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UPGRID

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

Scope and Boundaries of Project Demonstrations

Report on common KPIs

D1.4 r2

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EXECUTIVE SUMMARY

Based on the EEGI methodology for KPI calculation, two levels of KPIs have been defined for the UPGRID project: High level KPIs and Detailed KPIs. High level KPIs are directly linked with the EEGI functional objectives (in fact, they share the names). According to the demo List of Sub-functionalities defined in D1.1 – *Technical specification of project demonstrators*, if a demo is addressing sub-functionalities included in an EEGI functional objective the associated high level KPI will be calculated. Therefore the contribution of each demo to the EU goals defined in the EEGI framework will be evaluated.

UPGRID project has defined twenty-five detailed KPIs which will be combined to calculate the high level KPIs linked with the EEGI functional objectives. Table 1 shows the list of detailed KPIs included in each high level KPI calculation.

TABLE 1: DETAILED KPIS DISTRIBUTION AMONG HIGH LEVEL KPIS.

SOURCE: UPGRID PROJECT.

High Level KPIs (EEGI Functional Objectives)		Number of associated Detailed KPIs
D1	*Active Demand for increased network flexibility*	7
D2	*Enabling maximum energy efficiency in new or refurbished urban using smart distribution grids*	0
D3	*Integration of DER at low voltage*	5
D4	*Integration of DER at medium voltage / high voltage*	0
D5	*Integration of storage in network management*	0
D6	*Integration of infrastructure to host Electrical Vehicles*	4
D7	*Monitoring and control of LV networks*	13
D8	*Automation and control of MV networks*	4
D9	*Network management methodologies for network operation*	7
D10	*Smart metering data utilization*	8
D11	*Novel planning approaches for distribution networks*	1
D12	*Novel approaches to asset management*	8
D13	*New approaches for market design*	9

In order to define the UPGRID detailed KPIs some EEGI labelled projects have been analysed to use the synergy between projects. Specifically GRID+, IGREENGrid, GRID4EU, DISCERN and IDE4L. According to the list of sub-functionalities, some of the KPIs were selected from these projects. The proposed detailed KPIs list for UPGRID project is a combination of directly borrowed KPIs, adapted KPIs and new KPIs to make sure that the impact of all the defined sub-functionalities was going to be measured in each demo by at least one indicator. An adapted KPI follows the original project main concept but its formula has been slightly modified to fit with UPGRID project. A new KPI is an indicator formulated for the UPGRID project that has not been used in the analysed projects.

The proposed UPGRID methodology for the KPI calculation consists on combining the detailed KPIs through a weight sum to obtain the high level KPIs. These weigh matrixes have been adapted to each demo depending on the components, developments to be deployed in the scope of the UPGRID project and the own vision / objectives of each demo. This means, the relative weight might differ from one demo to another.

The first release of D1.4 – *Report on common KPIs* was focused on the methodology for the KPI calculation that will be used for the UPGRID project and on the qualitative definition of these KPIs. This second release of the deliverable includes a further description of the KPIs ready to be calculated when the data produced by the demos is available. This timing shift will facilitate achieving a compromise between adapting KPI definitions to demos and demos to KPI definitions.

All the information included in this deliverable will be used in T8.1 – *KPIs analysis* to calculate the indicators once the demos produce the required data. If additional KPIs are identified in other work packages that are ongoing or even not started by the time of closing the present deliverable such as WP2 – *Innovative distribution grids applications and functions*, WP7 – *Market and business framework* and WP9 – *User engagement, societal research and dissemination of project results;* they will be added in T8.1 following the methodology described in this deliverable.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ABBREVIATIONS AND ACRONYMS

ΔE	Energy losses *(Detailed KPI)*
ΔT_{LV}	Average time for LV faults *(Detailed KPI)*
ΔT_{MV}	Average time needed for fault location in MV *(Detailed KPI)*
A	Active participation *(Detailed KPI)*
ACER	Agency for the Cooperation of Energy Regulators
ADV	Available information categories *(Detailed KPI)*
AMI	Advanced Metering Infrastructure
AMR	Automatic Meter Reading
ASIDI	Average System Interruption Duration Index
AV	Availability of intelligent network components *(Detailed KPI)*
BAU	Business as Usual
BMS	Battery Management System
CAPEX	Capital Expenditures
CDV	Characterized information categories *(Detailed KPI)*
CEER	Council of European Energy Regulators
CIM	Common Information Model
CML	Customer Minutes Lost
CT	Current transformers
DC	Data Concentrator
DER	Distributed Energy Resource
DLMS	Distribution Line Message Specification
DRES	Distributed Renewable Energy Sources
DSM	Demand Side Management
DSO	Distribution System Operator
DTC	Distribution Transformer Controller
EDP	EDP Distribuição – Energia, S. A.
EDSO4SG	European Distribution System Operators for Smart Grids
EEGI	European Electricity Grid Initiative
ENERGA	Energa Operator S.A.
ENTSO-E	European Network of Transmission System Operators for Electricity
EU	European Union

EV	Electric Vehicle
FPI	Fault Passage Indicator
GE	General Electric
GHG	Reduction in greenhouse gas emissions *(Detailed KPI)*
GIS	Geographic Information System
HAN	Home Area Network
HC_{EV}	Hosting Capacity of Electric Vehicles *(Detailed KPI)*
HV	High Voltage
ID	Identification
IEA	International Energy Agency
IED	Intelligent Electronic Device
ILT	Improved Life-time of transformers *(Detailed KPI)*
INESC	Instituto de engenharia de sistemas e computadores do Porto
IP	Internet Protocol
IT	Information Technology
ITC	Information Technology and Communication
ITE	Instituto Tecnológico de la Energía
KPI	Key Performance Indicator
LCC	Life Cycle Cost
LPID	Light Protocol Implementation Document
LV	Low Voltage
MDV	Monitoring information categories *(Detailed KPI)*
MV	Medium Voltage
NMS	Network Management System
NOC	Network Operation Centre
NOS	Optimus – NOS Comunicações, S. A.
OMS	Outage Management System
OPEX	Operating Expense or Operational Expenditure
P_{DER}	Generation flexibility *(Detailed KPI)*
P_{DSM}	Demand flexibility *(Detailed KPI)*
PHEV	Plug-in Hybrid Electric Vehicle
PLC	Power Line Communication
POWEL	Powel AS
PRIME	Power Line Intelligent Metering Evolution
PS	Primary Substation
PV	Photovoltaic
QS_{LV}	Quality of Supply Improvement in LV *(Detailed KPI)*

QS_{MV}	Quality of Supply Improvement in MV *(Detailed KPI)*
Quota	Consumers being metered automatically *(Detailed KPI)*
R	Participant recruitment *(Detailed KPI)*
R&D	Research and Development
R&I	Research and Innovation
RC	Replacement Costs
RD&D	Research, Development and Demonstration
RES	Renewable Energy Source
RTU	Remote Terminal Unit
SAIDI	System Average Interruption Duration Index
SAIFI	System Average Interruption Frequency Index
SAP	Simple Acquisition Protocol
SCADA	Supervisory Control And Data Acquisition
SE	Schneider Electric Industries
SET-PLAN	Strategic Energy Technology Plan
SIAF	Success index in advanced functionalities *(Detailed KPI)*
SIER	Success index in event reading *(Detailed KPI)*
SIMC	Success index in meters connectivity *(Detailed KPI)*
SIMR	Success index in meter reading *(Detailed KPI)*
SM	Smart Meter
SNMP	Simple Network Management Protocol
SS	Secondary Substation
SW	Software
T	Task
TOC	Table of Contents
TSO	Transmission System Operator
UES	Use of equipment standards *(Detailed KPI)*
UPS	Use of protocol standards *(Detailed KPI)*
VF	Load curve valley filling *(Detailed KPI)*
VL	Fulfilment of voltage limits *(Detailed KPI)*
VS	Versus
VTF	Vattenfall Eldistribution AB
WP	Work Package

1. INTRODUCTION

The main objective of WP1 – *Scope and Boundaries of Project Demonstration* is to define in detail the scope of the four demonstrations[1] to be performed in the project. The main purpose of this work package fourth task, T1.4 – *Definition of common KPIs to monitor the performance of the demos*, is to monitor the performance of each of the UPGRID demonstrations that will be running for approximately 18 months. Therefore this task has been focused on the definition of some common indicators to be applied later on during the last six months of the project.

UPGRID intended from the beginning to use as a general framework the KPIs that are being used in other smart grids projects in Europe and see how these KPIs can be adapted to the features and objectives of the demos in order to pave the way for enabling a robust and feasible monitoring of their performance. For this reason, the European Electricity Grid Initiative (EEGI, [1]) methodology for KPI calculation has been followed for the UPGRID KPIs definition [2]. In the same way, EEGI labelled projects KPIs have been analysed and adapted to the UPGRID project.

The main output of T1.4 is D1.4 – *Report on common KPIs*. It is a document that collects the selected KPIs for monitoring the UPGRID demos. It contains KPI definitions, formulas and formats of data with an enough degree of concretion to be able to calculate them in T8.1 – *KPIs* analysis when all the UPGRID demos provide the data.

T1.4 was scheduled in parallel with T1.1 (sub-functionalities description) and T1.2 (component description). This means that demo leaders started to identify sub-functionalities, components and KPIs at the same time. This has provided a useful first approach to KPIs (qualitative identification and description). The concretion of demos at M6 makes them not possible to confirm the availability of concrete data format and granularity for a precise KPI formula.

For this reason D1.4 was split up into two releases. The first release of D1.4 contained the description of the complete methodology regarding KPIs to be applied in UPGRID project based on the EEGI methodology, a preliminary list of KPIs (based on other EU projects) taking into account the selected demo sub-functionalities (D1.1) to evaluate the impact of the project in the EEGI framework and a qualitative description of these KPIs. The second release of D1.4 (present document) includes, a part from the KPI methodology already described in the first release, a refined list of KPIs and the detailed description and formulation of each of them ready to be calculated when the data is available. In order to prepare D1.4 second release, physical meetings involving the four demos will have been arranged to discuss every KPI in detail (consolidate the selection of KPIs, their formulas and most suitable data to be calculated).

[1] In the UPGRID project four demos will be deployed in four locations in Spain, Portugal, Sweden and Poland.

Figure 1 shows the evolution of the works included in T1.4 and the relation of this task with other tasks and deliverables of the UPGRID project as inputs and outputs of T1.4.

