Real proven solutions to enable active demand and distributed generation flexible integration, through a fully controllable LOW Voltage and medium voltage distribution grid

Market and business framework for rolling out of UPGRID innovative concepts

Report on market barriers for deployment of UPGRID innovative concepts

D7.1

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EXECUTIVE SUMMARY

The current report provides insight into the most important regulatory and market barriers that may hinder the deployment and the wider dissemination of UPGRID technologies. It is driven by other UPGRID work packages (WPs) and tasks: task 1.1 that defined the UPGRID sub-functionalities (see Annex I), the four demo WPs that materialise the sub-functionalities' real deployments and task 8.4 that performs cost benefit analysis (CBA) on them. In this context, the following classes of functionalities and the associated UPGRID innovation concepts are identified as presented in the following table.

TABLE 1.1. CLASSES OF FUNCTIONALITIES AND UPGRID INNOVATIVE CONCEPTS

Classes of functionalities		UPGRID innovative concepts
F1	Network monitoring, visualization and asset management	▪ Increased distribution network monitoring through the use of smart meters (SMs), distribution transformer supervision meters, advanced low-voltage (LV) supervision, smart grid cabinets for Secondary Substations (SSs) and Remote Terminal Units (RTUs) with Medium Voltage (MV) and LV monitoring sensors and Fault Passage Indicator (FPI) functionality. ▪ LV sound network representation. ▪ Multiservice PoweRline Intelligent Metering Evolution (PRIME) subnetwork. ▪ M2M Health and diagnosis tools to monitor communications. ▪ Web-based tool for energy consumption management.
F2	Improved supply restoration at low voltage (LV) and middle voltage (MV) levels (mainly LV)	▪ Use of LV Network Management System (LV NMS) with LV dispatching functional capabilities (desktop and mobile solutions). ▪ LV NMS integration with existing system (interfaces).
F3	Improved voltage quality (i.e. voltage magnitude)	▪ Smart transformer for automatically regulating voltage levels. ▪ Smart event processing and analysis for maintenance support, ▪ Virtual register for detailing voltage monitoring.
F4	LV network reconfiguration	▪ LV cable cabinet.
F5	Active Demand	▪ Combined use of Advance Meter Infrastructure (AMI) and Home Energy Management Systems (HEMS) for Active Demand Management (ADM). ▪ Market Hub.
F6	Electrical vehicle (EV) flexibility	▪ Monitoring of EV charging points.
F7	Integration of active micro-generation at the LV level	▪ New LV monitoring and control for photo voltaic (PV). ▪ LV grid remote control operation over PRIME infrastructure.

A set of market and regulatory issues are examined per Demo for each functionality class identified in the above table. The following list summarizes the covered topics:

I. Issues surrounding...
   a. the progress of the wide-spread Information and communication technology (ICT) and Smart Metering equipment roll-out.
   b. the functional capabilities of this equipment (e.g. being state-of-the-art or not).
   c. the data acquisition and data distribution across market actors.

II. Issues around...
   a. well-defined penalties and incentives able to motivate the Distribution System Operators (DSOs) towards achieving improved quality of supply, reduction of losses and reduced capital-intensive network reinforcement.
   b. the existence of an established supervising body that provides guarantees that incentives and penalties are applied in a timely fashion.

III. Issues related to...
   a. the existence of a regulatory framework that is conducive to innovation given that innovation may lead to more efficient network investment and operation.
   b. network investment planning and whether or not the regulatory framework prohibits for any reason the investment in Distributed Energy Resources (DER) technologies and UPGRID novel solutions and concepts.
   c. the existence of stable markets for flexibility for DER assets to participate so as to offer their flexibility potential.

The analysis found that issues (I) produce no market / regulatory barriers in any of the UPGRID Demo Areas. That is, the wide-scale roll-out of intelligent network monitoring equipment will continue without any market or regulatory barriers across all Demo Areas, with regulations surrounding the handling of the measured data for use only for improved network performance.

Regarding (II), no barriers are identified either in any of the four Demo Areas. That is, well-defined penalties and incentives are established within each regulatory framework surrounding quality of supply and cost-efficient capital investment. Additionally, in all Demo countries there is a supervising entity (National Regulatory Authority or also the Government) that guarantees fair and timely implementation of these penalties and incentives.

In terms of Issues (III), there are barriers that are related to the fact that

- stable markets where DER technologies (Demand Side Response (DSR), Electrical Vehicle (EV), Distributed Renewable Energy Sources (DRES)) can trade their flexibility have not yet been established (applies to all Demo Areas).
- the regulatory framework is not conducive for innovation (applies mainly to the Spanish, Swedish and Polish Demo Areas).
- the network investment planning process is regulated to provide to DSOs full return on investment only when the DSOs invest in technologies that belong to a list of technologies recognized by the Regulator (and this list currently does not include UPGRID technologies) and at established reference costs (applies to Sweden).

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ABBREVIATIONS AND ACRONYMS

ADM	Active Demand Management
AMI	Advanced Metering Infrastructure
CAPEX	Capital expenditure
CBA	Cost Benefit Analysis
DG	Distributed Generation
DTC	Distribution Transformer Controller
DER	Distributed Energy Resource
DRES	Distributed Renewable Energy Sources
DSO	Distribution System Operator
DSR	Demand Side Response
EU	European Union
EV	Electric Vehicle
FCS	Field Crew Support
FPI	Fault Passage Indicator
GIS	Geographic Information System, e.g. NetBas
HEMS	Home Energy Management System
ICT	Information and Communication Technology
LV	Low Voltage
MV	Medium Voltage
NMS	Network Management System
OPEX	Operational expenditure
PLC	Power Line Communication
PRIME	PoweRline Intelligent Metering Evolution
PV	Photovoltaic
R&D	Research and Development
RES	Renewable Energy Source
RTU	Remote Terminal Unit
SCADA	Supervisory Control And Data Acquisition
SM	Smart Meter
SNMP	Simple Network Management Protocol
SS	Secondary Substation
THD	Total Harmonic Distortion
TOC	Table of Contents
TOTEX	Total expenditure

ToU	Time of Use
TSO	Transmission System Operator
WP	Work Package

1. INTRODUCTION

Under the traditional distribution network planning regime, networks were designed to operate in passive mode resting on the assumption that the high level of redundancy would be adequate to cater for expected worst-case conditions such as high peak loading. That is, most operational issues were effectively resolved at the planning stage primarily through asset redundancy. However, the growing penetration of different Distributed Generation (DG) technologies and the imminent extensive electrification of transport demand pose questions regarding the economic sustainability of this regime. New technologies are emerging that aim to keep the MV and LV networks reliable during this transition. For instance, the LV monitoring and controllability enhancement using the solutions deployed in UPGRID project (e.g. smart meter data utilisation, LV sound network representation, LV NMS and LV control over PRIME) contribute to greater network visibility and, thus, more effective management of the LV network. This facilitates DSOs to reduce the uncertainties regarding feeder capacity levels and to increase the hosting capacity without jeopardising the quality of supply.

UPGRID project aims at testing in real-world the concept of active network management whose objective is to improve the utilisation and cost-effectiveness of distribution networks, mainly at LV level. The conducted LV monitoring and control provides DSOs with the appropriate interface to conduct further functions. Under this approach DSOs deal with constraints occurring in different system conditions by taking into account the dynamic nature of generation and demand while exercising real-time monitoring and control through a number of flexible components.

In this context, the principal aim of the current work is to identify barriers in the present regulatory and commercial framework of each of the UPGRID Demo countries (Spain, Portugal, Sweden and Poland) which may limit or prevent the wide-scale roll-out of the UPGRID innovative concepts and solutions.

1.1 SCOPE OF THE DOCUMENT

The UPGRID project, through its four Demos and the corresponding developed functionalities, models the transition to a smart distribution network by deploying a series of smart technologies to achieve objectives characteristic of the smart grid era.

However, the implementation of these technologies as part of UPGRID does not guarantee their wider dissemination and deployment, which is a key objective of UPGRID. Specifically, without an appropriate regulatory and market framework the dissemination of the generated knowledge runs the risk of finding little application. In this regard, the scope of UPGRID task 7.1 is to inform about each Demo’s regulatory and market framework and identify existing barriers, expanding the initial analysis conducted within deliverable D1.2 [2].

1.2 CONNECTION OF TASK 7.1 WITH THE REST WPS

The current report contains fundamental links with the rest WPs; this interconnection is of high importance.

Specifically, considerable links exist with: tasks 1.1 that defined the UPGRID sub-functionalities [1], the four demo WPs that materialise that sub-functionalities real deployments and task 8.4 that performs CBA on them [3][1], [4].

1.3 STRUCTURE OF DELIVERABLE D7.1

The remaining sections of this report are organized as follows: Chapter 2 presents an analysis of key European – funded projects in terms of the market and regulatory references that they include and that can be of relevance to UPGRID. Chapter 3 mentions the functionalities developed per Demo Area and includes relevant market and regulatory Issues. Chapters 4, 5, 6 and 7 present analysis of these issues for each of the Demo Areas while Chapter 8 concludes the analysis.

[11] D8.4 has not been published at the moment of finishing the present deliverable.

2. OVERVIEW OF THE MARKET AND REGULATORY FRAMEWORK WITHIN EU-FUNDED PROJECTS

The European Union has been placing significant attention on Research and Development (R&D) projects geared to accelerate the transition from the current passive electricity network to a smarter and more sustainable grid, with specific focus on distribution networks. To this end, a list of EU-funded projects can be identified within the Community Research and Development Information Service or CORDIS, which is the European Commission's primary information source for EU-funded projects since 1990.

In order to carry out the literature review presented in this Chapter, an initial selection of smart grid projects was made from within the aforementioned CORDIS database with the main criterion being their relevance to the smart grid era as well as their close relation with functionalities developed as part of the UPGRID project. Subsequently, these projects were analysed with the purpose of recognizing within their deliverables topics that are touching upon market and regulatory issues.

