general enough to allow for the necessary abstraction to reduce the complexity of the system, and sufficiently specific to develop meaningful and concrete evaluation criteria for standards. Standardisation committees, on the other hand, will be mostly concerned with use case specific requirements, taking into account all the detailed functional requirements of the specific use case(s) that shall be covered. however, not all Smart Grid systems identified by the SGCG will be treated by STARGRID and for the purpose of this document we concentrate on three Areas of Interest (using our own terminology), and namely:

• DER integration and grid control;

• Demand response and customer energy management;

• Smart metering.

As explained above, STARGRID organized a specific workshop and will collect the results of an on-line survey to consolidate the identified system-specific requirements.

2.2 CATEGORIES OF SMART GRID STAKEHOLDERS

Smart grid deployment implies a multitude of actions for designing, building and modernisation of power systems taking into consideration all stakeholders' requirements accordingly to their specific roles and the interactions among relevant actors (for example, equipment, devices, systems, programs and software tools, that support decisions and exchange information necessary for performing applications).

The main groups of stakeholders are given below:

- Bulk generation operators;
- Grid operators:
  - distribution system operators (DSO), and
  - transmission system operators (TSO).
- Distributed generation operators (DER operators) for:
  - photovoltaic systems;
  - wind turbines/farms;
  - cogeneration plants;
  - hydroelectric power stations.
- Manufactures of "smart" equipment, according to the key technologies identified by the Smart Grid information Clearinghouse [14]:
  - advanced components;
  - advanced control methods;
  - sensing and measuring devices, control devices;
  - improved interfaces and decision support;
  - integrated communication;

  - end customer products (e.g. smart appliances)
- Service and market providers:
  - aggregators (they want to create conditions for new market emergence);
  - energy trading (wholesale /retail trading),
  - meter operators;
  - telecommunication providers;
  - data management;
  - system integrators;
  - research, and others.
- Regulation and standardisation:
  - regulation authorities and politics (in particular, regarding EU policies, like the 2020 goals and the common electricity markets for electricity and gas);
  - standardisation organisations.
- Customers.

Except possibly for bulk generation operators, all of the above stakeholder groups are directly involved in the three Areas of Interest considered by STARGRID: DER integration and grid control; applications for demand response and customer energy management; smart metering. Having in mind the above mentioned aspects, there is no doubt that all smart grid stakeholders, thanks to their reliable experts in the energy and security domains, can provide technical expertise, during the analysis process of specific requirements gathered from relevant use cases and documents, to identify gaps between technical specifications and industrial requirements. Thus, the interoperability level between all interfaces may be evaluated by the overall analysis process of the functional/technical requirements in the existing documents, taking into account all smart grid stakeholders' requirements according to their specific roles, as actors on different application layer of the whole power system. The outcome of the analysis will result in recommendations for the development of harmonised standards and technical regulations.

2.3 TYPES OF SMART GRID STANDARDS

The generic term of "Smart Grid standards" covers those specifications that are important to the development of modern power system's capabilities, which respond to the new environmental and socio-economical challenges.

Taking into consideration the importance of the documents necessary for the development of smart grid strategy, the following categories can be distinguished:

- Standards which treat the most important aspects related to the sustainability and interoperability of Smart Grids. Those standards come first in rank. Sometimes parts of the requirements included in those documents are incorporated in regulations, thus being transformed into legal provisions. For instance, documents related to: safety and security practices (according to the roles and responsibilities of the actors on functional, information, communication and component layers), the interaction with external actors (business layer); the action on the environment etc.

- Guidance (e.g. codes of best practices that provide assistance in uniform deployment of the Smart Grid). This includes standardisation roadmaps and standards inventories.

- Informative standards that provide the background information on modern power system technologies (performance, design, construction, and environmental requirements), commercial aspects (e.g. product quality, product certification, test methods, contractual provisions, special requirements) and others. These documents are intended to be used by providers of technologies, products and services.

Besides it, each stakeholder perceives the standards according to its domain of interest and the interactions between different actors across smart grid plan. As a result, we can distinguish standards of: core, high, medium and low level, as they are named within IEC Roadmap.