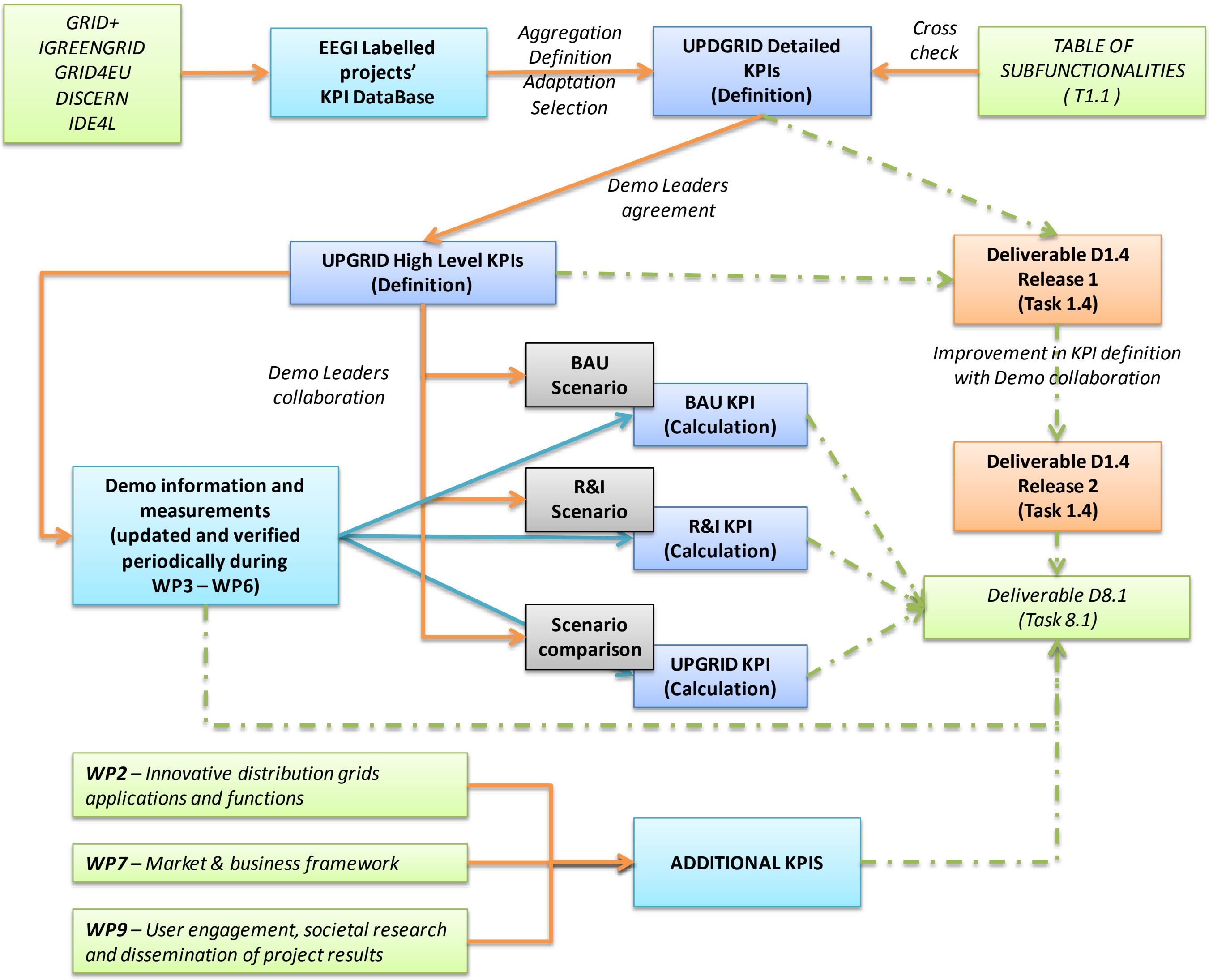

FIGURE 1: KPI CALCULATION ALONG THE UPGRID PROJECT.

SOURCE: UPGRID PROJECT

The sub-functionalities that each demo will develop in the scope of the UPGRID project and how will they do it has been the main input of T1.4. This description was performed in T1.1 – *Technical specification of project demonstrators*. The coordination of work packages 3 to 6 *(Demonstrations in real user environment: Spain, Portugal, Sweden and Poland)* and T1.4 will be crucial to guarantee that the required data in the initial KPI definition will be available by the end of (or during) the demos for the KPI calculation in T8.1 – *KPIs analysis*. Therefore, T1.4 will be the main input for T8.1. The KPI calculation will be also a valuable input for other tasks in WP8 and WP9 like T8.4 – *Cost-benefit analysis* and T9.3 – *Societal research*.

This document has been divided in six main sections. After a brief introduction (section 1), section 2 provides a brief description of the EEGI KPI calculation methodology as a background and justifies why this KPI framework has been selected for the UPGRID project. Next in line, section 3 is a description of the main EEGI labelled projects that have been analysed gathering for KPIs to be borrowed or adapted to be used in the UPGRID project: GRID+, IGREENGrid, GRID4EU, DISCERN and IDE4L.

Then section 4 describes the proposed UPGRID methodology for KPI calculation along the project. It includes the description of the UPGRID high level KPIs directly linked with the EEGI functional objectives, the list of UPGRID detailed KPIs borrowed or adapted from other EU projects and also other defined specifically for UPGRID, the calculation methodology to build high level KPIs from detailed KPIs and the evolution that the KPIs will have along the project. Sections 5 and 6 expand on section 4 providing the exhaustive definition of UPGRID detailed KPIs and high level KPIs, respectively.

Finally, Annex I includes the tailored template that will be used during the entire project for the detailed KPI definition. Annex II consists of the templates defined in Annex I fulfilled for the UPGRID detailed KPIs at the stage of closing the present deliverable. Annex III includes the relation between UPGRID sub-functionalities and the detailed KPIs. Finally Annex IV summarizes the classification of the most relevant protocols and standards in the UPGRID demos (these last tables have been borrowed from D1.3 – *Report on standards and potential synergies* and are used for the calculation of KPIs U_25 – *Use of equipment standards* and U_26 – *Use of protocol standards*).

2. EEGI KPI METHODOLOGY DEFINITION

UPGRID project has chosen the EEGI roadmap structure as the framework to classify the UPGRID contributions to the research and innovation activities on Electricity Grids at European level by the SET-PLAN. The European Electricity Grid Initiative (EEGI) is one of the European Industrial Initiatives under the Strategic Energy Technologies Plan (SET-PLAN) and proposes a 9-year European research, development and demonstration (RD&D) programme to accelerate innovation and the development of the electricity networks of the future in Europe [1].

EEGI's objectives are the base of the EEGI Roadmap 2013-22 and Implementation Plan 2013-2022, which has been prepared by ENTSO-E[2] and EDSO4SG[3] in close collaboration with the European Commission, CEER[4] and other relevant stakeholders. UPGRID project has followed the EEGI roadmap structure of the EEGI roadmap 2013-2022 [2]. This document is an upgraded version of the June 2010 EEGI R&I roadmap which was initiated early 2012 in response to EU energy policy evolutions.

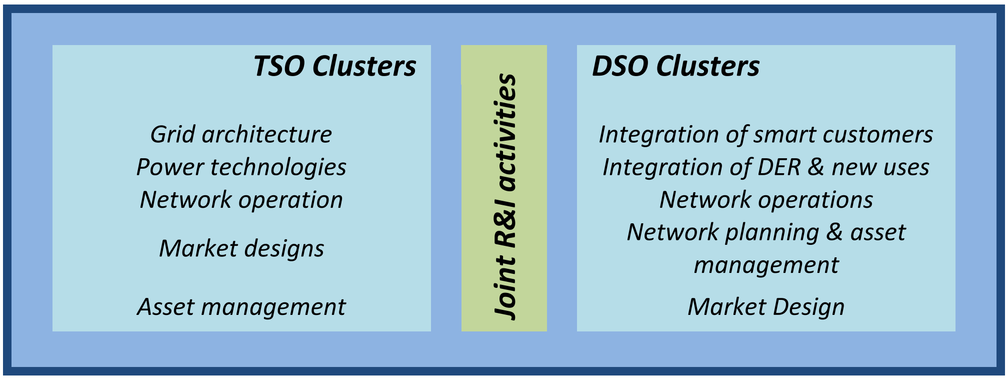

FIGURE 2: RESEACH AND INNOVATION ACTIVITIES OF THE EEGI ROADMAP. SOURCE: UPGRID PROJECT BASED ON [3]

Transmission and Distribution operators are defined in the EEGI roadmap as regulated companies for which the value chain of services involves similar skills used in similar activities. In view of a low carbon economy, such enablers will help the renewable energy industry to sell green electricity to distant markets, to increase usage of variable energy sources by balancing them across vast geographical regions, to remove congestions, to flourish electricity markets, to enable the electrification of the transport sector and the development of active demand management.

[2] ***ENTSO-E***: *European Network of Transmission System Operators for Electricity (www.entsoe.eu).*

[3] ***EDSO4SG***: *European Distribution System Operators' Association for Smart Grids (www.edsoforsmartgrids.eu).*

[4] ***CEER***: *Council of European Energy Regulators (www.ceer.eu).*

The innovation activities described in the EEGI roadmap cover the full value chain of activities performed by Network Operators grouped into five clusters as shown in Figure 2. The main goals of each DSO cluster objectives are the following:

- **Cluster 1: Integration of smart customers**. Peak shaving and energy saving with a full range of incentives covering: availability of real-time prices signals, application of time-of use tariffs and possibility of visualizing and controlling their own power consumption using the latest technology.

- **Cluster 2**: **Integration of DER and new uses**. The expected step changes cover: upgraded network design criteria which extend the network hosting capacity while still leading to secure operations and high power quality, improved DER connection criteria, grid protection standards with specifications towards manufacturers, extended electricity recharge infrastructure in order to enable the easy, secure and flexible recharging of EV and PHEV with regulatory recommendations to support EV/PHEV penetration, proposing business models for EV recharging, integrating storage solutions in the network to flatten the load curve and increase the quality of service and contributing to lowering the cost of storage through promoting standard, open, flexible solutions.

- **Cluster 3**: **Network Operations**. Handling future demands of higher reliability, renewable integration and increased use of smart metering will require network flexibility, with interactions on monitoring and control. A software based solution addresses these demands. Monitoring today is mainly to collect a limited number of parameters with a low degree of actions that can be taken.

  More flexible network requires developing: MV Advanced network control functions, preventive maintenance approaches, outage management and quality of supply (AMR data opens up a number of opportunities that have not been previously available. By using AMR data detailed information can be obtained on only how the low voltage network is performing but also on losses, load characteristics and power quality. Experiences from existing low voltage networks can be used for optimal low voltage network planning), load control (AMR data can also be used in outage management: the goal is to look into which system functionalities are needed to use such a tool. Introducing AMR provides a communication channel to each customer, thus used for information exchange and load control. Enabling load control opens up the possibility of better using the capacity in the entire network and also reducing outages), load modelling (the introduction of a simulation tool that utilizes AMR data in low voltage network planning as stated above will help the operator better control the network), development and validation of techniques to enhance the elasticity of demand by incentivizing customers (public and/or private support) via demand response and interactions with novel aggregation techniques of small customers to enhance the impact onto the electricity market and system.

- **Cluster 4**: **Network planning and asset management**. The major objectives are: develop new planning methodologies able to account for new network architecture, develop and share knowledge on ageing process in order to better understand and specify the needs for smarts devices and tools enabling an efficient management of the network components' maintenance and lifetime, develop and experiment new asset management methodologies, sensors and software tools based on this knowledge and field test them, develop and experiment new algorithms for load forecasting, based on quasi-real-time system data, define upgrade policies for the ITC components which comply both with existing and future assets and introduce asset management methodologies that address both hardware and software issues.