This comprehensive analysis has resulted in the selection of two projects as the most relevant ones, namely the evolvDSO, and the ide4L as each covers a different and important part of the electricity market and regulatory framework. In particular, the evolvDSO [5] project focuses on aspects relevant to the evolving roles of DSOs within the smart grid era, while ide4L [6] looks into the central concepts of Aggregation and Distribution Automation. For each of these projects, emphasis has been placed on extracting the main high-level conclusions generated from their market and regulatory framework analysis.

2.1 THE EVOLVDSO PROJECT

EvolvDSO, a European-Commission funded FP7 project, was underway from September 2013 until December 2016 with the involvement of sixteen partners (including Enel, EDP, INESC and RWTH) spread over eight countries (Italy, Portugal, France, Ireland, Denmark, Germany, Austria and Belgium).

The main motivation behind the implementation of this project was the need for DSOs to adapt to challenges that the increasing penetration of DRES in distribution systems brought about. From this perspective, it was deemed essential to analyse how these challenges could trigger the creation of new roles for DSOs and how these roles could fit within the evolving market and regulatory framework delineated within the smart grid paradigm.

Prior to mentioning these evolving DSO roles, it would be essential to describe in brief the methodology that was followed by the evolvDSO partners and that allowed for the main evolvDSO motivation to materialize into concrete well-defined new DSO roles. In this regard, the project began with the definition of a number of evolving scenarios, which tried to capture the future from within multiple perspectives around the growth in renewables, the level of smart grid technologies uptake and the number of sources of system flexibility.

In order to cope with this evolution, it was recognized by the partners that the roles and the services provided by the DSOs should evolve so as to retain or even augment the level of the provided service quality to the end user within the future smart grid paradigm.

As a result, a number of functionalities relevant to business and system development as a whole were developed and described in detail for each DSO service, thereby leading to the definition of technical requirements and tools needed for the support of the evolving DSO roles. The developed software and optimization tools covering a number of domains were validated through field simulation tests, carried out in real - life conditions. The synthesis of the tools, business and system use cases (functionalities) along with the perspectives of the different partners of the project led to the definition of the evolving DSO roles, corresponding to various levels of innovation as presented in Figure 2.1.

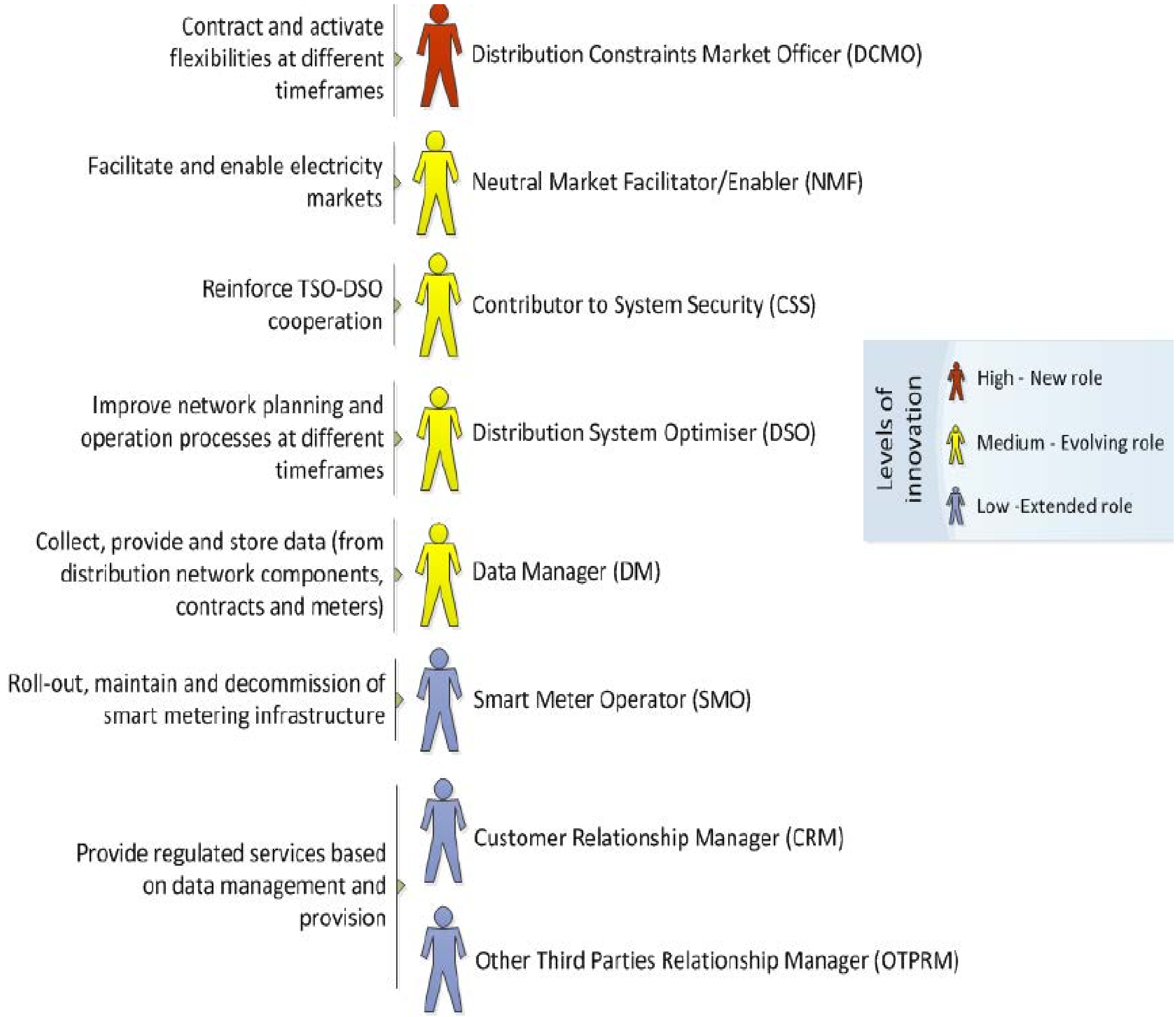

FIGURE 2.1. EVOLVING DSO ROLES FOR ADDRESSING THE CHALLENGES OF THE SMART GRID ERA [5].

Note that the 'Distribution Constraints Market Officer' role constitutes a suggested new and highly innovative DSO role aiming at the reliable provision of the service of contracting flexibility resources for use during events of local network constraints, through the use of novel software and optimization tools including a distribution network expansion model, a contingency simulation tool accompanied by other network reliability tools. In other words, this role will be central to the recognition of flexibility sources in the distribution network as well as to the exploitation of these sources by considering all market actors on a fair and equal basis.

In order to implement the evolving DSO roles, the evolvDSO project recognizes the importance of establishing a hosting market and regulatory environment that encourages innovation. To this end the deliverables of the evolvDSO project place emphasis on the fact that DSOs have been unbundled from generation companies in all the countries that participate in the evolvDSO project and this particular aspect is characterized as positive towards the creation of a level playing field for all market actors in the smart grid era.

Moreover, the topic of remuneration schemes is analysed by stating the fact that incentive remuneration takes place in all participating countries and is shown to be incentivizing them to operate in a cost efficient manner. As part of this remuneration approach, DSO-performance indices and costs are compared to an industry standard with the remuneration being allocated in accordance with the achieved efficiency. Additionally, in terms of the current situation surrounding the quality of service it is recognized that current regulatory frameworks have started placing relatively greater importance on aspects relevant to Customer service, voltage quality and continuity of supply, as reliability [7] in the provision and supply of electricity has been at the forefront of attempts made to develop a smarter grid. In this vein, all participating countries monitor quality of service even if there may not be considerable or any amount of remuneration scheme tied to this monitoring.

Additionally, analysis performed within the deliverables of the evolvDSO project involves market designs within Europe. In this context, it is recognized that the trend towards market synchronization is growing noting as a particular example the price coupling of northern European markets to the Central West Europe CWE and mentioning the North Western European price coupling as well. Another vital aspect of current market and regulatory frameworks is relevant to DSR and in broader terms to the demand – side flexibility resources. It is recognized that such level of flexibility is very limited when it comes to small users or Aggregators.

However, it is envisaged that the full roll out of SMs will enable Consumers to actively participate in DSR programs. Thus, although currently such programs are aimed mostly at large industrial Consumers, Consumer aggregation is expected to take place in the near future after the introduction of Smart Metering systems at end-user level. Additionally, in a more general perspective and concerning flexibility through controllability of resources (e.g. controlling and managing the DRES or consumption units) it is noted that currently in countries that allow such controllability capabilities, the DSOs are only allowed to perform actions on third parties only in cases of emergency and not for optimal network planning.

The analysis concludes that there are three main topics to be addressed in future regulatory frameworks. These are the following.

- The need for greater levels of coordination between the wholesale market, the TSO and the DSO.
- The need for DSOs to perform active network management, preventive and operational.

- The need for augmented levels of flexibility by allowing the DSOs to freely tap into such sources.

This analysis ends by noting that national regulatory frameworks will evolve in different ways in both the short and medium term, while the harmonization on a European level may occur in the long term after challenges are surpassed that deal with local circumstances. However, the harmonization at its core will involve markets and regulatory frameworks promoting a fair and efficient exchange of relevant information, providing incentives for innovation and encouraging stakeholders' participation at the greatest possible levels.

2.2 THE IDE4L PROJECT

The ide4L, a European-Commission funded FP7 project, was underway from September 2013 until August 2016 with the involvement of twelve partners including DTU, KTH, RWTH and Schneider Electric spread over multiple European countries including Finland, Spain, Sweden, Germany, Denmark and Italy.

The main motivation behind the implementation of this project was the need for enabling large-scale renewable energy sources penetration while at the same time enhancing the reliability of network operation.