Along with the true Standards, it is deemed necessary, in order to guarantee the harmonisation of the requirements for all stakeholders, to include in the analysis also the documents relevant to industrial and regulatory initiatives that may strongly affect the development of new standards in the near future. This is the case, for example, of the Grid Codes in preparation by the ENTSO-E, which are envisaged to urge deep changes in existing standards, as those establishing the (inter)connection rules and the security provisions.

Within the STARGRID project we distinguish between the following types of standards-like documents:

- Standard series
- Standard
- Technical specification
- Technical report
- Industry standard
- Code

The terms "Standard", "Technical report", and "Technical specification" are used consistently with the IEC definition, a "Standard series" is a collection of standards, usually sharing a common identifier (such as IEC 61850), and an "Industry standard" is any specification issued by an industry consortium, a company, or the like, without involving the general public in the process. A "Code" is a technical specification with legally binding provisions, typically providing requirements for the grid connection of devices, generation units, or other grid units to an electricity network.

3 GENERAL REQUIREMENTS

In general, the requirements are closely related to the interests of smart grid stakeholders, and their goals represent the general objectives for any system, including the power system as one of the critical infrastructures.

General requirements on smart grid standardization from societal point of view and also the most important requirements per stakeholder group are provided as follow.

3.1 HIGH-LEVEL REQUIREMENTS FOR SMART GRIDS RELATED TO STANDARDS

The following high-level requirements can provide an evaluation framework for smart grid solutions provided in the existing documents [1], [6],[15], [16] and [17]:

- Interoperability – networks, systems, devices, applications or components to exchange and readily use information, securely, effectively and with little or no inconvenience to the user. The system will share a common meaning of the exchanged information and this information will elicit agreed-upon types of response." [definition by NIST]
- Performance – the smart grid requires high-performance hardware and software;
- Security – the network should be secured with strong cryptography and security across all layers and at every endpoint;
- Multi-purpose architecture (modularity);
- Manageability – utilities should be able to apply standard IT skill sets in managing the network and applications;
- Scalability – the hardware and software needs to scale and support millions of endpoints (in other words, scalability means criteria for a cost effective system while recognizing various functionalities, various intelligent electronic devices, sub-station sizes and substation voltage ranges);
- Self-configuring, self-healing – in case of a problem, the network shall be able to quickly detect, respond and recover while minimizing downtime and losses. For this reason, the flexibility of the automation system is required to enable the development of hardware and software configurations. The automation system expandability depends on the functional and physical architecture and the resulting dependency between functional parts.
- Affordability – the Smart Grid shall reduce the overall operating costs for the electricity network. Technological components will be used at a large scale, and standards must enable the development of reasonably priced products.
- Consumer empowerment – smart grid should enable customers to control their usage (the consumption of energy);
- Longevity – future proof solutions

3.2 HIGH-LEVEL REQUIREMENTS FOR STANDARDS OF INDIVIDUAL STAKEHOLDER GROUPS

The general requirements as well as the specific requirements are being collected by STARGRID partners in different ways: online survey - questionnaires, workshops and an analysis of all relevant publications prepared by the entities involved in development of Smart Grid standards. For example, NIST, IEEE, CIGRE, ENTS0-E **Fehler! Verweisquelle konnte nicht gefunden werden.** (as new partner of CENELEC in CLC/BTWG 143-2, ENTSO-E standardization activities) and EURELECTRIC [18] represent only a part of the well-known partners of the European and international standardisation organizations.

The project will gather and analyse industry opinion regarding existing Smart Grid technical regulations , standards and drafts included visit to a selected number of industry fairs.

All stakeholders directly involved in the electricity generation, transmission, distribution and consumption have different expectations. For the purpose of this document, the high-level requirements of each stakeholder group are given below:

a) Requirements from the perspective of grid operators (DSO and TSO):

- Enable the system security with a high level of reliability and quality: the regular coordination at the level of generation and adequate performance of equipment connected to the networks;

- Support the robustness to face disturbances and to help to prevent any large disturbance or to facilitate restoration of the system after a collapse; enable quick detection, response and recovery while minimizing downtime and losses.