- **Cluster 5**: **Market design**. There are several market design issues which ought to be addressed at EU level for future distribution networks: charging electricity costs with tariffs reflecting the marginal cost of electricity, reliability- and quality of supply- based regulations (impact on DER deployment with harmonization over EU-27 for DSOs and TSOs), quality and safety market impacts induced by the large scale deployment of DER, regulation options to encourage the development of electricity storage and distributed energy resources, management of the costs of ownership for DER units when contributing to system services, coupling of electricity and transport regulations (plug-in hybrid cars) and development of standards for DER (distributed generation and storage systems) interconnection to the network and telecommunication systems for DER control.

  Simulation tools suited to the understanding of markets at distribution level ought to be jointly developed before detailed studies at regional levels could answer the above questions.

This collective roadmap based on cluster objectives for Network Operators has allowed transmission and distribution operators to propose their functional objectives for their research and innovation activities. EDSO4SG proposes the following functional objectives (D_i) for each cluster objective (C_i) to cover the value stages brought by distribution operators to the electricity system.

TABLE 2: EEGI ROADMAP CLUSTER AND FUNCTIONAL OBJECTIVES FOR DSOS.

SOURCE: UPGRID PROJECT BASED ON [3]

C1	**Integration of smart customers**	**D1**	*Active Demand for increased network flexibility*
		D2	*Enabling maximum energy efficiency in new or refurbished urban using smart distribution grids*
C2	**Integration of DER and new uses**	**D3**	*Integration of DER at low voltage*
		D4	*Integration of DER at medium voltage / high voltage*
		D5	*Integration of storage in network management*
		D6	*Integration of infrastructure to host Electrical Vehicles*
C3	**Network operations**	**D7**	*Monitoring and control of LV networks*
		D8	*Automation and control of MV networks*
		D9	*Network management methodologies for network operation*
		D10	*Smart metering data utilization*
C4	**Network planning and asset management**	**D11**	*Novel planning approaches for distribution networks*
		D12	*Novel approaches to asset management*
C5	**Market design**	**D13**	*New approaches for market design*

In order to determine exactly what specific elements will be displayed in the four demos, UPGRID has considered an additional level following the cluster and function objectives structure of the EEGI roadmap. This third level, collect demos' sub-functionalities that correspond directly with the implementations and process that will be developed or implemented in the scope of the UPGRID project [4]. Therefore in the UPGRID context, sub-functionalities are defined as implementations and processes (hardware and software) aimed at providing a service to achieve a purpose facilitated by standards and right technological choices to attain expected impacts which can be categorised in smart grid Function Objectives and Clusters [5]. These sub-functionalities have been defined in UPGRID deliverable D1.1 "*Report on Technical Specifications*" [4].

The proposed UPGRID KPIs included in this deliverable have a strong link with the UPGRID sub-functionalities defined in task T1.1 and consequently follow the structure of the EEGI roadmap to evaluate the impact and the contribution of the project to the cluster and functional objectives defined by EEGI for DSOs.

2.1 EEGI KPI CALCULATION METHODOLOGY

EEGI has analysed the energy targets for future electricity sector decarbonisation and it has developed a complete roadmap for 2022, where a set of Key Performance Indicators (KPI) are defined in order to quantify the proposed goals for a low carbon economy at affordable costs [3].

The EEGI framework is developed under the GRID+ project [6], oriented to support the development of EEGI initiative. With this purpose, three levels of KPIs have been introduced, each level having a specific management goal of the Research and Innovation Roadmap. These KPIs are not only oriented to evaluate the results of R&I project, but also to estimate their contribution to achieve EU goals.
The following picture illustrates the developed EEGI framework for the definition of expected impact KPIs:

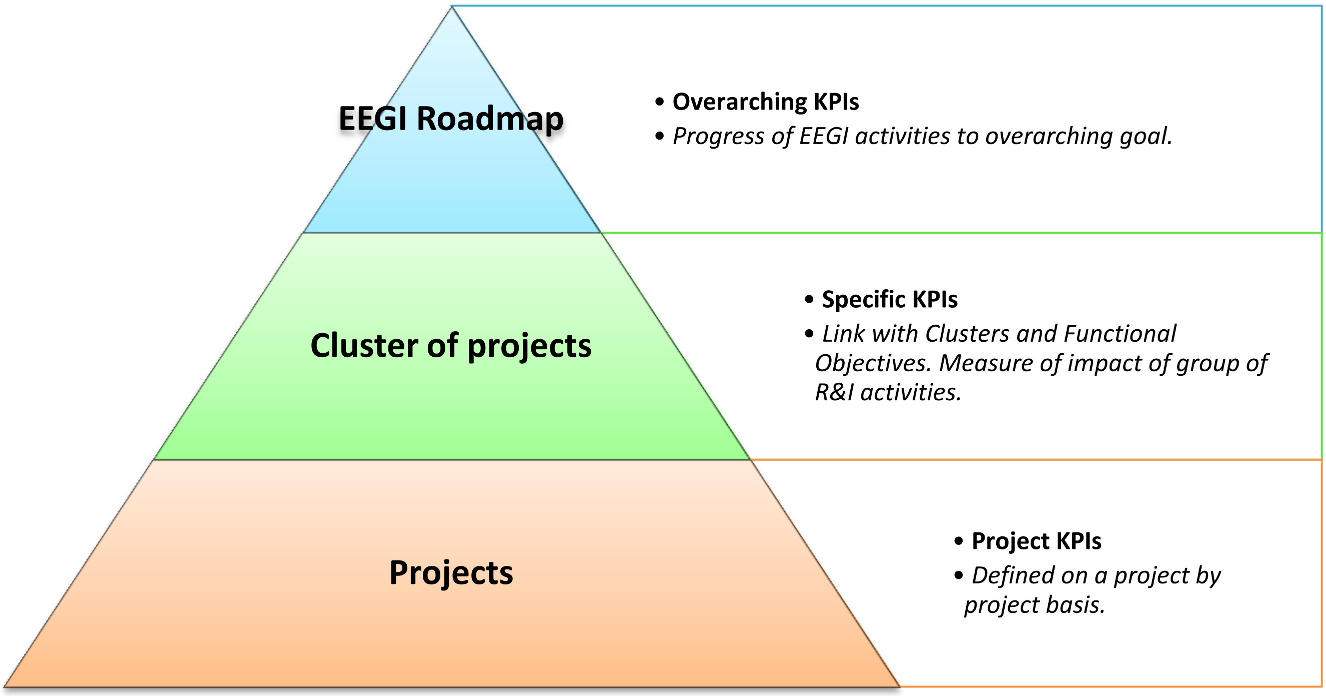

FIGURE 3: EEGI KPI DEVELOPED FRAMEWORK FOR EXPECTED KPIS.

SOURCE: UPGRID PROJECT BASED ON [3]

The *Overarching KPIs* consists of a limited set of network and system performance indicators which trace clear progress brought by EEGI activities towards its overarching goal. They are intended to provide a very high level understanding of the benefits that would be achieved by European R&I projects and will be evaluated at a system level (they are considered as the *EEGI Programme KPIs* related to the EEGI R&I Roadmap). Next in line, the *Specific KPIs* provide an overview of other specific technical parameters relevant for network operators in order to reliably achieve their overarching goals. Therefore they are not directly related to overarching goals but to the different innovation Clusters and Functional Objectives of the EEGI Roadmap. Finally, the *Project KPIs* are proposed by each R&I project of the EEGI Roadmap. The results from the Project KPIs will be used to evaluate the Overarching and the Specific KPIs.

To quantify the impact delivered by a R&I project the EEGI methodology proposes to compare what would be the expected benefits from applying a R&I solution versus the expected benefits of applying a Business as Usual (BAU) solution as a reference. This concept has been depicted in Figure 4.

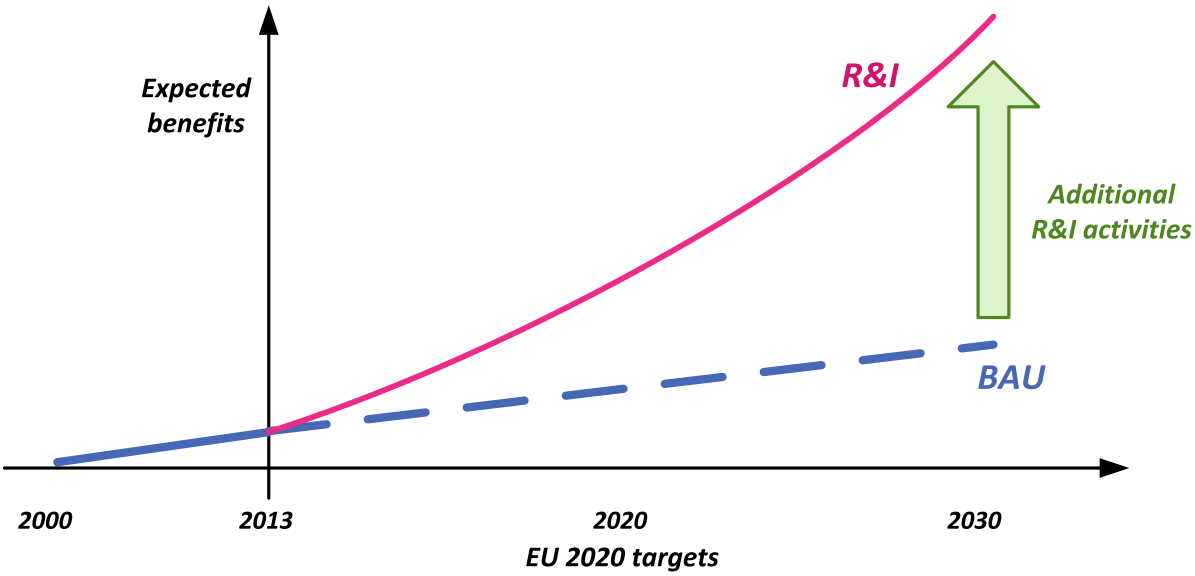

FIGURE 4: EXPECTED BENEFITS OF R&I ACTIVITIES WITH RESPECT TO BAU.

SOURCE: [7]

The ***Business as Usual (BAU)*** scenario shows what would be the situation if conventional solutions are applied (it reflects the normal evolution that the network would have). The ***Research and Innovation (R&I)*** scenario corresponds to a future situation where innovative solutions provided by R&I project results are implemented. This impact can be technical, economical or both. EEGI methodology also considers ***Reference Scenario***. This scenario is a temporal reference for BAU and R&I scenarios that corresponds to the current date.

Once the scenarios are defined, EEGI proposes a step-by-step methodology to measure the KPIs. This methodology has been depicted in Figure 5 and it may be defined as follows:

- **STEP 1**: Determination of the reference scenario of initial situation, the problems to solve, needs to satisfy, and the drivers that trigger a network/system improvement.