As a result of operating within the aforementioned context of large-scale renewables penetration, the project placed emphasis on the development of technologies that will facilitate and enhance Active Distribution Network management so as to further the deployment of flexible smart technologies such as EVs and DSR within both low and medium voltage distribution networks. Such technologies include real-time monitoring and network state estimation, Aggregator scheduling and optimization, real - time and day-ahead congestion management and fault location/ isolation and supply restoration. All developed technologies were tested at Demonstration sites located in Denmark, Italy and Spain showcasing their successful implementation and readiness to be incorporated as integral parts of future networks.

Prior to the development of the aforementioned smart technologies, the ide4L project partners agreed that it would be necessary to lay out a clear definition for the concept of active network management. The reason for this lied in the need for future regulatory frameworks to adopt and embed such a terminology in a clearly defined way. This deliverable also lays the foundation for the definition of the Aggregator concept.

In particular, small-scale DERs that do not fall under the supervision and control of DSOs can be grouped under an Aggregator in order to operate in the energy market as one entity that sells services to DSOs or TSOs alike. At this point, a distinction is made between commercial and technical Aggregators. The former integrate small-scale DERs together in order to optimize their operation in the electricity market, whereas the latter do so in order to provide services to TSOs and DSOs alike. In this context, future regulatory frameworks need to allow such entities to have a full and transparent market presence. Particularly, commercial Aggregators may provide flexibility services such as:

- Price elasticity at the day-ahead market for managing price risk,
- Demand Response provision for managing risks and for minimizing balance costs.

- Distributed Generation flexibility to the day-ahead and intraday markets.

At the same time, technical Aggregators may offer ancillary services such as the following.

- Back-up power to TSOs.
- Power flow management (e.g. production curtailment, load shedding or demand response) to DSOs.
- Reactive power provision support and voltage control.

This defined concept of Aggregation is gaining traction and has already been mentioned in recent European energy law developments including the Energy Efficiency Directive 2012/27/EU and the Framework Guidelines on Electricity Balancing (ACER 2012). These legislation sources mainly emphasize the link between Aggregation and demand response provision. However, within the context of the ide4L project this concept is enhanced and aligned with the vision that Eurelectric has set out for Aggregation.

According to this vision, future regulatory frameworks should enhance Aggregation by allowing Aggregators to target long-term (grid planning and forward markets), day-ahead (energy/capacity markets) and intra-day (energy/capacity markets) time horizons. Aggregators could procure flexibility services such as constraints management at the TSO and DSO levels for reliability and quality of service through the resolution of thermal and voltage constraints as well as transient stability issues. In order for the described vision pertaining Aggregation to be realized, future regulatory frameworks need to address a number of issues, as follows.

- Market rules should be brought in line with the characteristics of Aggregated Prosumers.
- The European network code on electricity balancing should provide a level playing field for all flexibility providers.
- For the effective provision of constraint management and balancing operational management, regulation should take into account further coordination between TSOs and DSOs, thereby avoiding possible technical restrictions arising from the lack of information exchange between these actors.

Additionally, the ide4L project focuses extensively on the concept of distribution automation given its complexity due to the multitude of interacting actors. These actors will play an important role in future market designs and should be recognized within the evolving regulatory frameworks. For example, the interaction among commercial aggregators, DSOs and TSOs for the purchase and sell of flexibility resources is explained in detail noting their importance for efficient network operation. Examples of actors that will participate in future electricity networks and markets are as follows.

- Intelligent Electronic Devices distributed across the network and located in primary/secondary substations.
- DSOs and TSOs.
- Home Energy Management Systems, as the interface between Prosumers and other actors.

2.3 KEY POINTS

This section provides some key considerations regarding the applicability of the lessons learnt from the aforementioned EU-funded projects to UPGRID. Perhaps the most important conclusion that can be extracted relates to the fact that new and evolving roles for DSOs may well accommodate the functionalities implemented within UPGRID ([1] and Annex I) based on clearly delineated roles and services for all market users. UPGRID functionalities, sorted by order of significance for the project, which can be accommodated by these new DSO roles, are as follows:

- Monitoring and control of LV network (D7) can be accommodated by the role of Smart Meter Operator that involves the roll-out, maintenance and decommission of smart metering infrastructure as well as by the Distribution Constraints Market Officer involving controlling flexibility sources across the network.
- Smart metering data utilization (D10) can be accommodated by the role of the Data Manager whose aim is to collect, provide and store data collected from distribution network components, contracts and meters.
- Network management methodologies for network operation (D9) can be realized by the Distribution Constraints Market Officer involving activating flexibility sources across the network to achieve cost-effective and more reliable network operation. Additional support can be provided by the role of Distribution System Optimizer, which essentially pertains to conducting optimization for achieving optimal network operation.
- Novel approaches for market design (D13) can be accommodated by the role of the Neutral Market Facilitator/Enabler whose role is to enable and facilitate novel designs for markets and achieve efficient market operation.

3. IDENTIFICATION OF FUNCTIONALITIES AND RELEVANT REGULATORY ISSUES

The current Chapter provides insight into the market and regulatory issues corresponding to the functionalities implemented within each of the Demo Areas. This insight is founded upon the initial listing of functionalities as well as the subsequent CBA as included within deliverables D1.1 [1] and D8.4 [3] respectively.

In this context, section 3.1 displays a list of functionalities identified per Demo Area, while section 3.2 provides a mapping of these functionalities to relevant market and regulatory issues.

3.1 IDENTIFICATION OF FUNCTIONALITIES

Based on the extensive list of functionalities identified in UPGRID deliverable D1.1 (see Annex I) as well as the core functionalities determined in UPGRID deliverable D8.4, in the current report, classes of functionalities are identified for conducting analysis that allow the determination of market and regulatory barriers affecting the wider dissemination of smart UPGRID technologies.

As an initial step of the analysis, it is important to include the functionalities identified in UPGRID deliverable D1.1. These are shown in the tables shown below.

TABLE 3.1. LIST OF SUB-FUNCTIONALITIES SELECTED FOR CLUSTER 1: INTEGRATION OF SMART CUSTOMERS

D1. Active Demand for Increased Network Flexibility	
UPGRID Sub-functionalities	
LV customer consumption characterization	D1.1
Home Energy Management System to provide data to dynamic pricing simulator	D1.2
End user engagement to improve distribution network operation	D1.3

TABLE 3.2. LIST OF SUB-FUNCTIONALITIES SELECTED FOR CLUSTER 2: INTEGRATION OF DER AND NEW USES

D3. Integration of DER and new uses	
Sub- Functionalities	
Remote management of DER	D3.1

D6. Integration of infrastructure to host EVs	
Sub- Functionalities	
Consumption characterization of EV charging points (street stations)	D6.1

TABLE 3.3. LIST OF SUB-FUNCTIONALITIES SELECTED FOR CLUSTER 3: NETWORK OPERATIONS

D7. Monitoring and control of LV networks	
Sub- Functionalities	
Operation (control & multiservice) of LV grid devices using PLC-PRIME for different telecontrol applications (concept test)	D7.1
Queries to request advanced meter data to support operation	D7.2
Improvement the LV NMS visualization by integrating data measurements from inside SS (e.g. transformer meter, advanced LV supervision)	D7.3
Improvement the LV NMS visualization by integrating data measurements from LV network devices (e.g. customers SM, EV charging points, DER)	D7.4
Integration of the MV power transformer status from the MV systems to the LV NMS	D7.5
Integration of measurement data to support state estimation in LV NMS	D7.6
Integration of measurement data to support power flow analyses in LV NMS	D7.7
Integration of LV power flow and MV power flow analyses	D7.8
LV regulation at SS level using a new smart transformer	D7.9
LV meshed network operation - Remote reconfiguration (not fully automatic) of the LV network (grid protection)	D7.10
LV meshed network operation - identifying the optimal topological configuration	D7.11
Interoperability test of the integration of LV NMS with equipment from different manufacturers	D7.12

D8. Automation and control of MV networks	
Sub- Functionalities	
Monitoring MV network by fault detectors	D8.1

D9. Network Management Methodologies for network operation	
Sub- Functionalities	
Define a sound LV network (schematic diagrams and parameters of components)	D9.1
Use CIM for LV network modelling & data exchange between e.g. AMI, GIS, MV, SCADA, LV NMS	D9.2
Interface to manage PRIME subnetwork with Simple Network Management Protocol (SNMP)	D9.3
Implementation of NMS based on SNMP at SS level	D9.4
Visualization of data from LV NMS in a geographical context	D9.5
Internal DSO business processes review in relation with Outage Management	D9.6
Load and DG forecasting	D9.7

D10. Smart Metering Data Utilization	
Sub- Functionalities	
Integration and processing of meter events or/and other sources (e.g. telecom data) in the Outage Management System (OMS)	D10.1
Calculation of indicators for SM infrastructure e.g. the availability - KPI indicators to be used in a geographical context to assist the Network Operation Centre (NOC)	D10.2
Algorithm to determine connectivity of SM to the grid (identification of phase and line to which each SM is connected to)	D10.3
Calculation of non-technical losses using data from metering devices both in SS and LV network	D10.4

TABLE 3.4. LIST OF SUB-FUNCTIONALITIES SELECTED FOR CLUSTER 4: NETWORK PLANNING AND ASSET MANAGEMENT

D11. New Planning approaches for distribution networks	
Sub- Functionalities	
Data analytics based on historical network state data to assist network planning	D11.1

D12. New approaches to asset management	
Sub- Functionalities	
Data analytics based on historical network state data to assist maintenance	D12.1
Transformer replacement optimization based on historical data from meters inside SS	D12.2
Life Cycle Cost (LCC) calculations of best technical / financial solution with new equipment (e.g. ED)	D12.3
Deploy some mobile devices (e.g. tablet, smart phone) for accessing and visualizing remotely information from LV system (e.g. geographical context, assets and outage location) to support grid crews	D12.4

TABLE 3.5. LIST OF SUB-FUNCTIONALITIES SELECTED FOR CLUSTER 5: MARKET DESIGN

D13. New approaches for market design	
Sub- Functionalities	
Web portal for increasing the consumer awareness in order to leverage their participation in electricity markets	D13.1
Create market hub for relationship between DSO and suppliers	D13.2
Dynamic / Real time pricing based on DSO services and infrastructure (DSM) (simulator)	D13.3
Dynamic contractual power control	D13.4

The combination of the aforementioned Function Objectives and UPGRID Sub-functionalities has enabled the determination of groups of functionalities, per Demo Area, for recognizing market and regulatory issues. These are listed below (F1-F7), along with a brief description.