Based on the recommendations for smart grid standardisation in Europe, as developed by the European standardisation organisations, the distribution companies represented by EURELECTRIC (and EDSO for Smart Grids) have identified the major standardisation priorities for the distribution business. Their work is focused on the following main application areas:

- Peak Demand Management;
- DER integration and management;
- EV integration and management;
- Flexible load integration and management;
- Power Quality management;
- Grid Optimisation (operation, maintenance and loss reduction);
- Storage systems.

b) Requirements from the perspective of distributed generation operators:

- Transparent and non-discriminatory criteria for grid access;
- Clear and stable rules for the operation of DER.

c) Requirements from producers' perspective:

- The stability of standards and regulatory requirements.
- Clear testing and certification procedures.
- The interoperability solutions can only be achieved through the effective employment of standardisation, possibly by using open standards to the maximum extent possible. Technical interoperability requirements include hardware, equipment, components and systems, procedures and human dimensions.

• The security requirements well defined in conformity with the maturity of the industry-level.

• The equipment manufacturers are interested in early standardisation, because they need suitable standards for the design of new products.

d) Requirements from the perspective of service providers:

• Clearly defined processes for market communication, including standardised data models and message specification.

• Non-discriminatory data access.

• Standards should comprise principles for assessment methods of data risks within the smart grids, taking into consideration data privacy and security at various interfaces points and the system as a whole.

• Suitable standards and principles to support all relevant legal requirements, especially the fundamental right of individuals (they should be able to control the use of their personal data and information).

e) Requirements from the perspective of regulation authorities and governments in order to create a competitive and sustainable energy market:

• compatibility of standards with regulatory aims.

• open standards to apply economies of scale, promote competition and innovation, and speed up the smart grid deployments.

f) Requirements from customer' perspective:

• When integrating the "smart" consumer appliances and intelligent devices in the smart grids, the consumers' preferences and privacy shall be respected.

• Standards should enable simple and standardised handling of devices.

• Communication software/standards shall be opened, to avoid vendor-lock in; flexible, secure, and limited in number.

• Assurance of data protection and privacy.

• Health concerns appropriately addressed.

• Customers are wailing to reduce the electricity cost, to meet environment targets and to enjoy of the power quality.

4 SYSTEM-SPECIFIC REQUIREMENTS

In this section we collect functional/technical and non-functional requirements related to specific Smart Grid systems. These systems comprise a set of Use Cases and Business Cases (although the latter will not be mentioned here), and the system requirements can be thought of as integrated requirements of these Use/Business Cases.

Functional requirements have a great impact on the overall power systems. The public and private /companies available standards can give technical specifications for equipment design, building, conformity assessment, test methods, etc. The conformity assessment is important for the good functioning of the power system because this is the best way to assure that various units/components are in line with the functional requirements. When the functional requirements are translated into more exact figures, we obtain a set of technical requirements for each component in the power system (for example, a set of technical requirements for grid connection of generators). Therefore, the evaluation criteria of smart grid solutions in the existing technical documents are mainly focusing on the fulfilment of technical/business requirements imposed by all categories of actors, considering the optimum condition for grid operation.

In general, the smart grids consist of different areas with more specific requirements of safety, security and flexibility as a consequence of the integration of renewable energy resources with great impact on the overall system. In this respect, the interconnection rules, monitoring and grid control, demand responses and smart metering systems are few special topics that imply achieving of an appropriate documentation for development and analysis of relevant use cases. Therefore, one of the goals of STARGRID project is to evaluate the industry initiatives and standardization landscape focussing on the stability of power systems - the interconnection rules, monitoring and grid control in relation to DER integration, on the one hand, as well as on required capabilities for Smart Grid – especially to ICT applications and security, on the other hand. The choice of relevant use cases is based on input from affected stakeholders.

For the purpose of this document, specific Smart grid requirements have been identified and evaluated by STARGRID partners on basis of generic use cases provided by Smart Grid Coordination Group (SG-CG) in the Use Cases Management Repository. In addition, a set of general high-level use cases associated to the Advanced Metering Infrastructure (AMI) in the "First Set of Standards" document of SG-CG have been analysed. All mentioned uses cases and related requirements have been evaluated by the STARGRID partners within different teleconferences and workshops. In this context, first workshop has been the "Industry statement for a conformed standardisation framework", held in Brussels, on May 16th 2013, and an online survey will be conducted, on which the prioritisation of requirements presented in the following section will be based. Moreover, the second workshop has been organised in Bucharest –Romania, on September 11th2013, and also it was followed by an on-line survey.