- **STEP 2**: Analysis of the future situation when the conventional evolution of the network happens (BAU situation).

- **STEP 3**: Calculation of the correspondent KPI to evaluate the BAU situation.
- **STEP 4**: Analysis of the future situation when smart grid solutions are deployed in the network (R&I situation).
- **STEP 5**: Calculation of the correspondent KPI to evaluate the R&I situation.
- **STEP 6**: Comparison of both scenarios, and calculation of the final indicator applying the proposed formula.

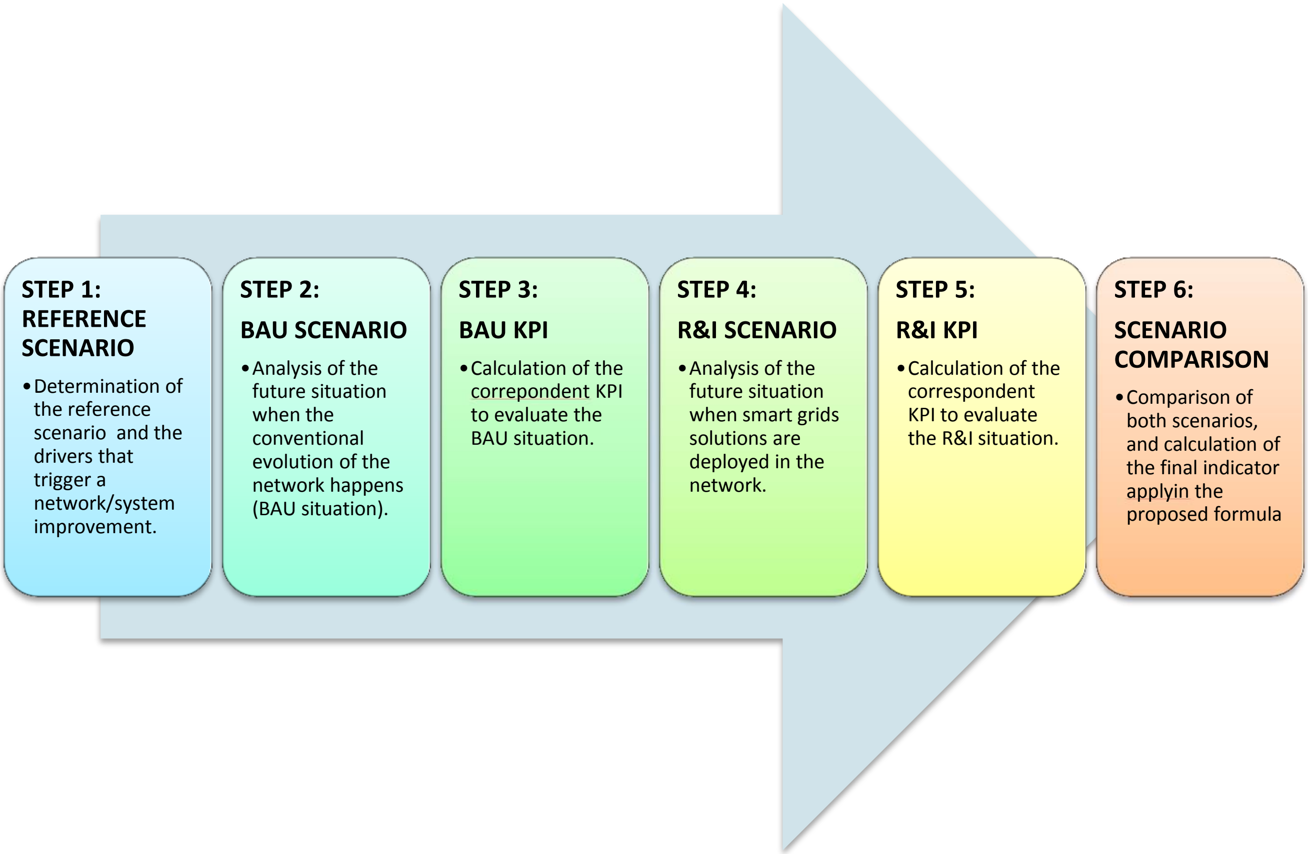

FIGURE 5: EEGI STEP BY STEP KPI CALCULATION METODOLOGY.

SOURCE: UPGRID PROJECT BASED ON [3]

3. EEGI LABELLED PROJECTS KPI ANALYSIS

The EEGI Project Label acknowledges [8] that a specific project is in line both with the spirit of the EEGI (i.e. knowledge sharing of results, system level innovation, etc.) and EEGI Functional Objective as specified in the EEGI Research and Innovation Roadmap [9].

The UPGRID project has considered as a general framework the KPIs that are being used in other smart grids projects in Europe labelled by EEGI and analyzed how these KPIs can be adapted to the features and objectives of the UPGRID demos in order to pave the way for enabling a robust and feasible monitoring of their performance.

The following sections provide a general overview of the EEGI labelled projects analyzed by the UPGRID project.

3.1 GRID+

GRID+

Supporting the Development of the European Electricity Grids Initiative (EEGI)

[2011-2014]

The GRID+ Project aims at designing a set of accompanying activities to make sure that the European Electricity Grids Initiative (EEGI) will pass through the critical 2012-2014 period. This involves preparation of Horizon2020, initial operation of the Agency for the Cooperation of Energy Regulators (ACER) and increased specification duties of the network operators [6].

GRID+ project work package 3 "*Monitor*" addresses the definition, updating and use of KPIs, setting up of a labelling procedure and reviewing financing mechanisms. Part of the outputs of this WP was included in deliverable D3.4- "*Define EEGI Project and Programme KPIs*" published on 15/04/2013 [7].

This document defines two categories of KPIs. The first one aims at measuring the completion of R&I objectives of the EEGI roadmap (Implementation Effectiveness KPI); the second one aims at measuring the expected impact of individual projects towards achieving the overall EEGI R&I Roadmap objectives (Expected Impact KPIs).

UPGRID project focused its analysis in the Expected Impact KPIs to gather KPIs to measure the expected impact of a project towards achieving the overall EEGI R&I Roadmap objectives. The following GRID+ KPIs were selected to be used as a basis for the development of UPGRID KPIs:

- Increased RES and DER hosting capacity.
- Reduced energy curtailment of RES and DER.
- Power quality and quality of supply.
- Extended asset life time.
- Increased flexibility form energy players.
- Improved competitiveness of the electricity market.
- Increased hosting capacity for electric vehicles (EVs) and other new loads.

3.2 IGREENGRID

IGREENGrid

IntegratinG Renewables in the EuropeaN Electricity Grid

[2013-2015]

The IGREENGrid project focuses on increasing the hosting capacity for Distributed Renewable Energy Sources (DRES) in power distribution grids without compromising the reliability or jeopardizing the quality of supply [10].

IGREENGrid project includes six large scale demonstration activities which are located in different European countries. They have been developed in real environments, to test the performance of R&I solutions dedicated to the integration of DRES. According to this, IGREENGrid demos have the entire requirement to be part of the EEGI innovation actions and they have a great potential to provide significant feedback to the EEGI team about the use of the KPIs on the basis of field measurements.

IGREENGrid deliverable D4.1 "*Report listing selected KPIs and precise recommendations to EEGI Team for improvement of list of EEGI KPIs*" published on 08/08/2014 includes an analysis of the connection between the IGREENGrid and EEGI performance indicators. On the basis of the DSO's field experience, suggestions and comments for the use of EEGI KPIs are formulated, highlighting the criticalities associated to the application of EEGI KPIs to real demo experiences [11].

The following IGREENGrid KPIs were selected to be used as a basis for the development of UPGRID KPIs:

- DRES hosting capacity.
- Quality of supply:

- Fulfilment of voltage limits.
- Variability of voltage amplitude.
- Analysis of voltage deviations.

- Usage time of R&I solution.
- Forecasting accuracy.
- Greenhouse gas emissions.

3.3 GRID4EU

GRID4EU

Large-Scale Demonstration of Advanced Smart GRID Solutions with wide Replication and Scalability Potential for EUROPE

[2011-2016]

The GRID4EU project lays the groundwork for the development of tomorrow's electricity grids. This project will test the potential of smart grids in areas such as renewable energy integration, electric vehicle development, grid automation, energy storage, energy efficiency and load reduction. GRID4EU consists of six demonstrators, which will be tested over a period of four years in each of the European countries represented in the consortium [12].

In the scope of work package 2, deliverable D2.2 "*Project KPIs definition and measurement methods*" published on 05/10/2012, defines a first set of GRID4EU project KPIs. GRID4EU KPIs are defined as those indicators that are common across different demos. This means that different demonstration projects providing different solutions will use these same indicators to measure specific benefits brought about by tested solutions in the different demonstration projects. The methodology for measuring these indicators will vary from demo to demo, but the indicator definition could be common to the different demos [13].

The following GRID4EU KPIs were selected to be used as a basis for the development of UPGRID KPIs:

- Energy losses.
- Fault awareness, location and isolation time.
- Network hosting capacity.
- Line voltages profiles.
- Use of standards.

- Recruitment.
- Active participation.

3.4 DISCERN

DISCERN

Distributed intelligence for Cost-Effective and Reliable Distribution Network Operation

[2013-2016]

The basis of the overall concept of DISCERN is to utilise the experience of major European DSOs with innovative technological solutions for a more efficient monitoring and control of distribution networks. The complementary nature of the demonstration sites with regard to the specific challenges as well as technological and operational solutions serve as the main resource of DISCERN [14].

The overall aim of DISCERN is to assess the optimal level of intelligence required for distribution networks and to determine if replicable technological options may be deployed in a cost effective manner. In so doing DISCERN would improve reliability, observability and controllability across European networks in response to the increasing pressure on DSOs to better use assets and improve the efficiency of operations. DISCERN deliverable D1.2 "*Intermediate demonstration projects KPI fulfilment report. Definition and calculation methodology of DISCERN KPIs*" published on 29/01/2015 builds on the roadmap developed in the early stages of the project and provides the detailed development of the KPI framework that has been established to support an enable the latter parts of DISCERN. This refined list of KPIs was used as a basis to detail each KPI to the relevant level of explanation and to provide a clear and unambiguous definition of the structure and intent of each KPI [15].

The following DISCERN KPIs were selected to be used as a basis for the development of UPGRID KPIs:

- Hosting capacity DER.
- Improvement SAIDI/ASIDI.
- Improvement SAIFI.
- Improvement voltage quality (monitoring).
- Reduction in time required for fault awareness, localization and isolation.
- Amount of load participating in demand response.
- Percentage reduction in complaints of customers because of outages.
- Availability of network components (ITC).

- Percentage of reduction in energy losses.
- Amount non-technical losses identified.
- Percentage of consumers being metered automatically.