F1. Network monitoring and visualization

This group of functionalities involves the deployment and use of ICT equipment across the network (smart meters, distribution transformer supervision meters, advanced LV supervision, smart grid cabinets for SSs, RTUs with MV and LV monitoring sensors and FPI functionality) that enables remote extraction of valuable information (e.g. consumption measurements, loading levels, working status, etc.). This information forms an integral part of the successful implementation of all other functionalities as these data give DSOs more knowledge about the current LV network status (e.g. historical network and asset state data collection, geographical information etc.).

F1 finds application in the following Demo Areas, through D7.2, D7.3, D7.4, D7.5, D7.6, D7.7, D7.8, D9.1, D9.2, D9.3, D9.4, D9.5, D10.3, D11.1, D12.1 (Annex I):

- Spanish Demo
- Portuguese Demo
- Swedish Demo
- Polish Demo

F2. Improved supply restoration at both LV and MV levels (mainly LV)

This group of functionalities, mainly applied to LV level (as UPGRID is more focused on LV) involves more rapid fault detection and supply restoration, given that prior to its implementation faults were detected only following calls made by Customers. In UPGRID this functionality involves the installation and use of ICT infrastructure and systems with the principal deployed system for all four demos being the LV NMS that makes use of Outage Management capabilities and LV sound network modelling based on data that it receives. This is supported by desktop solutions for dispatching centres and mobility tools to support LV operation of field crews.

F2 finds application in the following Demo Areas, through D9.6, D10.1, D12.1, D12.2, D12.4 (Annex I):

- Spanish Demo
- Portuguese Demo
- Swedish Demo
- Polish Demo

F3. Improved voltage quality (i.e. voltage magnitude)

This group of functionalities involves better management of the voltage magnitude at various buses relating to countering both undervoltage and overvoltage complicating issues.

UPGRID allows for instantaneous recognition of poor voltage quality by allowing the network operators to send queries to the installed smart metering equipment and receive voltage information without the need for installing dedicated metering devices or sending specialized crew members to identify the issue (e.g. smart meter event processing analysis and virtual register for detailed voltage monitoring).

The instantaneous recognition of these cases may allow performing faster voltage field corrections and predicted fault/failures avoidance. As an example, the modification of the distribution tap changer positions and the use of smart transformers (a method dubbed as ‘Coordinated Voltage Control’), as is the case in the Swedish Demo Area, can allow implementation of F3. Before UPGRID, voltage quality - related complaints were addressed by sending crew to the premises of the Customers following corresponding notification (usually made by phone).

F3 finds application in the following Demo Areas, through D7.9 (Sweden) and technologies such as Smart event processing and analysis for maintenance support and Virtual register for detailed voltage monitoring:

- Spanish Demo
- Portuguese Demo
- Swedish Demo

F4. LV network reconfiguration

This group of functionalities involves switching actions performed for instance at seasonal basis leading to network topology changes. These changes are performed on the basis of having conducted power flow analyses for indicating potential issues with losses (which is treated appropriately via network reconfiguration). The new UPGRID LV cable cabinet with monitoring supports this operation.

F4 finds application in the following Demo Areas, through D7.10, D7.11, D8.1 (Annex I):

- Portuguese Demo
- Polish Demo

F5. Active Demand

This group of functionalities involves control of the load (e.g. demand shifting from peak to off-peak periods) of a number of Consumers in order to accommodate the peak demand in the most cost-efficient way with the view towards reinforcement deferral, loss reduction and improved quality of supply (e.g. in the event that an outage occurs, the possibility of shifting may prevent reduced non-supplied energy).

Note that in UPGRID this is performed as a test-case for the extraction of relevant techno-economic conclusions about the viability of the technology and the willingness of Customers to participate voluntarily by receiving signals from the DSO and then reacting on these. This implies visibility of Consumer consumption profiles (LV customer consumption characterisation) and requires end-user engagement to improve network operation; these are materialised mainly via the following UPGRID concepts: HEMS and Market Hub.

F5 finds application in the following Demo Area, through D1.1, D1.2, D1.3, D13.1, D13.2, D13.3, D13.4 (Annex I):

- Portuguese Demo.

F6. EV flexibility

This functionality involves visibility of the consumption profile of the connected EV fleet to the network (see description of sub-functionality ’Consumption characterization of EV charging points’ [1]). However, it is to be noted that no controllability over the assets exists and no smart charging takes place for reducing peak demand.

F6 finds application in the following Demo Area, through D6.1 (Annex I):

- Portuguese Demo

F7. Integration of active micro-generation at the LV

The Polish Demo has PV capacity installed within its Area in order to not only achieve environmental objectives but also for network reinforcement deferral and reduction of losses (given that power is provided to end-users closer to their premises). This UPGRID functionality involves the control of this micro-generation capacity essentially involving the on/off capability (curtailment of the output of the PV units) performed remotely (according to sub-functionality ’Remote Management of DER’ [1]) without other capabilities such as power-factor control. Moreover, the possibility for LV grid remote control operation through the PRIME infrastructure has been developed within the Spanish demonstrator allowing controllability of PV inverters which may allow for active micro-generation as well.

This functionality finds application in the following Demo Area, through D3.1 (Annex I):

- Polish Demo

The following section lists market and regulatory Issues tied to the aforementioned groups of functionalities.

3.2 IDENTIFICATION OF MARKET AND REGULATORY ISSUES

This section identifies the market and regulatory topics of interest for each of the functionalities determined in the previous section. The performance of the different Demos with respect to these issues and the decision on whether or not these issues constitute market and regulatory barriers affecting the wider deployment of the developed UPGRID solutions in the different Demo Areas is explored in Chapters 4, 5, 6 and 7.

Notice that these issues, as seen below, are sorted based on the importance of the Function Objectives of the UPGRID project [1]. That is: Monitoring and control of LV network, Smart metering data utilization, Network management methodologies for network operation and Novel approaches for market design.

I. Issues surrounding...

   a. the progress of the wide-spread ICT and Smart Metering equipment roll-out (F1).

   b. the functional capabilities of this equipment (e.g. being state-of-the-art or not).

   c. the data acquisition and data distribution across market actors.

   This set of issues is at the epicentre of UPGRID given that the basis of all UPGRID Demo projects is the utilization of metering infrastructure (e.g. consumer SMs, distribution transformer supervision meters at SS and other devises along the network) data so as to improve network operation via their implemented functionalities. That is, if any barriers exist, then it becomes challenging to achieve optimal automatic/remote fault detection and supply restoration (F2), high quality of voltage supply (F3), LV network reconfiguration (F4), optimal demand - side management (F5) as well as management of the EV fleet (F6) and active-management of DG connected (F7) to the grid.

   At this stage it is important to refer to some regulation that is relevant to Issues (I) and that applies to all UPGRID Demo Areas.

- Directive 2006/32/CE that stated that member countries of the EU, including all UPGRID Demo countries, shall ensure that final Customers are provided with meters that accurately reflect the final Customer’s actual energy consumption and that provide information on the actual time of use [19]. This Directive set the foundations for wide-spread ICT equipment roll out.

- Directive 2009/72/CE (common rules for the internal market in electricity), which states that Member States, including all UPGRID Demo countries, shall ensure that the implementation of intelligent metering systems may be subject to an economic assessment conducted before September 3rd 2012, and subject to this assessment Member States shall prepare a timetable with a target of up to 10 years for the implementation of intelligent metering systems [21]. This assessment aimed to evaluate the long-term costs and benefits to the markets and to the individual Consumers; the specifications of the CBAs are outlined in [17].
- Directive 2012/27/EU (Energy efficiency) that stated that Member States, including all UPGRID Demo countries, shall ensure that final Customers for electricity are provided with competitively priced individual meters that accurately reflect the final Customer's actual energy consumption and that provide information on actual time of use [22].

II. Issues around...

a. well-defined penalties and incentives able to motivate the DSOs towards achieving improved the continuity of supply (F2) and voltage (F3), improved losses (F4) and reduced capital-intensive network reinforcement (F5, F6 and F7).

b. the existence of an established supervising body that provides guarantees that the incentives and penalties are applied in a timely fashion.

In essence, the importance of this topic lies in the fact that absence of properly designed incentives/penalties may lead to significantly reduced benefit that can be extracted by the developed functionalities.

III. Issues related to...

a. the existence of a regulatory framework that is conducive to innovation given that innovation may lead to more efficient network investment and operation.

b. network investment planning and whether or not the regulatory framework prohibits for any reason the investment in DER technologies and UPGRID novel solutions and concepts.

c. the existence of stable markets for flexibility for DER assets to participate so as to offer their flexibility potential.

The following Chapters analyse the defined market and regulatory topics of interest (I-IV) for each of the Demo.

4. MARKET AND REGULATORY BARRIERS FOR THE SPANISH DEMO

The set of market and regulatory issues analysed in 3.2 are investigated taking into account the specific functionalities implemented within the Spanish Demo.

4.1 SMART METERING AND ICT EQUIPMENT

In Spain there is a legal mandate establishing the process towards the full roll-out of electricity Smart Metering equipment in compliance with the following acts of legislation:

- Royal Decree 809/2006 that established that from July 1st 2007 onwards the DSOs must replace analogue meters with SMs, which will possess telemetry and remote management capabilities for all Customers with less than 15kW contracted capacity so that differentiation of consumption in different time periods is enabled. Thus, an action plan was set out similar to that shown in Figure 4.1 [8] that illustrates this replacement process so that by the end of 2018, the rolling out of SMs will have covered 100% of these Customers [11].
- Ministerial Order October 18 ITC/3022/2007 [12] that delves into much more detail on specifications and requirements related to metrology presented in Royal Decree 1110/2007 for electrical energy meters for power supplies with contracts up to 15kW.
- Royal Decree 1110/2007 that established that all household electricity meters must be converted to SMs, with well-determined functionalities [9].
- Ministerial Order IET/290/2012 that reviewed the electricity rates in relation to the meter replacement plan [10] and enabled a vast rollout of meters exactly as shown in Figure 4.1 so that 35% of the SM roll-out is completed prior to 31/12/2014, 35% prior to 31/12/2016 and the remaining 30% by 31/12/2018.
- Ministerial Order ITC/3860/2007 that established that the roll-out plan of remotely managed SMs should cover 100% of households by the end of 2018 [20].