4.1 DER INTERGRATION AND GRID CONTROL

This system is split in two parts – Interconnection rules and Grid Control.

4.1.1 INTERCONNECTION RULES

The Smart Grid concept reunifies technologies, concepts, architectures and strategies intended to increase the performances of distribution and transmission systems. One of the main targets of smart grid deployment is the improvement of power supply service for consumers. These can be used in the operation or establishment of the electricity networks. The integration of new technologies into power systems requires the access to the electricity networks by different interconnection actions. In general, the interconnection rules refer to:

- the interconnection between two neighbouring power systems or the interconnection of certain sides of these power systems, that are operating isolated;
- the connection of one generator to the interconnected electricity network (when the electricity network has at least one connexion to the power system);

- the connection of one generator to the isolated electricity network (microgrid), either as single power source or in parallel with other sources. In this context, the microgrids can operate either to direct current (DC) or alternating current (AC).

The types of the above interconnections may be achieved in the following ways:

- synchronous connection by direct connection;
- asynchronous connection using equipment based on power electronics devices;

The synchronous interconnections:

- the interconnection between two neighbouring power systems or the interconnection of certain parts of these power systems, that are operating isolated and at the same frequency;
- the grid connections, without intermediate equipment, of one synchronous or induction generator to an interconnected or an insulated electricity network in which there is already connected at least one source.

The asynchronous interconnections imply the use of intermediate equipment (in general, based on power electronics devices):

- the interconnection between two neighbouring power systems operating at different nominal frequencies;
- the connection of one synchronous or asynchronous generator, which is operating at variable frequency, to an interconnected or insulated network (AC or DC);
- the connection of a DC power source to an interconnected or insulated AC network.

4.1.1.1 Interconnection rules - Use Cases

The generic use cases for grid connection have been identified by SG-CG. Below we present a list of relevant generic use cases, together with the identifier in the SG-CG Use Case repository, where appropriate:

- ***Voltage control and power flows optimization* – WGSP-0200**

This use case is related to the automatic control of voltage profile and power flows in active distribution grids with locally connected generators.

- ***Microgrid Management* – WGSP-0400**

A microgrid is a low-voltage and/or medium-voltage grid equipped with additional installations which aggregates and manages largely autonomously its own supply- and demand-side resources. Some microgrids may produce enough electricity to meet the power needs of the users within the microgrid.

4. 1.1.2 Interconnection rules - Stakeholders

The stakeholders' group involved on "interconnection rules" is composed of: the grid operators (TSO and DSO), generators (Bulk generation: wind farms, large photovoltaic systems, cogeneration plants etc.), prosumers that combines the roles of producer (e.g. distributed energy resources) and consumer, smart devices/equipment manufacturers (e.g. FACTS), service providers, regulation authorities, end customers. In addition, any

interested group, such as research institutions and universities can contribute to smart grid projects' development [19].

4.1.2 GRID CONTROL

Power grid is monitored and controlled by a very large number of control centres, each being responsible for a portion of the grid. Therefore, the design of communication architecture between substations and control centres, and also between control centres, should be based on the reliable standards (e.g. standards for frequency control and voltage control). Supervisory Control and Data Acquisition (SCADA) systems are used to obtain data from the field or to exchange data between control centres.

Electric system reliability can be quantified taking into account the basic and functional aspects of power systems, namely adequacy and security. Some grid related use cases are describing existing functionalities, especially from power automation, network operation and monitoring. In this respect, the main use case clusters selected by Working Group Sustainable Processes (WGSP) of the Smart Grid Coordination Group (SG-CG) for monitoring and grid control are the following: blackout management, reconfiguring the network in case of fault, controlling the grid (locally/remotely) manually or automatically and access control to devices residing in a substation. Additionally, grid flow monitoring can be taken into account.

4.1.2.1 Grid control - Use Cases

Generic Grid Control Use Cases have been identified by SG-CG. Below we present a list of relevant generic Use Cases, together with the identifier in the SG-CG Use Case repository [11], where appropriate:

- ***Fault Location, Isolation and Restoration (FLIR)* – WGSP-0100**

FLIR automates the management of faults in the distribution grid. It supports the localization of the fault, the isolation of the fault and the restoration of energy delivery.