3.5 IDE4L

IDE4L

Ideal grid for all

[2013-2016]

The main objectives of IDE4L project are to demonstrate the next generation of active distribution networks which full comply with new sustainable energy and efficient use of electricity frameworks, to develop advanced distribution network automation systems, including utilization of ancillary services of distributed energy resource and aggregator and to develop advanced applications that enable monitoring and control of whole network and embedded distributed energy resources [16].

IDE4L deliverable D7.1 “KPI Definition” published on 02/12/2014 provides a comprehensive context and description of the KPI definition and selection procedure, in order to assess the performance of the IDE4L architecture and use cases. The IDE4L use cases are going to be tested in different environments: development laboratories, demonstration laboratories and field demonstrators. In order to evaluate the solutions, algorithms and procedures to be tested, a proper methodology has been defined. The IDE4L KPI set has been developed using the EEGI methodology as the reference framework [17].

The following IDE4L KPIs were selected to be used as a basis for the development of UPGRID KPIs:

- LV real-time monitoring.
- MV real-time monitoring.
- LV state estimation.
- MV state estimation.
- Voltage stability of the electricity system.
- Success index in meter reading.
- LV load/generation forecaster.
- LV state forecaster.
- SAIDI.

- SAIFI.
- Reduction of energy cost.
- Reduction of technical network losses.
- Peak demand reduction ratio.
- Reduction in CO_2 emissions.
- RES curtailment.
- Demand response.

4. UPGRID KPI CALCULATION METHODOLOGY

4.1 HIGH LEVEL KPIS

After the analysis of the different frameworks for KPIs using the judgement and experience of the project participants, the EEGI framework has been adopted as a reference for the UPGRID KPI study, due to its simplicity and level of development.

In order to evaluate the contribution of each UPGRID demo in achieving the EU goals, the UPGRID high level KPIs are matched with the EEGI functional objectives. An output of the KPI calculation will be the fulfilment of a table by each demo which format is presented in Table 3. It will represent the contribution of each UPGRID demo to each EEGI functional objective from the BAU scenarios to the R&I scenario after applying the UPGRID innovations.

TABLE 3: UPGRID HIGH LEVEL KPIS.

SOURCE: UPGRID PROJECT

EEGI CLUSTER	HIGH LEVEL KPI (EEGI Function Objective)	UPGRID DEMOS
Integration of smart customers	D1. Active Demand for increased network flexibility	X
	D2. Enabling maximum energy efficiency in new or refurbished urban using smart distribution grids	
Integration of DER and new uses	D3. Integration of DER at low voltage	X
	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
Network operations	D7. Monitoring and control of LV networks	X
	D8. Automation and control of MV networks	X
	D9. Network management methodologies for network operation	X
	D10. Smart metering data utilization	X
Network planning and asset management	D11. New planning approaches for distribution networks	X
	D12. Novel approaches to asset management	X
Market design	D13. Novel approaches for market design	X

As the UPGRID list of sub-functionalities was built in deliverable D1.1 using the EEGI framework, at this early stage of the project is possible to know which demo is contributing to each functional objective and therefore to the EU goals. In Table 3 the cells that will contain a high level KPI after the KPI calculation have been marked according with the list of sub-functionalities of deliverable D1.1 [4].

If additional KPIs are identified in other work packages that are ongoing or even not started by the time of closing the present deliverable such as WP2 – *Innovative distribution grids applications and functions*, WP7 – *Market and business framework* and WP9 – *User engagement, societal research and dissemination of project results;* they will be added in T8.1 following the methodology described in this deliverable. The list of sub-functionalities included in D1.1 may be affected (completed) as a result of this process.

High level KPIs will be built as the weighted sum of detailed KPIs. These detailed KPIs will be calculated once per demo (combining as defined in each case the BAU and R&D scenarios). They will measure the impact of the new components or developments deployed in each demo. The results of one or more demo developments may impact on one or more detailed KPIs. Using a weight matrix, the detailed KPIs will be combined to calculate each high level KPI. This means that each detailed KPI will be used in one or more high level KPI calculation. Figure 6 illustrates the high level calculation procedure from detailed KPIs.

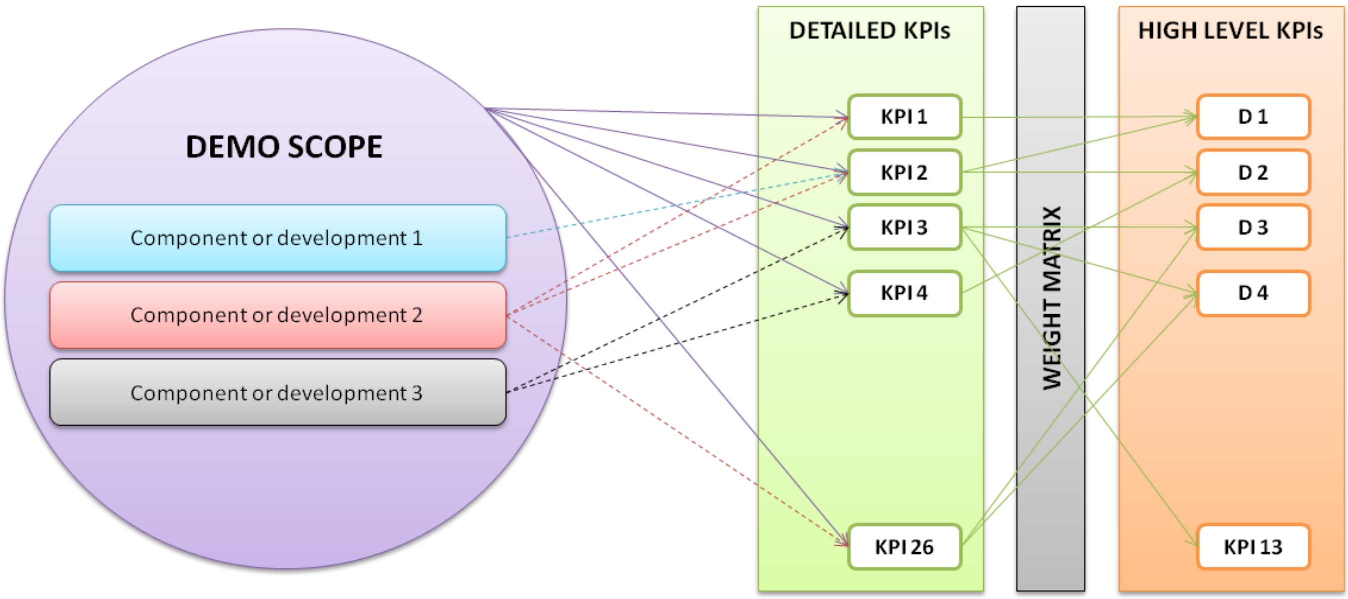

FIGURE 6: HIGH LEVEL CALCULATION PROCEDURE FROM DETAILED KPIS.

SOURCE: UPGRID PROJECT

In order to clarify this calculation procedure, an example has been included below. For this example an imaginary component to be deployed has been considered and the impact in the high level and detailed KPIs has been analysed.

Imagine that one component to be deployed in one of the UPGRID demo is:

- *A storage system to be installed in secondary substations with a BMS (battery management system) able to receive orders from the DSO to inject or consume energy from the grid.*

This component will impact positively (together with other components and developments) in the following UPGRID detailed KPIs:

- ***P_{DSM}: Demand flexibility*** *(the storage system will increase the total amount of consumed power that the DSO is able to move along the day).*
- ***P_{DER}: Generation flexibility*** *(the storage system will increase the total amount of generator power that the DSO is able to move along the day).*
- ***VL: Fulfilment of voltage limits*** *(distributed energy resources may help to reduce the voltage drop in electric lines as part of the load is balanced with the generated (or storage) energy).*
- ***ΔE: Energy losses*** *(distributed energy resources help to reduce the technical losses in the distribution grid lines in radial operation as they help to balance the load locally and reduce the total amount of energy coming from the lines).*
- ***AV: Availability of intelligent network components*** *(as this kind of storage system being able to receive orders from the DSO is a smart component that represents a significant R&I step in distribution network operation).*

This means that the impact of the deployment of this component (together with the impact of other components or developments in each demo) will be taken into account during the calculation of the previous detailed KPIs (which will be calculated only once per demo taking into account the sum of the impacts of each component or development for that demo). To sum up, the detailed KPIs of each demo will be only calculated once and contain the evaluation of the impact of all the components and developments deployed in that demo.

The first detailed KPI of the list (P_{DSM}: Demand flexibility), will be combined with some of the other KPIs on the list to calculate, with a weighted sum, the following high level KPIs:

- ***D1: Active demand for increased network flexibility****.*
- ***D5: Integration of storage in network management****.*
- ***D13: Novel approaches for market design****.*

Specifically, the second high level of the previous list of KPIs (D5: Integration of storage in network management) will be calculated as the weighted sum of P_{DSM}, P_{DER}, VL and ΔE as it has been shown in the following table.

TABLE 4: EXAMPLE OF THE CALCULATION OF AN UPGRID HIGH ELVEL KPI.

SOURCE: UPGRID PROJECT

	Detailed KPI	Detailed KPI value	Weight	Contribution to high level KPI
P_{DSM}	*Demand flexibility*	*80 %*	*35 %*	*0,80 x 0,35 = 0,28*
P_{DER}	*Generation flexibility*	*75 %*	*35 %*	*0,75 x 0,35 = 0,26*
VL	*Fulfilment of voltage limits*	*15 %*	*15 %*	*0,15 x 0,15 = 0,02*
ΔE	*Energy losses*	*20 %*	*15 %*	*0,20 x 0,15 = 0,03*

D5	***Integration of storage in network management***	***59,50 %***

The weight matrix to build each will be assigned by each demo leader and may be different from one demo to other depending to the component and developments to be deployed and the own vision and objectives of each demo.

The detailed KPIs used for the calculation of each high level KPI, the high level KPIs that is going to calculate each UPGRID demo according with the sub-functionalities list built in D1.1 and the weight matrix for each high level KPI (and each demo) have been summarized in section 6 of this deliverable.

4.2 DETAILED KPIS

The UPGRID detailed KPIs correspond to the "project KPIs" defined in the EEGI methodology. These KPIs are the indicators that show the achievements of the individual R&I projects. The definitions of these KPIs are specific to each individual project and therefore it is not possible for the EEGI to provide a universal set of KPI definitions and calculation methodologies that could be practically applied to all projects. However, the EEGI expects that in some cases projects would have some of the same or similar KPIs.

In order to follow the EEGI recommendations and fulfil part of its expectations, the UPGRID project has reviewed the KPIs that are being used in other smart grids projects in Europe labelled by EEGI and analyzed how these KPIs can be adapted to the features and objectives of the UPGRID demos in order to pave the way for enabling a robust and feasible monitoring of their performance. This analysis has been included in section 3 of this deliverable.

Table 5 includes the list of the proposed UPGRID detailed KPIs and their relation with other EEGI labelled projects. This list of KPI has been cross-checked so far with the list of sub-functionalities included in D1.1 [4] in order to be sure that the impact of each sub-functionality was going to be measured at least by one UPGRID detailed KPI. The number of KPIs selected in each of the indicated project in Table 5 depend of how close their thematics are with regards UPGRID as well. Moreover, having selected the KPIs showed in Table 5 does not mean they have been finally calculated in the indicated projects.