Note that in the Demo region alone there are already more than 190 thousand SMs installed, while more than 12 million SMs were installed in Spain by the end of 2015[11] (the goal is to have around 28 million SM points by 2020 [17], with more than 50% of analogue meters having been replaced by SMs).

Notice also that Spain did not conduct an official CBA regarding the long-term costs and benefits of smart metering equipment to the system and the society [17], nonetheless, the wide-scale roll-out proceeded with no barriers.

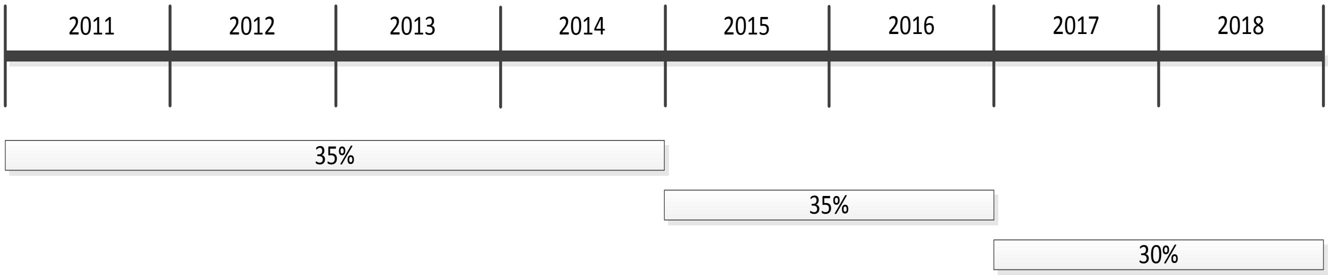

FIGURE 4.1. SMART METERING ROLL-OUT [11].

That is, no market and regulatory barriers exist with regards to the progress of the wide-spread rollout of ICT and SM- equipment; the terms surrounding the roll-out of SMs are clearly defined.

Additionally, EU Recommendation 2012/148/EU [23] defined ten common and minimum functional requirements [14] for household SM systems (i.e. all SM systems should at least be equipped with these) to possess in order to yield benefits for Consumers as well as for all other stakeholders (e.g. metering and system operator). As can be seen in [17], the functionalities of the rolled out SM equipment comply with the ten minimum functionalities with the exception of one functionality (frequent update of meter readings), which however is to be fulfilled with technological advancements. Thus, no market and regulatory barriers exist with regards to the functional capabilities of the SM equipment.

Furthermore, the market for the meter activity is fully regulated [17], noting that Customers (with contracted power less than 15 kW) have the legally recognized freedom of choice to either accept a meter installed by the DSO (thereby paying a rental fee) or install their own meter. Note that the DSO is responsible for installing the equipment and also has the ownership of it. The financing of the smart meter roll-out is secured through SM rental fees and the investment needed in SSs and communication technologies is recognised in the DSO investment plan.

Additionally, the DSO is the party accountable for granting third-party access to the gathered metering data. This essentially establishes the DSO as the entity with the role of the Neutral Market Access facilitator aiming at the fair distribution of data across all market actors taking into account the high level of consumer protection as set out in the Third Energy Package (see Annex I.2 of [21]). Thus, no market and regulatory barrier exists with respect to data acquisition and data distribution across market actors [17].

No barriers have been identified regarding the use of smart meters (e.g. consumer smart meters and supervision meters at SSs) data by sub-functionalities implemented in the Spanish demo either. Note that some of the most relevant innovative concepts developed that leverage these kinds of data[2] are: launching requests to consumer SM from the LV NMS to frame the location of LV incidents and achieve restoration of service, integration of SM events in the LV NMS for LV incident automatic recognition, feeding of the LV sound network representation with near-time measurements and SM event

[2] Data confidentiality and security mechanisms are implemented.

processing and analysis for the maintenance and operational support of the multiservice PRIME subnetwork. Another key point that facilitates the lack of obstacles is the use of the already deployed AMI infrastructure (due to the mandate roll-out) and other advanced solutions for monitoring and automation in SSs (deployed taken advantage of the legal mandate on smart metering).

4.2 INCENTIVES AND PENALTIES FOR QUALITY OF SUPPLY

The Spanish regulation has established that the DSO remuneration is tied to incentives to increase the efficiency of network management for improved quality of supply. The allowed revenues of a DSO are increased (or decreased) if they perform better (or worse) than set the regulation[3]. More specifically, regulatory incentives for DSOs are summarized as follows.

- Incentives to reduce the actual investment cost.
- Incentives to reduce losses.
- Operational and maintenance efficiency incentives.
- Quality of service - related incentives (power, voltage).

Notice also that quality of service targets are explicitly included in the distribution development plans submitted by the DSOs. No market or regulatory barriers exist in relation to the existence of well-defined penalties and incentives related to quality of supply (level of unserved demand, voltage quality, and level of losses) as well as efficiency around network investment.

Note also that the distribution sector is regulated under an incentive-based regime with incentives being provided to DSOs for the reduction of losses and of the actual investment cost as well as for improved efficiency and quality of service; the DSO´s allowed revenues (i.e. there is revenue cap) are increased (or decreased) if they perform better (or worse) than some predefined quality targets.

Additionally, there are well-established regulated bodies for making sure that penalties and incentives are appropriately applied. The responsibility for setting the distribution tariff level is with the Ministry of Energy [15] and with the Regulator (National Commission of Markets and Competition) [16] with the former setting the methodology and providing final approval of the allowed revenues and the latter providing the definition of the tariff structure. No barriers exist around the presence of supervising entities providing guarantees that penalties and incentives for quality of supply are timely and effectively implemented.

It is to me noted that the goal of high quality of supply has been a principal motivator for the massive implementation of the Spanish demo development since continuity of high quality supply has been a principal objective of the Demo. To this end, the lack of barriers to this objective facilitates its realization. For example, the knowledge by network operators and field crews about the LV network together with the provided tools (e.g. LV sound network representation and LV NMS) allows faster and more efficient response to various LV incidents. Moreover, the new uses given to SM data (e.g.

[3] Regarding both its own past performance ratios and also based on those for the whole electricity system

recognition and logging of events as well as voltage measurements) allow detecting voltage quality issues (related to voltage magnitude) and this triggers improved field work efficiency, thereby improving the quality of supply to Consumers.

4.3 NETWORK INVESTMENT PLANNING AND INNOVATION

DSOs include in their investment plans all solutions at their disposal, at that moment, that they consider more appropriate to improve the network following the regulated procedure for that. DSOs submit first their proposals for network investment plans to the Regional Authorities for approval (DSOs are regulated natural monopolies), later to the National Regulatory Authority (CNMC [16]) for limit checking and finally to the Government. This is based on auditable cost incurred.

DSOs are not opposed to the DER participation in markets[4] provided they do so under the same conditions that apply to the rest of the participating technologies. That is, Spanish DSOs have a neutral technology position without favouring or discriminating over any developed technology and also the Regulation does not prohibit investment in new technologies as long as they are proven to raise system efficiency. Therefore, in Spain, there are no barriers for the development of smart solutions from the point of view of investments.

In order for the DER technologies to offer their flexibility as an option for the DSO network investment plans, medium/long term markets or bilateral contracts should be established as currently such formations have not been created yet. Without being able to ensure the flexibility within such a timeframe, DER cannot be considered within the DSO investments plans.

Regarding DER, notice that although DER is not developed in the Demo Region the functionalities developed within the Spanish Demo can facilitate future DER integration. These developed technologies enhance the LV network visibility (e.g. smart metering data utilization, LV sound network representation and LV NMS) and allow its controllability (e.g. LV control over IP over PRIME). This will have an impact, among other aspects, on the LV hosting capacity, which can be increased since the availability of more information on the LV network status in near-real time (e.g. feeder capacity limits and voltage values) as well as the capability of controlling these generation units (if approved by regulation) can allows DSOs to be less conservative regarding the amount of DG connected to the network while still ensuring quality of supply.

The current remuneration model for distribution networks should be complemented to reflect the new type of investments that need to be made, with a higher level of risk and shorter payback terms (communications, software, etc.). This is because it is not the same to invest in networks and facilities with a 40-year service life and in innovative software, hardware and technologies.

[4] DER has already the market for energy.

With respect to innovation within the Spanish regulatory framework, it is to be noted that there are no specific mechanisms to incentivize expenditure for R&D/pilot projects. This is recognized by the Spanish DSOs, which themselves recognize that the national regulatory framework hampers R&D and innovation [18]. Also, the main sources of funding for R&D projects are external mainly stemming from the European Union. Hence, the following barriers have been identified:

- Costs related to R&D projects are not being supported through any kind of mechanisms.
- Funding for innovative projects is mostly limited to external sources such as the European Union.
- Risks surrounding investment in new technologies have not properly been accounted for.

5. MARKET AND REGULATORY BARRIERS FOR THE PORTUGUESE DEMO

The set of market and regulatory issues analysed in 3.2 are investigated for Portugal taking into account the specific functionalities implemented within the Portuguese Demo.