- **Generic use case *Monitoring the distribution grid* – WGSP-0600**

Once connected with a communication line the new smart grid devices and their communication possibilities (smart metering, substations) should also be used for better monitoring the grid on lower voltage levels. The European regulations provided by ENTSO-E can be used for the transmission grid. This information will be provided by SCADA system of the Distribution System Operator (DSO) and for further evaluation (e.g. fault identification, outage monitoring, etc.) and control. The increasing amount of DER providing energy to the distribution grid also on the lower voltage levels results in the need for better monitoring of power quality.

- **Generic use case *Emergency Signals* - WGSP-2300**

For emergency situations in the grid, the grid operator has a portfolio of options available in order to influence the situation (e.g. via reserve power). This use case describes the option to shut down consumption by intelligent load shedding via direct load management, if all other options have failed.

- **Congestion management by direct control - WGSP-0901**

The objective of this use case is to avoid grid congestion and local blackouts, by direct control of a DER (load(s) and/or generation unit(s)) in a specific grid area. Based on a load forecast and monitoring, the DSO can make direct monitoring and control of controllable DER units, based on the need for congestion management. This use case limits the connected DER regardless the user or market operator controls. As general rule, the grid congestion management shall be performed by matching the capacity through a bottleneck in the power grid with the power flow through it. This can be done by reduction of the power consumption (load) or raising the power production on the side of the bottleneck the power flows. Typically this would be where the consumers are.

In case of more load requests than grid capacity the local technical agent (e.g. grid operator) will reduce loads in accordance with local grid codes or other agreements with DER owner.

4.1.2.2 Grid control - Stakeholders

The relevant stakeholders for "grid control" are the following: grid operators (TSO and DSO), protection and communication equipment manufacturers, communication network operators (the engineers involved in the security assurance of power systems), service providers, regulation authorities.

4.1.3 DER INTERGRATION AND GRID CONTROL - REQUIREMENTS

- Requirements concerning the System architecture:
  - Grid management (Configuration and re-configuration; fault diagnosis, self-healing, island operation);
  - Safety (of the Grid and of the DER); protection schemes;
  - Safety of the personnel;
  - Seamless communication between control centres , substations and DER installations;
  - EMC compatibility.
- Requirements concerning operational aspects:
  - Forecasting of power and loads;
  - Electrical Connection of DER to the grid and disconnection;
  - Remote control of DER;
  - Integration into legacy grid control systems;
  - DER Monitoring and Sensors;
- Requirements concerning the provision of services:
  - Support Quality of Supply (Continuity, Voltage and Frequency stability, Fault Ride Through - FRT capability) - Ancillary Services;
  - Provision of flexibility by DER (control aspects).
- Requirements concerning Markets:

- Connection procedures;
- Aggregation of power and loads;
- Non- discriminatory Power Market access;
- Services Market (operation/flexibility conditions; revenue of the service).

- Requirements concerning Data handling:

  - Information and data exchange (definition of the information and data models);
  - Compliance of Testing and certification specifications (e.g. simulation models requirements);
  - Objective and non-discriminatory data access rules for service providers (like aggregators).
  - Access to the electric and energy market (including procurement).
  - Security of data and protection of the information.

- Requirements concerning Regulation:

  - Harmonized and stable technical interconnection rules at national and EU level.

4.2 SMART METERING

An important component of smart grids is the intelligent measurement which provides the necessary information to the power system operators and also to the users of energy for achieving an efficient energy market. In this respect, by 2020, 80% of the electricity users should be provided with intelligent metering systems for the energy used at European level.
Making a smart metering system requires achieving of an advanced metering infrastructure (AMI), which should provide a reliable communication between the smart meter and the network operator. The data provided should include the mark time for the information provided, the status of the system, the energy used, equipment controls, and the possibility of restoration in case of failure. AMI is a first step in the development of an advanced network infrastructure (Advanced Grid Infrastructure - AGI) which can give the nature of the smart grid to the power system structures. The advanced metering structure also plays an important role for the effective integration of renewable energy in the public distribution networks.