For this reason, most of these KPIs have been adapted from other EEGI labelled projects and even a small portion of the proposed KPIs have been borrowed directly from other projects. Nevertheless, seven of them have been defined specifically for UPGRID project to cover all the sub-functionalities. Some other European projects have been analyzed to cover this gap in the KPI definition. I.e. for the KPIs covering demand side management topic, the public deliverables of the ADVANCED project were analysed [18].

TABLE 5: PROPOSED UPGRID DETAILED KPIS AND THEIR RELATION WITH OTHER EEGI PROJECTS. SOURCE: UPGRID PROJECT

#	UPGRID KPI		EEGI LABELLED PROJECTS	DEFINED FOR UPGRID PROJECT
1	P_{DSM}	*Demand flexibility*	x	
2	P_{DER}	*Generation flexibility*	x	
3	HC_{EV}	*Hosting Capacity of Electric Vehicles*	x	
4	VL	*Fulfilment of voltage limits*	x	
5	ΔT_{LV}	*Average time for LV faults*	x	

6	ΔT_{MV}	*Average time needed for fault location in MV*	x	
7	QS_{LV}	*Quality of Supply Improvement in LV*	x	
8	QS_{MV}	*Quality of Supply Improvement in MV*	x	
9	ΔE	*Energy losses*	x	
10	*MDV*	*Monitoring information categories*	x	
11	*ADV*	*Available information categories*		*x*
12	*CDV*	*Characterized information categories*		*x*
13	*AV*	*Availability of intelligent network components*	x	
14	*SIMR*	*Success index in meter reading*	x	
15	*SIER*	*Success index in event reading*		*x*
16	*SIAF*	*Success index in advanced functionalities*		*x*
17	*SIMC*	*Success index in meters connectivity*		*x*
18	*Quota*	*Consumers being metered automatically*	x	
19	*ILT*	*Improved Life-time of transformers*		*x*
20	*R*	*Participant recruitment*	x	
21	*A*	*Active participation*	x	
22	*VF*	*Load curve valley filling*		*x*
23	*UES*	*Use of equipment standards*	x	
24	*UPS*	*Use of protocol standards*	x	
25	*GHG*	*Reduction in greenhouse gas emissions*	x	

4.3 KPI DEFINITION WORKING PROCEDURE

As it is has been already mentioned, the UPGRID KPI definition is based on the work performed in the scope of T1.1, this is the identification of the UPGRID sub-functionalities list and the classification of these sub-functionalities in the EEGI functional objectives. In the scope of the UPGRID definition methodology the EEGI functional objectives were used as the UPGRID high level KPIs. The UPGRID detailed KPIs were borrowed and adapted from other EEGI labelled projects. During the Madrid face to face meeting (July 2015) the four demo leaders linked the UPGRID list of sub-functionalities with the detailed KPIs.

The next question to be answered was: which detailed KPIs should be used to calculate each high level KPI? Once the former two links were established (sub-functionalities vs. high level KPIs and sub-functionalities vs. detailed level KPIs) the link between detailed KPIs and high level KPIs was almost automatically performed. The last step was to define the weight matrixes for each high level KPI to prioritize the detailed KPIs in their definition. This final step was also done with the collaboration of the demo leaders according with the objectives addressed in each demo.

The UPGRID KPI definition process has been illustrated in Figure 7:

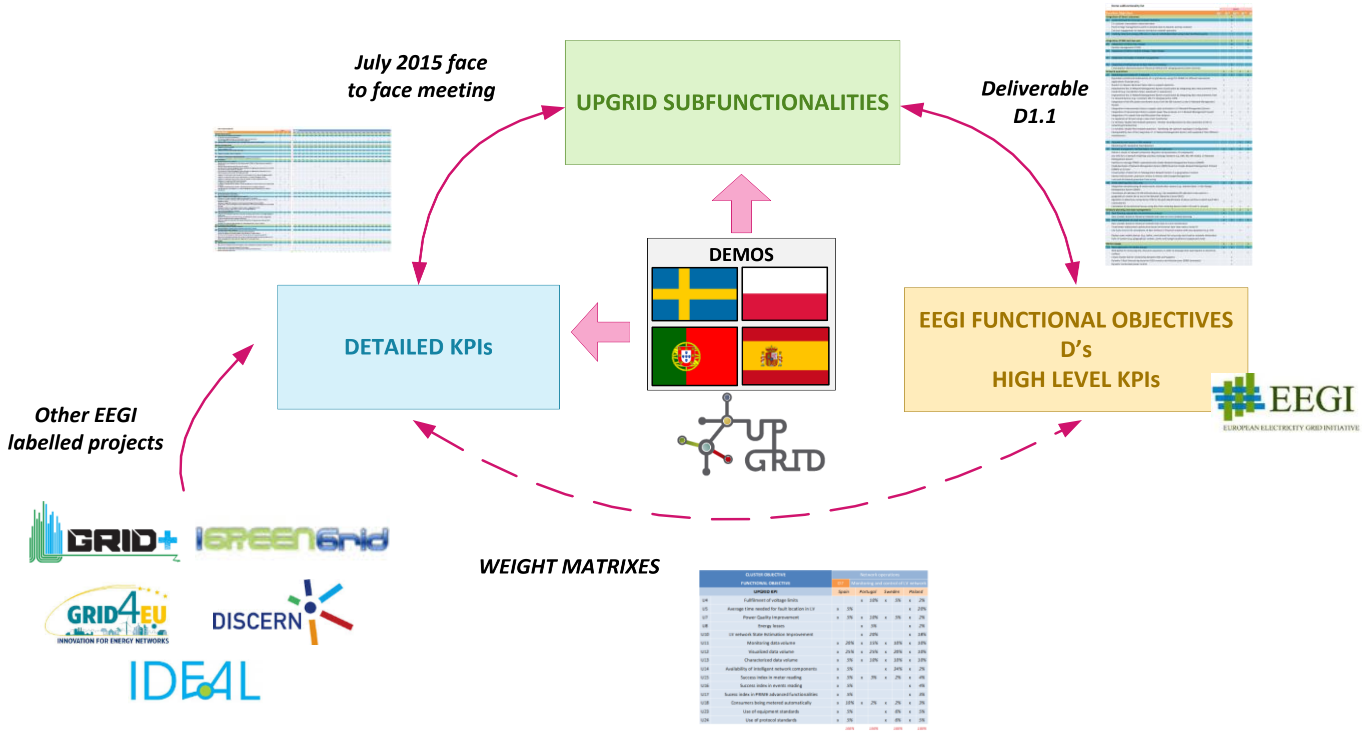

FIGURE 7: UPGRID KPI DEFINITION WORKING PROCEDURE.

SOURCE: UPGRID PROJECT

4.4 KPI EVOLUTION ALONG THE UPGRID PROJECT

According with the UPGRID project schedule, the KPI calculation is a process that starts in task T1.4 (Definition of common KPIs to monitor the performance of the demos) and will finish in task T8.1- *KPIs analysis*. Nevertheless, the KPI calculation process will "remain in background" during the demos work packages (WP3 to WP6) to guarantee that all the required information for the KPI calculation will be produced by the demos. Also additional KPIs might be identified in WP2, WP7 and WP9 that will be added in WP8. Figure 8 illustrates the evolution that the UPGRID KPIs will have along the project.

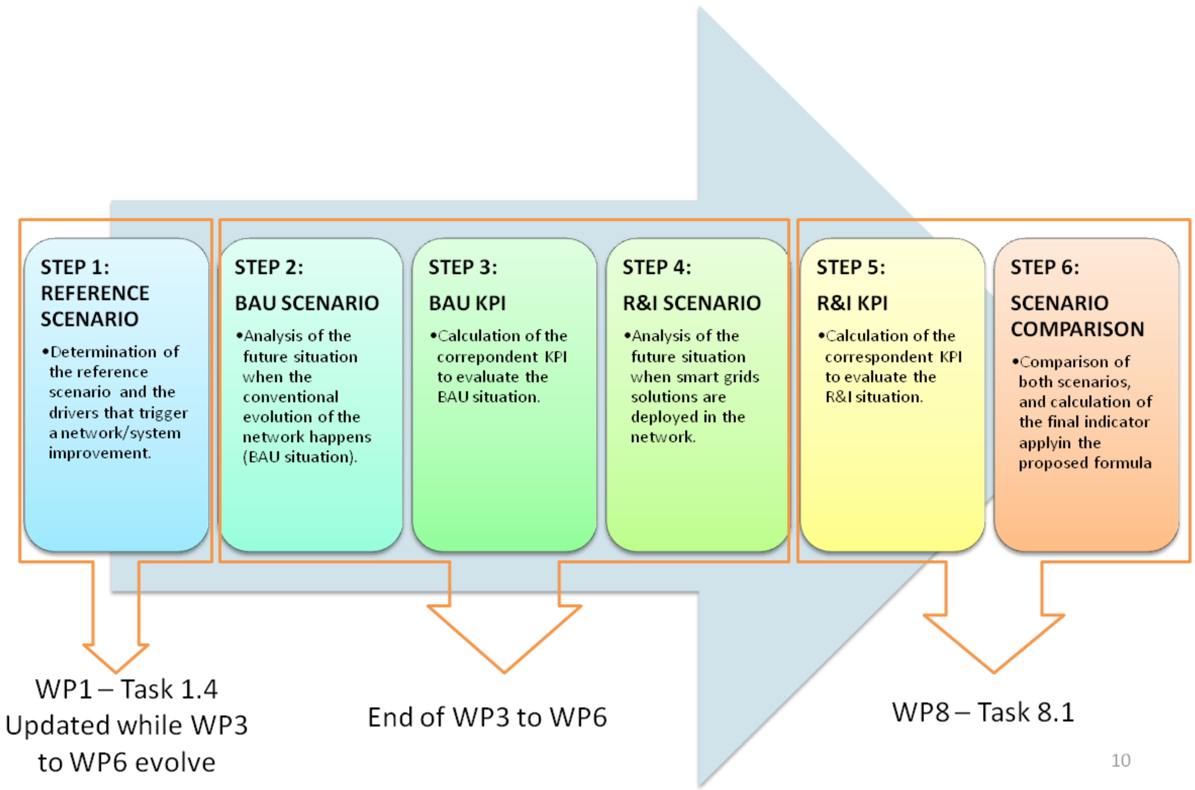

FIGURE 8: KPI EVOLUTION ALONG THE UPGRID PROJECT.

SOURCE: UPGRID PROJECT

5. PROPOSED UPGRID DETAILED KPIS DEFINITION

This section includes the description of the detailed KPIs of the UPGRID project presented in section 4. Further details of each detailed KPI can be also found in Annex II of this deliverable.