5.1 SMART METERING AND ICT EQUIPMENT

In both 2012 and 2014 a CBA was performed regarding the SM rollout in Portugal with the results indicating that such development would yield benefits for the entire society as a whole. However, Portugal reported the results of the CBA as inconclusive [17] and to be annually re-evaluated; the full SM roll-out has not been formally decided. Nonetheless, more than 500 thousand SMs have been installed across the country and all defined requirements (in the 2012/148/EU) for the ten minimum functionalities for SM infrastructure are fulfilled [17]. Thus, no market and regulatory barriers exist in terms of the wide-scale roll-out of SM equipment and the definition of the functional capabilities of SM equipment, which cover a wide range of functionalities and are fully compliant with the common minimum functionalities set out by the European Commission.

Additionally, the DSO is the party responsible for the implementation of the SM equipment installation as well as the ownership of the infrastructure (i.e. SMs). Also, the DSO is responsible for granting third-party access to the metering data, essentially acting as the Neutral Market Facilitator guaranteeing equitable access and sharing of the collected data across the market actors, with the consent of the Customers [13]. Thus, no market and regulatory barriers exist in terms of data acquisition and data distribution across market actors.

Note that EDP is operating advanced monitoring infrastructure that in addition to SMs (i.e. EDP Boxes) that are deployed across all LV clients (offering advanced smart meter functionalities, such as real time readings on demand, load diagrams, voltage monitoring and remote services), it also includes the use of Distribution Transformer Controllers (DTCs) which work as data concentrators in all SSs (e.g. log events, include sensors, offering local metering, monitoring and automation devices such as PQ monitoring and MV switching) with a communication network based on PRIME for the SMs and GPRS / 3G technologies for the DTC at SS level. Additionally, the demonstrator also addresses aspects on the residential infrastructure side through the installation and test of Home Energy Management System (HEMS) in some consumer households that enable a series of sub-functionalities such as appliance monitoring and control; there are no barriers to the wide-scale roll out of such equipment if proven to operate satisfactorily.

5.2 PENALTIES AND INCENTIVES FOR QUALITY OF SUPPLY

The Portuguese National Regulatory Agency (ERSE) defines the annual allowed revenues for each regulatory period, and within the definition of OPEX well-defined efficiency targets are set. Such targets are related to quality of service, and level of losses; the allowed revenues are thus increased (or decreased) if the DSO performs better (or worse) than these set standards/targets. ERSE supervises this entire process making sure that it runs smoothly so that the DSOs receive efficiency rewards and pay penalties depending on a fair assessment of their performance. This is performed by adjusting the allowed revenues (based on estimated information) to the actual revenues (recalculated with real information) in due time so that proper correction in the financial compensation is made.

In addition to ERSE, which has the main responsibility for calculating the allowed revenues and setting the distribution tariffs, as well as defining the penalties and incentives for quality of supply, a Tariff Board, which includes regulated companies and members of Consumer associations provides advisory role (Electricity law DL 215A/2013). Furthermore, targets related to quality of service are explicitly taken as inputs in the distribution development plan, which is set out by the DSOs and which quantifies the investments related to the quality objectives determined by the Regulator.

No regulatory or market barriers are identified regarding the effective establishment of penalties and incentives for quality of supply as well as the presence of supervising bodies ensuring that this process runs smoothly. Note that quality of supply has been a principal motivator behind the implementation of the Demonstrator, with the LV NMS and its Outage Management System module serving as the main driver for this goal.

5.3 NETWORK INVESTMENT PLANNING AND INNOVATION

The DSOs in Portugal invest in those technologies that are at their disposal and that they consider being better fit for ensuring the quality of service and the system security without any discrimination for some technologies. DSOs have a neutral position when it comes to which technologies they should invest or not to improve system quality and, therefore, Consumer experience.

The investment process begins with the DSOs submitting their distribution network investment proposals to the Regulator for review and once these plans are approved, the DSOs become responsible for implementing them with the Regulator supervising the schedule and their budget as well. Notably, these plans contain studies related to DER, and in particular the degree of integration with renewables is taken into consideration, reflecting the renewable generation targets being set by the Government at national level. The Regulator does not in advance favour or prohibit investment in any technology.

Regarding DER assets (EVs, DSR, DRES), markets for flexibility where such sources can participate have not yet been established. Also, DSOs have little access to sources of flexibility across the network. In fact, the sources of flexibility available to DSOs are capacitor banks and transformer tap changers for the purpose of voltage control as well as relays for automatic load shedding.

Regarding EVs, a new liberalized model for electric mobility has been introduced, in which any player that respects the legislated requirements can become an EV supplier of energy or an EV charging point operator. Legislation also ("greener behaviours" i.e. “Fiscalidade Verde”) establishes tax incentives (tax exemption) for the exchange of passenger cars at the end of their life (with 10 or more years) with EVs. However, there is still no regulation related to EV charging points’ controllability, which also applies to the Demo Area specifically that is characterized by lack of EV controllability.

In terms of DSR, the legislation allows the use of demand reductions to deal with emergencies and to increase system operational flexibility with all Consumers connected to voltage levels from MV and above being able to procure their energy in the daily market or through bilateral contracts for “flexibility” purposes such as voluntary reduction of their consumption in response to a power reduction order given by the DSO or the TSO. LV Consumers can only provide their flexibility resource as a response to time-of-use-tariff schemes that divide the day in peak and valley hours; plans for introduction of dynamic tariffs to LV Consumers are still on paper without actual implementation.

In fact within the Demo Area developed technologies such as the UPGRID Control module of the LVNMS constitute the interface that empowers network operators and Consumers with tools that lead to a more proactive LV management and operation, such as direct control of network loads including Public Light circuits and EV charging points, and sending requests to Market Hub that aims to regulate all the interactions between the DSO and the market agents (Retailers, Aggregators, etc.). Thus, UPGRID facilitates the gathering of knowledge surrounding the efficient operation of DER assets.

It is also important to notice that DER sources as well as Aggregators are formally recognized within the regulatory framework in terms of their role, which is important in terms of creating a well-established market for electricity.

Regarding incentives for innovation within the Portuguese regulatory framework, it is to be noted that there are regulatory mechanisms to incentivize expenditure for R&D/pilot projects such as establishment of higher rate of return corresponding to expenses related to R&D or pilot projects, or also revenues stemming from realized system benefits (e.g. reduced OPEX). Additionally, innovation can flourish by having DSOs trying out innovative ideas for achieving higher efficiency surrounding network operation, which is more tied to OPEX type of expenses; such types of regulatory mechanisms for incentivizing OPEX-related innovation do not currently exist. Hence, this situation is recognized by the Portuguese DSOs stating that the national regulatory framework rather fosters R&D and innovation [18].

6. MARKET AND REGULATORY BARRIERS FOR THE SWEDISH DEMO

The set of market and regulatory issues analysed in 3.2 are investigated for Sweden taking into account the specific functionalities implemented within the Swedish Demo.

6.1 SMART METERING AND ICT EQUIPMENT

The roll-out of SM equipment has long been completed at 100% coverage [17] with the goal being to have around 5.2 million SM points by 2020 [17]. Note that Sweden became the first EU country to mandate automatic meter reading due to the adoption of legislation requiring that from July 1st 2009 the monthly billing should be based on actual electricity consumption. This mandate encouraged widespread deployment of automatic meter reading technology and resulted in practically a full roll-out of Smart Meters on a voluntary basis (all other UPGRID Demo Countries followed a mandatory deployment strategy, rather than a voluntary one) [17]. Additionally, all SM functionalities are compliant with the EU recommendations for minimum SM functionalities [17]. Thus, the roll-out of SMs has been completed across Sweden and their functionalities can be characterized as state-of-the-art. Note that some DSOs still utilize monthly measurements (as the regulation stipulates), but hourly measurements are expected to become the norm for all Customers without any envisaged barriers.

Furthermore, the DSO is the party responsible for SM implementation and maintenance, while having their ownership and this process is being funded mainly through network tariffs. The DSO is recognized as having the role of Neutral Market Facilitator guaranteeing equal access to measured data (voltage, current, etc.) for all eligible market players (e.g. retailers, Balancing companies etc.). There is no discrimination in terms of sharing these data as the process is fully regulated. Thus, no market or regulatory barrier is identified with respect to data acquisition and data handling; all data stemming from SM and monitoring equipment are being handled by well-established entities (DSOs).

Note that the Swedish Demo within UPGRID is focusing on enhanced LV supervision and real-time LV network monitoring by combining data from meters, SS measurements and the SCADA system. The implementation of the LV NMS (that provides operational visibility and control of the LV network) along with an LV Dashboard for big data analysis on logged events and data stemming from various network sources such as SMs and RTUs (deployed in many SSs) that register thousands of network signals and the Intelligent Line Monitoring System (wireless current sensors) for overhead line fault detection/location are all part of an extensive monitoring and visualization infrastructure developed within the Demo. These data also allow for testing interoperability of SS technical solutions from various manufacturers as well as demonstrate advanced system solution for LV monitoring from three different system suppliers. No market or regulatory barriers are identified that can hamper the wide-scale roll-out of these solutions.

6.2 PENALTIES AND INCENTIVES FOR QUALITY OF SUPPLY

The Swedish regulation has established well-defined penalties and incentives related to quality of supply. In fact, the full-roll out of SM equipment with the capability of remote readings, allows significantly enhancing the monitoring and maintenance of high levels of quality of supply. The strict policy surrounding quality of supply has led the DSOs to take measures for guaranteeing it as, for example, the complete coverage of all overhead LV distribution network cables with enhanced insulation, which also applies to MV levels with more than 70% of the total length of the power lines being insulated.

Additionally, DSOs are obliged to undertake risk and vulnerability analyses and to produce strict action plans on how improvement actions will take place aiming at security of supply. Furthermore, the regulation states that Consumers who are affected by disruptions longer than 12 hours have the right to compensation from the DSO. This compensation is then calculated according to a formula defined in the Swedish electricity act.