4.2.1 SMART METERING – USE CASES

The following high-level use cases are taken from the technical report [22]. More detailed use cases can be found in the same document.

- *Remote reading of metrological registers and provision of these values to esignated market organization(s)* – SMCG-TR-UC-1;
- *Two-way communication between the metering system and designated market organization(s)* – SMCG-TR-UC-2;
- *To support advanced tariffing and payment systems*– SMCG-TR-UC-3;
- *To allow remote disablement and enablement of supply, and flow / power limitation*– SMCG-TR-UC-4;

- *To provide secure communication enabling the smart meter to export metrological data or display and potential analysis to the end consumer or a third party designated by the end consumer*– SMCG-TR-UC-5;
- *To provide information via web portal/gateway to an in-home/building display or auxiliary equipment*– SMCG-TR-UC-6.

4.2.2 SMART METERING - STAKEHOLDERS

The development of smart metering systems is determined by specific requirements of contemporary society, especially with the involvement of the metering operators, network operators, end customers (end users), equipment suppliers, the energy market operators, regulation authorities. Government aims at increasing the efficiency of the energy usage through on-line information of the energy used and incentives for appropriate modification of users' behaviour. In this document are given the main requirements of relevant end customers, manufacturers of smart equipment and providers.

4.2.3 SMART METERING - REQUIREMENTS

- Requirements concerning the System architecture:
  - Interoperability
  - Scalability
  - Security
  - Longevity
  - Modularity
- Requirements concerning the provision of services:
  - Remote meter reading and management
  - Remote connection/disconnection
  - Quality of Supply control
  - High availability
  - Load profile data
  - Usability of AMI for additional services
  - Provision of data from the AMI for grid control purposes (e.g. voltage and phase measurements)
  - Allow advanced information, management and control systems for services suppliers and customers
  - Provision of a variable price signal to customers
  - Fair and non-discriminatory data access for service providers
- Requirements concerning Consumer empowerment:
  - Billing based on actual consumption
  - Data privacy

- Affordability
- On-demand meter data access
- Data visualisation (consumption and billing information)
- Seamless change of provider (facilitate switching and moving)

► Requirements concerning Communications

- Standardised interfaces and data exchange formats
- Noise limitations ensuring PLC viability
- Secure communications (ensuring data integrity & confidentiality)
- Bidirectional communications
- Support for multiple and upcoming communication technologies
- Standardised data profiles

► Requirements concerning Regulation

- Mandatory security provisions (authentication and encryption, data management)
- European harmonisation of metering regulations

4.3 DEMAND RESPONSE AND CUSTOMER ENERGY MANAGEMENT APPLICATIONS

This section deals with use cases related to the provision of demand side flexibility to the grid or market. Several standardization projects exist in this field, dealing either with standards for communication of demand response signals from a service provider or grid operator to the end customer, for the intelligent devices required at the end customer's premises, or the gateway and customer energy management system (CEMS).

Another recent development in Europe is the proposed incorporation of demand response measures in the ENTSO-E Demand Connection Code (DCC) [20], partly as compulsory conditions for grid connection, partly setting the framework for bilateral contracts between grid operators and DR providers.

4.3.1 DEMAND RESPONSE – USE CASES

The following generic high-level use cases are taken from the use case repository [11], where more detailed use cases can be found as well.

► ***Receiving consumption, price or environmental information for further action by consumer or a local energy management system*** **– WGSP-2110**

This use case describes how information regarding price and environmental aspects is sent from upstream actors to CEM and how information regarding energy consumption or generation as well as smart device statuses are being sent back to the consumer and upstream actors.

► ***Direct load / generation management*** **- WGSP-2120**

Signals and metrological information are provided to the home/building via an interface called the Smart Grid Connection Point (SGCP). The following signals can be distinguished:

1. **Direct - load / generation / storage management**
2. **Emergencies**

The functions described below can be labelled as a "Direct load control" use case, following the definition of Eurelectric, which is referenced in the Sustainable Processes workgroup's report.

► ***Flexibility offerings*** **- WGSP 2128**

Flexibility offerings are sent from flexibility providers to one or more (potential) users of flexibility. These offerings are negotiated and if successful exercised by the acquiring party. The offerings state the available flexibility in the dimensions of time, power/energy and finance.