5.1 DEMAND FLEXIBILITY

Flexibility is an indication of the ability of the electricity system to respond to –and balance- supply and demand in real time. Demand flexibility is mainly measured through demand response capabilities. Nevertheless other grid initiatives may also enhance the demand flexibility of the grid, such as the integration of storage resources and specifically the integration of their operation in the distribution network operation.

This KPI will be calculated for each UPGRID demo as the sum of the amount of load capacity participating in demand side management. This KPI will be only calculated for an UPGRID demo if the demo is addressing sub-functionalities focused on enhancing demand flexibility.

Demand flexibility will be calculated using the following formula:

$$P_{DSM}(\%) = \frac{(P_{DSM})_{R\&I} - (P_{DSM})_{BAU}}{P_{peak}} \qquad (1)$$

where:

P_{DSM}	Represents the sum of the amount of load capacity that can be shifted thanks to DSM in the BAU and R&I scenarios.
P_{peak}	Represents the maximum electricity demand in the area under evaluation.

Other European EEGI labelled projects such as GRID+ and DISCERN have also considered demand flexibility indicators. Also other European projects such as ADVANCED have considered this kind of indicators.

5.2 GENERATION FLEXIBILITY

Flexibility is an indication of the ability of the electricity system to respond to –and balance- supply and demand in real time. Generation flexibility is mainly measured through generation response capabilities. Nevertheless other grid initiatives may also enhance the generation flexibility of the grid, such as the integration of storage resources and specifically the integration of their operation in the distribution network operation.

This KPI will be calculated for each UPGRID demo as the sum of the amount of generation capacity managed by the distribution network operator in LV and MV. This KPI will be only calculated for an UPGRID demo if the demo is addressing sub-functionalities focused on enhancing generation flexibility. Generation flexibility will be calculated using the following formula:

$$P_{DER}(\%) = \frac{(P_{DER})_{R\&I}}{\sum(P_R)_{R\&I}} - \frac{(P_{DER})_{BAU}}{\sum(P_R)_{BAU}} \qquad (2)$$

where:

P_{DER}	Represents the sum of the amount of flexible generation capabilities that the distribution network operator can shift in the BAU and R&I scenarios.
P_R	Represents the sum of the generation installed capacity on the system in the BAU and R&I scenarios.

Some of the demos are addressing the remote management of Distributed Energy Resources (DER). In the scope of the UPGRID project DER are: generators connected to the distribution network, generators connected downstream the customer’s meter but not generators connected to the transmission network.

Other European EEGI labelled projects such as GRID+ and DISCERN have also considered generation flexibility indicators. Also other European projects such as ADVANCED have considered this kind of indicators.

5.3 HOSTING CAPACITY OF ELECTRIC VEHICLES

This KPI intends to measure the contribution that UPGRID project has in increasing the capacity of the distribution network to host EVs. A direct contribution to this KPI may be enhancing the grid capacity (lines and transformers) or even the allocation of new charging points in the demo area. An indirect contribution may be the management or the analysis of the usage information of the existing charging points to characterise the user's behaviour and host more charging points with the same grid capability. Regarding this topic, UPGRID project is mainly addressing indirect actions to enhance the hosting capacity of electric vehicles.

This KPI will be calculated for each UPGRID demo as the sum of the available power of the characterized EV charging points (maximum power capability for each charging station). This KPI will be only calculated for an UPGRID demo if the demo is addressing sub-functionalities focused on enhancing the hosting capacity of electric vehicles.

Hosting capacity of electric vehicles will be calculated using the following formula:

$$HC_{EV}(\%) = \frac{(HC_{EV})_{R\&I} - (HC_{EV})_{BAU}}{P_{EV}} \quad (3)$$

where:

HC_{EV}	Represents the sum of the available power of the characterized EV charging points in the BAU and R&I scenarios.
P_{EV}	Represents the sum of the charging points installed power.

Other European EEGI labelled projects such as GRID+ has also considered hosting capacity of electric vehicles indicators.

5.4 FULFILMENT OF VOLTAGE LIMITS

The fulfilment of voltage limits is a common KPI used to evaluate the power quality and quality of supply of distribution networks. UPGRID project is addressing some actions to be implemented in the demo areas which will impact positively in the fulfilment of voltage limits. Some of these actions regard the remote management of DER. Other actions are related to the implementation of new algorithms to identify the optimum topological configuration of the distribution grid or even its remote reconfiguration after a fault. In addition, new regulation guidelines will be implemented using smart devices.

This KPI will be calculated for all UPGRID demos as all of them are considering the implementation of actions that will impact on the voltage limits fulfilment.

Fulfilment of voltage limits will be calculated using the following formula:

$$V(\%) = \frac{V_{BAU} - V_{R\&I}}{V_{BAU}} \quad (4)$$

where:

$V(\%)$	Evolution of the line voltage profiles.
V_{BAU}	Line voltage profiles in BAU scenario without R&I solutions.
$V_{R\&I}$	Line voltage profiles with R&I solutions.

Each UPGRID demo leader will select the most suitable indicator to calculate V_{BAU} and $V_{R\&I}$ depending on their information availability. Line voltage profiles are usually monitored through two values that are directly retrieved from power quality instrumentation: V_{max} and $V_{95\%}$. Nevertheless, in the scope of UPGRID project other indicators may be explored to evaluate the voltage limits fulfilment.
In the same way, each demo will defined the demo network nodes in which the fulfilment of voltage limits will be calculated.

- $\boldsymbol{V_{max}}$: The maximum reached line voltage during the defined monitoring period (i.e. 100 days).

$$VV_{max}(\%) = \frac{(V_{max})_{BAU} - (V_{max})_{R\&I}}{(V_{max})_{BAU}} \quad (5)$$

  - Positive value: Maximum measured line voltage has been reduced.
  - Negative value: Maximum measured line voltage has been increased.

- $\boldsymbol{V_{95\%}}$: The 95% percentage voltage value during monitoring period (i.e. 100 days), the value for which 95% of all voltage line measurements fall below.

$$VV_{95\%}(\%) = \frac{(V_{95\%})_{BAU} - (V_{95\%})_{R\&I}}{(V_{95\%})_{BAU}} \qquad (6)$$

  - Positive value: 95% line voltage has been reduced.
  - Negative value: 95% line voltage has been increased.

Other European EEGI labelled projects such as GRID+, IGREENGrid, DISCERN and GRID4EU have also considered fulfilment of voltage limits indicators.

5.5 AVERAGE TIME FOR LV FAULTS

The average time needed for fault location in LV is a common KPI used to evaluate the power quality and quality of supply of distribution networks. This KPI represents the percentage of reduction in time required for fault awareness, location and isolation (the last affected customer recovers the supply). One of the main objectives of UPGRID project is to enhance the tools to reduce the average time needed for fault location in LV like the integration of processing meter event or/and other sources in the outage management process.

Time needed for fault location in LV will be calculated using the following formula:

$$\Delta T_{\mathrm{LV}}(\%) = \frac{\left(\Delta T_{fault}\right)_{BAU} - \left(\Delta T_{fault}\right)_{R\&I}}{\left(\Delta T_{fault}\right)_{BAU}} \qquad (7)$$

where:

$\left(\Delta T_{fault}\right)_{BAU}$	Average time required for fault awareness, location and isolation in BAU situation.
$\left(\Delta T_{fault}\right)_{R\&I}$	Average time required for fault awareness, location and isolation with R&I solutions

Other European EEGI labelled projects such as GRID+, DISCERN and GRID4EU have also considered average time needed for fault location indicators.

5.6 AVERAGE TIME NEEDED FOR FAULT LOCATION IN MV

The average time needed for fault location in MV is a common KPI used to evaluate the power quality and quality of supply of distribution networks. This KPI represents the percentage of reduction in time required for fault awareness, location and isolation. UPGRID project is addressing several actions to be implemented in the demo areas which will reduce the average time needed for fault location. Some of these actions regard the revision and implementation of the DSO business processes in relation with the outage management integrating and processing fault detectors events or/and other sources. In addition, new smart devices will be deployed and tested to detect the fault and to support the maintenance grid crews.

Although all demos are considering the implementation of actions regarding the outage management optimization in LV, only some demos are also addressing actions in MV. Only these demos will calculate this KPI.

Time needed for fault location in MV will be calculated using the following formula:

$$\Delta T_{MV}(\%) = \frac{\left(\Delta T_{fault}\right)_{BAU} - \left(\Delta T_{fault}\right)_{R\&I}}{\left(\Delta T_{fault}\right)_{BAU}} \qquad (8)$$

where:

$\left(\Delta T_{fault}\right)_{BAU}$	Average time required for fault awareness, location and isolation in BAU situation.
$\left(\Delta T_{fault}\right)_{R\&I}$	Average time required for fault awareness, location and isolation with R&I solutions

Other European EEGI labelled projects such as GRID+, DISCERN and GRID4EU have also considered average time needed for fault location indicators.

5.7 QUALITY OF SUPPLY IMPROVEMENT IN LV

Although other KPIs have been defined in the scope of UPGRID project to evaluate the quality of supply of distribution networks, also a general quality of supply improvement KPI has been considered to evaluate the improvement in the frequency and duration of interruptions in LV.

Quality of supply in LV will be calculated using the Customer Minutes Lost (CML) indicator in BAU and R&I scenario using the following formula:

$$QS_{LV}(\%) = \frac{\mathrm{CML_{BAU}} - \mathrm{CML}_{\mathrm{R\&}I}}{\mathrm{CML_{BAU}}} \qquad (9)$$

where:

$\mathrm{CML_{BAU}}$	Customer Minutes Lost in BAU scenario.
$\mathrm{CML}_{\mathrm{R\&}I}$	Customer Minutes Lost in R&I scenario

Other European EEGI labelled projects such as GRID+, DISCERN and IDE4L have also considered power quality improvement indicators.

5.8 QUALITY OF SUPPLY IMPROVEMENT IN MV

UPGRID project is addressing several actions to be implemented in the demo areas which will impact positively in the reduction of duration and frequency of interruptions. Some of these actions regard the revision and implementation of the DSO business processes in relation with the outage management integrating and processing meter events or/and other sources. Other actions are related to the implementation of new algorithms to the remote reconfiguration of the distribution grid after a fault. In addition, new smart devices will be deployed and tested to detect the fault and to support the maintenance grid crews.

Quality of supply in MV will be calculated as the weighted sum of two classical indicators: SAIFI (System Average Interruption Frequency Index) and SAIDI (System Average Interruption Duration Index):

$$QS_{MV}(\%) = \mathrm{C}_{\mathrm{SAIFI}} \cdot \Delta_{\mathrm{SAIFI}} + \mathrm{C}_{\mathrm{SAIDI}} \cdot \Delta_{\mathrm{SAIDI}} \quad (10)$$

$$\Delta_{\mathrm{SAIFI}} = \frac{\mathrm{SAIFI}_{\mathrm{BAU}} - \mathrm{SAIFI}_{\mathrm{R}\&I}}{\mathrm{SAIFI}_{\mathrm{BAU}}} \quad (11)$$

$$SAIFI = \frac{\#interruptions}{\#customers} \quad (12)$$

$$\Delta_{\mathrm{SAIDI}} = \frac{\mathrm{SAIDI}_{\mathrm{BAU}} - \mathrm{SAIDI}_{\mathrm{R}\&I}}{\mathrm{SAIDI}_{\mathrm{BAU}}} \quad (13)$$

$$SAIDI = \frac{\#duration\_interruptions}{\#customers} \quad (14)$$

where:

$\mathrm{C}_{\mathrm{SAIFI}}$	Weight factor for SAIFI.
$\mathrm{C}_{\mathrm{SAIDI}}$	Weight factor for SAIDI.
interruptions	Total number of customer's interruptions within the observed period.
customers	Total number of customers served (average within the period).
duration_interruptions	Sum of all end customer interruptions duration within the observed period

Other European EEGI labelled projects such as GRID+, DISCERN and IDE4L have also considered power quality improvement indicators.