Note also that Swedish DSOs are regulated by revenue cap with provisions also existing for rewarding efficiency achievements (form of revenue control: revenue-cap based with efficiency adjustments). The entire process of incentives and penalties is supervised by the regulatory authority, which sets in advance the total allowed revenue frame over the course of a multi-year period, with each DSO being given a revenue cap. These revenues are expected to cover the expected costs of running the DSO operations over the period as well as to provide a reasonable return on the capital employed, taking into account efficiency targets. That is, the form of price-control is ‘revenue-based’ with efficiency and quality of supply cost components included. No market or regulatory barriers are present in terms of the existence of a well-established supervisory body for guaranteeing the smooth process of application of incentives and penalties.

Note that achieving quality of supply is a principal motivator driving the implementation of the UPGRID project in Sweden. Particular focus is placed not only on the utilization of SM equipment but also on the “smart transformer” that minimizes voltage variation (automatic voltage regulation function) and, therefore, enhances quality of supply on the LV grid. Additionally, the installation of FPIs and the implementation of the Outage Management System aim both at enhancing the fault indication process across the Demo Area. No barriers are identified to the wide-spread deployment of these solutions for this purpose.

6.3 NETWORK INVESTMENT PLANNING AND INNOVATION

The objective of a Swedish DSO is to ensure that an investment enhances the quality of supply and thus achieves greater Customer satisfaction. The regulatory framework in Sweden remunerates investments based on the logic of ‘norm costs’. That is, for every type of equipment there are costs provided upon which the return to the DSO will be given. If, for example, a DSO selects an asset that is more expensive than the norm cost, then the return that the DSO will receive will still be as if the norm cost was paid.

The DSOs can suggest investment in new technologies but they need to support this case to the Regulator (i.e. that the new technology is a unique asset with special characteristics) and in this case there is some risk that the Regulator may inform the DSO that the return will still be based on the 'norm cost' corresponding to the traditional transformer, which is included in the list of components with norm costs. This means that the regulatory framework incentivizes the DSOs to invest in those components for which norm costs are provided, otherwise DSOs run the risk of accruing lower return. This fact constitutes a regulatory barrier for the dissemination of the UPGRID concepts on a wider basis across Sweden.

It is anticipated that the next update of the planning standards that will be made in 2020 will incorporate the UPGRID technologies developed in the Swedish Demo (LVNMS, Smart Transformer) given the successful experience of the project.

Regarding DSOs investing in DER technologies on a wide scale, notice that there are no markets for flexibility where DER technologies (EVs, DSR, DRES) can trade their flexibility potential. Once these markets are established, they will assure the DSOs that they can take into account the flexibility offered by such technologies and allow DSOs to consider them in their network investment planning.

Notice, however, that the UPGRID developed technologies can assist in the integration of DER into the system. For instance, in terms of DRES the UPGRID Demo technologies (e.g. see sections 6.1 and 6.2) can assist with their integration given that potential challenges will be swiftly counteracted with the assistance of technologies such as the LVNMS and the Smart Transformer.

Regarding incentives for innovation within the Swedish regulatory framework, there are no specific mechanisms to incentivize expenditure for R&D projects and risks associated with the deployment of smart technologies are not well rewarded. When DSOs undertake such expenses, these expenses are treated like any other type of DSO cost i.e. there is no specific compensation for the risks involved in testing new technologies and concepts. DSOs do not receive any specific returns for innovation; This is recognized by the Swedish DSOs, which acknowledge that the regulatory framework is not conducive to innovation [18].

7. MARKET AND REGULATORY BARRIERS FOR THE POLISH DEMO

The set of market and regulatory issues analysed in 3.2 are investigated for Poland taking into account the specific functionalities implemented within the Polish Demo.

7.1 SMART METERING AND ICT EQUIPMENT

As previously mentioned, Member States were required to conduct economic assessment of the long - term costs and benefits of the roll-out of SM equipment. The outcome of this CBA was positive for Poland, which has decided in favour of large-scale roll-out of SM equipment [17]. According to the Ministry of Energy, around 17 million Smart Meters will be installed for domestic Customers [24] by 2020; no market or regulatory barrier is identified in Poland with respect to the progress of the wide-spread roll-out of SM equipment.

Regarding the SM functionalities, they are fully compliant with the minimum requirements set by the European Union [17]; no market or regulatory barriers are identified in terms of the functional capabilities of this equipment.

Additionally, the DSO is the entity responsible for the implementation of the SM and has their ownership. However this is not the case for the party responsible for the provision of third-party access to metering data. This party is the Central Hub, whose role is being played by the Metering Information Operator that is responsible for the routing of the metered information from the point they are gathered at the Consumer’s premises to the energy suppliers/DSOs/other third parties for their delivery in compliance with technical and quality standards [17]. Additionally, the introduction of the entity of the Metering Information Operator guarantees equal and fair access to the available metering data for all eligible market players. No market or regulatory barriers are present that could potentially affect data acquisition and equitable data handling.

In fact the Polish Demonstrator is focused on monitoring and control of the LV grid. The demonstrator’s main objectives are to maximize the LV grid observability and increase its reliability. That being said static information about the LV grid topology is collected as well as dynamic information like measurements or grid equipment’s current state. The deployed Supervisory Control and Data Acquisition (SCADA) MV/LV system, after integration with DMS, serves as the Network Management System (NMS) and forms the basis for the realization of all deployed functionalities. For example, the NMS allows for fast reaction to fault occurrences.

Notice that SMs and data concentrators at the SS acquire not only the billing information (consumption and production of energy), but also voltage levels and events at the client meters as well as the Total Harmonic Distortions (THDs), voltages, currents, powers and events at the SS transformer meters allowing for transformer monitoring and management. In addition, the MV side is observed via Fault

Passage Indicators (FPIs) integrated with remote terminal units (RTU). All these functionalities have been realized through the Common Information Model (CIM) for exchanging and processing LV network topology data and information about changes of the states of its components, involving the development of database structures, data exchange interfaces and views displaying this data.

7.2 PENALTIES AND INCENTIVES FOR QUALITY OF SUPPLY

Quality of supply is a principal objective set out by the Polish National Regulatory Authority (URE) stating that during the regulatory period the DSO can profit from savings resulting from efficiency achievements (targets, for example, for losses are set for each regulatory period). The supervisory body for guaranteeing smooth incentive-penalty implementation is URE with no government involvement.

Thus, the established process starts with the DSO proposing the amount of allowed revenues to URE, which may then approve of it or request amendments and take the final decision around the tariff structure, given that tariffs are the tools for the collection of the allowed revenues. This is a price control that has the form of 'revenue-cap' based on efficiency adjustments and is well-defined in the regulation [17]. URE performs the Tariff calculation in such a way as to not only allow for the coverage of costs relevant to DSO operation but also for providing a reasonable return on capital, always with the goal being the protection and empowerment of end-users, meaning that remuneration is provided to Customers for any low quality in the supplied energy.

No market or regulatory barriers are present in the Polish regulation surrounding the provision of high quality of supply as well as the existence of a supervisory body that will guarantee the fair and timely implementation of these incentives and penalties.

In fact, the development of SM and ICT equipment has facilitated the deployment of SCADA system, Geographical Information System (GIS) and Advanced Metering Infrastructure (AMI) systems within the Polish Demo to enhance the functionality scope of the Smart Metering and Smart Grid infrastructure. Deployment of SCADA MV/LV consists in the integration of new data into the system namely the LV grid topology acquired from GIS and data acquired from the LV infrastructure deployed within the scope of the project (e.g. state of fault passage indicators or the state of LV switchgear). Also, the application of fault detection inference based on Power line Intelligent Metering Evolution (PRIME) meter topology is also implemented.

Additionally, Field Crew Support (FCS) functionality is realized through the deployment of mobile devices that allow full network visualization and recognition of events across the network. The application implements grid topology elements on a map view. It also allows users to access detailed information about grid objects including their parameters, current state and last measurements captured by the DMS. What is more, for each measured value when defined thresholds are exceeded (either from below or from above), an alarm signal is sent to the SCADA MV/LV system and recorded in the DMS's event log.

All such enhanced network visualisation aims at significantly boosting the quality of supply and it becomes clear that quality of supply has been a main objective motivating the implementation of the Demo.

7.3 NETWORK INVESTMENT AND INNOVATION

The objective of a DSO is to ensure that an investment enhances the quality of supply and thus achieves greater Customer satisfaction. Note that the regulatory framework does not prohibit investment in any of the UPGRID developed technologies within Poland. If these technologies are proven to be effective then there is no barrier to their wide-scale dissemination and deployment.

As regards to investment in DER (mainly DRES, given the connected PV capacity within the Demo Region), the Polish Demo has implemented DER visualization and management functions within the DMS. For instance, a software tool has been integrated within the customer User Data Panel (UDP) for simulation of the generated energy from PV sources with the goal of increasing customer awareness on the possible benefits from the PV installations. This tool allows each Customer living in the project area to calculate how much energy could be produced from a theoretical PV panel if it was installed at their premises (the user is asked to define some panel characteristics such as efficiency, geographical orientation, etc.) and the Customer can compare his or her energy consumption with the simulated PV production.

Regarding DER management functions in case of overvoltage or under voltage a list of DER sources to be connected or disconnected from the grid is automatically generated and presented to the network operator to preserve safe and reliable network operation.

No market or regulatory barriers are identified for the wider realization of these functionalities other than the fact that there are no markets for flexibility established for DER to be able to trade their flexibility and this constitutes a potential barrier to the wider development of DER (this comment relates more to EV and DSR, but also to technological solutions developed within the Demo that could eventually participate in such markets for flexibility).

In terms of innovation, notice that DSOs are regulated by revenue (price cap) with provisions also existing for rewarding efficiency achievements (form of price control: revenue-cap based with efficiency adjustments). Regarding incentives for innovation within the Polish regulatory framework, there are no specific mechanisms to incentivize expenditure for R&D projects by also taking into account risks associated with the deployment of smart technologies. These expenses are treated like any other type of DSO cost i.e. there is no specific compensation for the risks involved in testing new technologies and concepts. Additionally, since innovation is closely related to OPEX type of costs, types of regulatory mechanisms for incentivizing OPEX-related innovation (see D7, D9 for example in paragraph 3.1) do not currently exist.