► ***Tariff synchronization*** **- WGSP-2140**

This use case describes how tariff synchronization between a CEMS and a smart meter takes place.

4.3.2 DEMAND RESPONSE – STAKEHOLDERS

The groups of stakeholders for "demand response" are: customers, grid operators, DER operators, energy market operators, smart manufacturers, service providers (aggregators in particular).

4.3.3 DEMAND RESPONSE – REQUIREMENTS

► Requirements concerning the System architecture:

- Modular architecture;
- Scalability;
- System Security.

► Requirements concerning the provision of services :

- Standardised market processes (such as customer or device de-/registration with a service provider);
- Fair and non-discriminatory data access for service providers.

► Requirements concerning the Ancillary Services:

- Direct remote load control;
- Incentives based load control;
- Baseline definition and service verification
- Support for Low Frequency Demand Disconnection and Low Voltage Demand Disconnection autonomous load disconnection in case of severe under frequency or under voltage;
- Support for System Frequency Control autonomous adaptation of suitable load/generation devices (e.g. temperature controlled devices) to the system frequency;
- Support for Active/Reactive Power Control load or generation remotely adaptable by the relevant network operator for re-/active power control;

- Support for Transmission Constraint Management load or generation remotely adaptable by the relevant network operator for the purpose of constraint management.

► Requirements concerning Consumer empowerment:

- Data privacy;
- Affordability;
- Simple handling of devices and software;
- Override option at any time in Demand Response programs;
- Data visualisation (e.g. operating schedules, tariff, weather forecasts).

► Requirements concerning Communication network:

- Standard communication interface: customer energy management system (CEMS) <-> market;
- Standard communication interface: CEMS <-> grid operator;
- Standard communication interface: grid operator <-> market;
- Bidirectional communications (feedback from the customer installation to grid or market operator);
- Integration of Home Gateways in legacy grid control systems;
- Security: authentication and encryption;
- Interface between customer energy management infrastructure and the advanced metering infrastructure (AMI) etc.
- Support for multiple and upcoming communication technologies.

► Requirements concerning Home Gateway:

- Standardised basic services, such as registration, access rights & authentication, data-transfer, etc.
- Standardised protocol translation (gateway functionality) ;
- Standardised runtime environment for applications; accessible to multiple service providers;
- Transparent forwarding of external control commands to connected devices;
- Providing status information on capabilities/connected devices to authorised third parties;
- Decent self-consumption;
- Specification of basic hardware requirements.

4.4 PRIORITISATION OF SPECIFIC REQUIREMENTS

Will be included in version 2 after the evaluation of the STARGRID online survey.

5 EVALUATION CRITERIA FOR SMART GRID DOCUMENTS AND ANALYSIS PROCESS

The evaluation criteria for standards are directly related to the stakeholder requirements identified above. As part of the standards analysis process we will evaluate in how far the requirements are fulfilled by a given standard/standardisation initiative. Along with the prioritisation of requirements obtained from a stakeholder survey, we will be able to assess the impact of standards and standardisation projects on the respective stakeholder groups.

An important step in the analysis process consists in taking of suitable decisions regarding which requirements are relevant to a given standardisation project – these can be requirements applying to the use cases explicitly in the scope of the project, or to adjacent use cases which are not covered, but could sensibly be included in the scope.

Besides the functional requirements related to specific use cases or business cases, the relation to other standards will be investigated during the analysis process, answering the following questions:

1. Are there any standards with (partly) overlapping scope? If yes, describe the overlap in terms of a Use Case, or a Use Case reference, and list the main differences between the standards.
2. Is the standard compatible with the IEC core Smart Grid standards? If applicable, specify the relevant interoperability layer(s) according to the SGAM and/or the OSI communication model and identify the (non-)compatible IEC standards.
3. Are there any mappings defined to other standards?
4. Any other known interoperability issues?

Other non-functional criteria that might play a role in the evaluation of standards include

a) Terms should be well-defined and used consistently throughout a standard (series), and preferably beyond.

b) Standards and standard series should be well structured in order to reduce complexity.

c) The scope should be clearly defined.

d) Readability.

e) Actual usage level of the standard.

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