This is recognized by the Polish DSOs, which acknowledge that the Polish regulatory framework is not conducive to innovation [18].

8. CONCLUSIONS

The current report identifies seven classes or groups of functionalities for each of which market and regulatory issues have been examined per Demo identifying the existence or absence of barriers for deploying UPGRID innovative concepts.

These functionalities are as follows:

F1. Network monitoring and visualization.

F2. Improved supply restoration at LV and MV levels (mainly LV).

F3. Improved voltage quality (i.e. voltage magnitude).

F4. LV network reconfiguration.

F5. Active Demand.

F6. EV flexibility.

F7. Integration of active micro-generation at the LV level.

The following market and regulatory conclusions regarding the deployment of UPGRID innovative concepts have been identified per Demo:

I. Regulatory issues surrounding the progress of the wide-spread ICT and SM equipment roll-out (F1) and issues relevant to functional capabilities of this equipment as well as data handling. Examining these issues is important for all identified functionalities F2-F7.

   This set of issues does not encounter any market or regulatory barriers in any of the UPGRID Demo Areas.

II. Issues around well-defined penalties and incentives able to motivate the DSOs towards achieving improved quality of supply. This set of issues is linked to the implementation of functionalities F2-F7.

   No market and regulatory barriers affecting electricity supply of high quality are identified within the regulatory framework of any of the Demos.

III. Issues surrounding the network investment planning for each of the Demo Areas. Topics that are examined include whether or not DER technologies (EV, DSR and DRES) can participate in stable markets for flexibility (and if such markets exist), and whether or not DSOs are prevented by the Regulation to invest in specific technologies. Barriers identified relate to the fact that there are no established markets for flexibility where DER sources can trade their flexibility potential.

   However, UPGRID technologies enhance the LV network visibility (e.g. smart metering data utilization, LV sound network representation and LV NMS) and allow its controllability (e.g. LV control over IP over PRIME). This has a practical impact on reducing LV feeder capacity uncertainties what can increase the hosting capacity. The fact of having more detailed and sound information allows DSOs to be less conservative regarding the amount of distributed generation (DG) connected into the network without jeopardising the quality of supply. This, together with the capability of controlling these generation units (if approved by regulation) can allow increasing the hosting capacity even more since there is a means, at a particular moment, to reduce the power injected into the network if necessary.

Additional topics examined pertain to whether or not a regulatory framework conducive to innovation exists. In this case, barriers are related to the fact that there are no specific mechanisms to incentivize expenses for R&D projects and the risks associated with smart technologies are not rewarded. That is, expenses for R&D projects are treated like any other type of DSO cost. Finally, there are barriers associated with investment planning in Sweden with smart UPGRID technologies developed in the Swedish Demo (such as the Smart Transformer) currently not being recognized as potential investment solutions.

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Annex I. LIST OF UPGRID SUB-FUNCTIONALITIES

Table 8.1 to Table 8.5 present the List of Sub-functionalities proposed by each demonstrator in the UPGRID project classified by Cluster and Function Objective. A total of thirty eight (38) sub-functionalities have been identified.

TABLE 8.1. LIST OF SUB-FUNCTIONALITIES SELECTED FOR CLUSTER 1: INTEGRATION OF SMART CUSTOMERS

Cluster, Function Objectives & Sub-functionalities		Demonstrators				Id. Code
		Spain	Portugal	Sweden	Poland	
Cluster 1: **Integration of Smart customers**			**X**			
D1	**Active Demand for increased network flexibility**		**x**			
	LV customer consumption characterization		x			D1.1
	Home Energy management system to provide data to dynamic pricing simulator		x			D1.2
	End user engagement to improve distribution network operation		x			D1.3
D2	**Enabling maximum energy efficiency in new or refurbished urban using smart distribution grids**					

TABLE 8.2. LIST OF SUB-FUNCTIONALITIES SELECTED FOR CLUSTER 2: INTEGRATION OF DER AND NEW USES

Cluster, Function Objectives & Sub-functionalities	Demonstrators				Id. Code
	Spain	Portugal	Sweden	Poland	
Cluster 2: **Integration of DER and new uses**		**X**		**X**	

D3	**Integration of DER at low voltage**		**x**		**x**	
	Remote management of DER		x		x	D3.1
D4	**Integration of DER at medium voltage / high voltage**					
D5	**Integration of storage in network management**					
D6	**Integration of infrastructure to host Electrical Vehicles**		**X**			
	Consumption characterisation of Electrical Vehicle (EV) charging points (street stations)		x			D6.1

TABLE 8.3. LIST OF SUB-FUNCTIONALITIES SELECTED FOR CLUSTER 3: NETWORK OPERATIONS

Cluster, Function Objectives & Sub-functionalities		**Demonstrators**				**Id. Code**
		Spain	**Portugal**	**Sweden**	**Poland**	
Cluster 3: **Network operations**		**X**	**X**	**X**	**X**	
D7	**Monitoring and control of LV networks**	**x**	**x**	**x**	**x**	
	Operation (control and multiservice) of LV grid devices using PLC-PRIME for different telecontrol applications (Concept test)	x			x	D7.1
	Queries to request advanced meter data to support operation	x			x	D7.2

Cluster, Function Objectives & Sub-functionalities		Demonstrators				Id. Code
		Spain	Portugal	Sweden	Poland	
	Improvement the LV Network Management System visualisation by integrating data measurements from inside SS (e.g. transformer meter, advanced LV supervision)	x	x	x	x	D7.3
	Improvement the LV Network Management System visualisation by integrating data measurements from LV network devices (e.g. customers SM, EV charging points, DER)	x	x	x	x	D7.4
	Integration of the MV power transformer status from the MV systems to the LV Network Management System	x			x	D7.5
	Integration of measurement data to support state estimation in LV Network Management System		x		x	D7.6
	Integration of measurement data to support power flow analyses in LV Network Management System	x	x	x	x	D7.7
	Integration of LV power flow and MV power flow analyses		x			D7.8
	LV regulation at SS level using a new smart transformer			x		D7.9
	LV meshed network operation - Remote reconfiguration (no fully automatic) of the LV network (grid protection)		x		x	D7.10
	LV meshed network operation - identifying the optimum topological configuration		x		x	D7.11
	Interoperability test of the integration of LV Network Management System with equipment from different manufactures			x		D7.12

Cluster, Function Objectives & Sub-functionalities		Demonstrators				Id. Code
		Spain	Portugal	Sweden	Poland	
D8	**Automation and control of MV networks**			**x**	**x**	
	Monitoring MV network by fault detectors			x	x	D8.1
D9	**Network management methodologies for network operation**	**x**	**x**	**x**	**x**	
	Define a sound LV network (schematic diagrams and parameters of components)	X		x	x	D9.1
	Use CIM for LV network modelling and data exchange between e.g. AMI, GIS, MV SCADA, LV Network Management System	X	x	x	x	D9.2
	Interface to manage PRIME subnetwork with Simple Network Management Protocol (SNMP)	X				D9.3
	Implementation of Network Management System (NMS) based on Simple Network Management Protocol (SNMP) at SS level		x			D9.4
	Visualisation of data from LV Management Network System in a geographical context	X	x		x	D9.5
	Internal DSO business processes review in relation with Outage Management	x				D9.6
	Load and distributed generation forecasting		x		x	D9.7
D10	**Smart metering data utilisation**	**x**	**x**	**x**	**x**	

Cluster, Function Objectives & Sub-functionalities		Demonstrators				Id. Code
		Spain	Portugal	Sweden	Poland	
	Integration and processing of meter events or/and other sources (e.g. telecom data) in the Outage Management System (OMS)	x	x	x	x	D10.1
	Calculation of indicators for SM infrastructure e.g. the availability-KPI indicators to be used in a geographical context the to assist the Network Operation Centre (NOC)		x			D10.2
	Algorithm to determine connectivity of SM to the grid (identification of phase and line to which each SM is connected to)	x	x	x	x	D10.3
	Calculation of non-technical losses using data from metering devices both in SS and LV network		x	x	x	D10.4

TABLE 8.4.: LIST OF SUB-FUNCTIONALITIES SELECTED FOR CLUSTER 4: NETWORK PLANNING AND ASSET MANAGEMENT

Cluster, Function Objectives & Sub-functionalities		Demonstrators				Id. Code
		Spain	Portugal	Sweden	Poland	
Cluster 4: **Network planning and asset management**		**X**	**X**		**X**	
D11	**New Planning approaches for distribution networks**	**x**			**x**	
	Data analytics based on historical network state data to assist network planning	x			x	D11.1

Cluster, Function Objectives & Sub-functionalities		Demonstrators				Id. Code
		Spain	Portugal	Sweden	Poland	
D12	**Novel approaches to asset management**	**x**	**x**	**x**	**x**	
	Data analytics based on historical network state data to assist maintenance	x				D12.1
	Transformer replacement optimisation based on historical data from meters inside SS				x	D12.2
	Life Cycle Cost (LCC) calculations of best technical / financial solution with new equipment (e.g. IED)			x		D12.3
	Deploy some mobile devices (e.g. tablet, smart phone) for accessing and visualise remotely information from LV system (e.g. geographical context, assets and outage location) to support grid crews	x	x		x	D12.4

TABLE 8.5. LIST OF SUB-FUNCTIONALITIES SELECTED FOR CLUSTER 5: MARKET DESIGN

Cluster, Function Objectives & Sub-functionalities	Demonstrators				Id. Code
	Spain	Portugal	Sweden	Poland	
Cluster 5: **Market design**	**X**	**X**		**X**	

D13	**New approaches for market design**	**x**	**x**		**x**	
	Web portal for increasing the consumer awareness in order to leverage their participation in electricity markets	x	x		x	D13.1
	Create market hub for relationship between DSO and Suppliers		x			D13.2
	Dynamic / Real time pricing based on DSO services and infrastructure (DSM) (simulator)		x			D13.3
	Dynamic contractual power control		x			D13.4