5.9 ENERGY LOSSES

The energy losses improvement evaluates the reduction of energy technical losses in the distribution network. UPGRID project is addressing some actions to be implemented in the demo areas which will impact positively in the reduction of energy technical losses. Some of these actions regard the remote management of DER. Other actions are related to the implementation of new algorithms to identify the optimum topological configuration of the distribution grid.

There also some UPGRID sub-functionalities focused on the identification (not reduction) of non-technical losses, like the calculation of non-technical losses using data from metering device both in secondary substation and low voltage network. This KPI will only consider the technical losses improvement (reduction) as there are no sub-functionalities specifically addressed to reduce non-technical losses.

This KPI will be calculated for each UPGRID demo as the total reduction of technical energy losses as a result of the combination of the different implemented R&I actions. This KPI will be only calculated for an UPGRID demo if the demo is addressing sub-functionalities focused on reducing energy losses.
The reduction in energy technical losses will be calculated using the following formula:

$$\Delta E(\%) = \frac{E_{BAU} - E_{R\&I}}{E_{BAU}} \quad (15)$$

where:

E_{BAU}	BAU scenario energy technical losses.
$E_{R\&I}$	Energy technical losses after the R&I deployment.

Other European EEGI labelled projects such as GRID4EU, DISCERN and IDE4L have also considered energy losses indicators.

5.10 MONITORING INFORMATION CATEGORIES

Monitoring data volume is an indication of the increase of data amount for new monitored currents, powers or voltages in primary substations, secondary substation or customer level. One of the main objectives of UPGRID project is the integration of measurement data for low voltage network control tools, for supporting state estimation and power flow algorithms or for the outage management procedures, among others.

This KPI will measure the amount of monitored information to support low voltage network control tools, like LV/MV Network Management Systems. The equipment providing information to the LV/MV Network Management System are the "intelligent network components" identified in section 5.13. These are:

- Smart meters, data concentrators, base nodes and RTU (PRIME).
- Smart plugs and gateways.
- Fault passage indicators (FPI).
- Smart transformers.
- Advanced LV supervisors (SS).
- DER controllers by nodes by nodes and RTU (PRIME).

This KPI will be calculated for all UPGRID demos as all of them are going to increase the total amount of monitored data volume.

Monitoring data volume will be calculated using the following formula:

$$MDV(\%) = \frac{MD_{R\&I} - MD_{BAU}}{MD_{BAU}} \quad (16)$$

where:

MD_{BAU}	Total monitored data according with the count criterion in BAU scenario.
$MD_{R\&I}$	Total monitored data according with the count criterion in R&I scenario.

There will be three possible count criterions for monitoring data volume. Each demo will use a different option according to its characteristics and nature. Therefore, monitoring data volume can be measured:

- **Option 1**: Counting **each new LV network measuring point** (i.e. a smart meter).

- **Option 2**: Counting **each information category available in each LV network measuring point** (i.e. smart meters provide measuring information, power quality information, events, etc.).

- **Option 3**: Counting **each parameter available in each LV network measuring point** (i.e. smart meters may provide information about power, currents, voltage, interruptions, events, etc.).

Example *(only and example, it may has not correspondence with any demo)**:***

To calculate this KPI, each demo will built a table to compare the monitored data before and after the UPGRID deployment for each intelligent network component.

Equipment	**Number of deployed devices**		**Information Category**	**Parameter/Report**	**Monitored data**	
	Before UPGRID	**After UPGRID**			**Before UPGRID**	**After UPGRID**
Smart Meter	100	120	Energy register	*Basic instant data values (22)*	*Yes*	*Yes*
				Advanced instant data values (43)	*No*	*Yes*
				Current billing values (14)	*Yes*	*Yes*
				Monthly billing values profile (21)	*No*	*No*
				...	...	...
			Meter events (6)	*Standard events*	*No*	*No*
				Switch control	*No*	*No*
				Quality and power failures	*No*	*Yes*
				Fraud detection	*No*	*No*
				Demand management	*No*	*Yes*
				Communication	*No*	*No*
			Meter parameters	...	...	...
			Contract definition	...	...	...
			...	...	...	...
Advanced LV supervisors	4	4	MV energy register	*Voltage (4)*	*Yes*	*Yes*
				Current (4)	*Yes*	*Yes*
			LV energy register	*Voltage (4)*	*No*	*Yes*
				Current (4)	*No*	*Yes*
			...	...	...	...
...	...	...	...	...	...	...

The KPI calculation taking into account the three different options will be:

Equipment	OPTION 1			OPTION 2			OPTION 3		
	MD_{BAU}	$MD_{R\&I}$	MDV (%)	MD_{BAU}	$MD_{R\&I}$	MDV (%)	MD_{BAU}	$MD_{R\&I}$	MDV (%)
Smart Meter	*100*	*120*	*20%*	*100 x 2 = 200*	*120 x 5 = 600*	*200%*	*100 x (22+14)= 3.600*	*120 x (22+43+14+6+6)= 10.920*	*203%*
Advanced LV supervisor	*4*	*4*	*0%*	*4 x 2 = 8*	*4 x 4 = 16*	*100%*	*4 x (4+4)= 32*	*4 x (4+4+4+4)= 64*	*100%*
Global	*104*	*124*	*19%*	*208*	*616*	*196%*	*3.632*	*10.984*	*202%*

Other European EEGI labelled projects such as IDE4L have also considered monitoring data volume indicators.

5.11 AVAILABLE INFORMATION CATEGORIES

Available data volume is an indication of the increase of data amount for new visualized currents, powers or voltages in primary substations, secondary substation or customer level. One of the main objectives of UPGRID project is to enhance the availability of the information gathered by the smart metering infrastructure for the distribution system operator and also for the final customer. This information will be integrated in the low voltage management tools visualization for the distributed system operator. Also the consumption information will be available in a web portal for increasing the customer awareness. Finally, the information will be also depicted in smart mobile devices to support maintenance grid crews.

One of the main objectives of UPGRID project is to enhance the availability of the information gathered by the smart metering infrastructure for the DSO and also for the customer. All demos are addressing sub-functionalities to enhance the data visualization through different platforms:

- LV Network Management System (DSO).
- MV Network Management System (DSO).
- Web portal (customers).
- Mobile devices (grid crews).

This KPI will be calculated for all UPGRID demos as all of them are going to increase the total amount of available data volume. It will be the sum of available information ready to be visualized through the former ICT platforms. However if a demo is not deploying i.e. grid crew mobile devices, this demo will only consider the remaining platforms.

Available data volume will be calculated using the following formula:

$$ADV(\%) = \frac{AD_{R\&I} - AD_{BAU}}{AD_{BAU}} \qquad (17)$$

where:

AD_{BAU}	Total available data according with count criterion in BAU scenario.
$AD_{R\&I}$	Total available data according with count criterion in R&I scenario.

There will be three possible count criterions for monitoring data volume. Each demo will use a different option according to its characteristics and nature. Therefore, monitoring data volume may be measured:

- **Option 1**: Counting each new measuring point in LV network whose information may be visualized through one platform. If this information is available in through three different platforms, it will be counted three times.

- **Option 2**: Counting each information category available in each new LV network measuring point that may be visualized through one platform. If a measuring point information category is available in through three different platforms, it will be counted three times.

- **Option 3**: Counting each parameter available in each new LV network measuring point that may be visualized through one platform. If a parameter is available in through three different platforms, it will be counted three times.

Example *(only and example, it may has not correspondence with any demo):*

To calculate this KPI, each demo will built a table to compare the available data before and after the UPGRID deployment for each platform.

Equipment	**Number of deployed devices**		**Information Category**	**Parameter/Report**	**Available data**				
					LV Network management system		**Web portal**		**...**
	Before UPGRID	**After UPGRID**			**Before UPGRID**	**After UPGRID**	**Before UPGRID**	**After UPGRID**	**...**
Smart Meter	100	120	Energy register	*Basic instant data values (22)*	*No*	*No*	*No*	*No*	...
				Advanced instant data values (43)	*No*	*No*	*No*	*No*	...
				Current billing values (14)	*No*	*Yes*	*No*	*No*	...
				Monthly billing values profile (21)	*Yes*	*Yes*	*No*	*Yes*	...
				...	...	...			...
			Meter events (6)	*Standard events*	*No*	*Yes*	*No*	*No*	...
				Switch control	*No*	*No*	*No*	*No*	...
				Quality and power failures	*No*	*Yes*	*No*	*Yes*	...
				Fraud detection	*No*	*Yes*	*No*	*No*	...
				Demand management	*No*	*Yes*	*No*	*No*	...
				Communication	*No*	*No*	*No*	*No*	...
			Meter parameters	...	...	...			...

			Contract definition	...	...	...			...
			...	...	...	...			...
...	...	...	...	...	...	...			

The KPI calculation taking into account the three different options will be:

Equipment	**OPTION 1**			**OPTION 2**			**OPTION 3**		
	AD_{BAU}	**$AD_{R\&I}$**	**ADV (%)**	**AD_{BAU}**	**$AD_{R\&I}$**	**ADV (%)**	**AD_{BAU}**	**$AD_{R\&I}$**	**ADV (%)**
Smart Meter	*100*	*2 x 120 = 240*	*140%*	*1 x 100 = 100*	*8 x 120 = 960*	*860%*	*100 x 21 = 2.100*	*120 x (14 +21 x 2 +6 x 5)= 10.320*	*391%*
...	...	...	...	...	...	...	...	...	...
Global	...	...	...	...	...	...	...	...	...

This KPI has been defined specifically for UPGRID project as no references where found in any other European EEGI labelled projects regarding available data volume indicators.

5.12 CHARACTERIZED INFORMATION CATEGORIES

Characterized data volume is an indication of the increase of data amount for new characterization analysis of currents, powers or voltages in primary substations, secondary substation or customer level. UPGRID addresses the data analytic based on the information gathered by the smart metering infrastructure to characterize low voltage consumption, to characterize the EV charging points behaviour and the grid state data to assist network planning and maintenance.

This KPI will measure the portion of information from the monitored information that will be characterized in the scope of UPGRID project to support DSO operation and planning tools and to provide information about the grid status and grid users behaviour. The data characterization is a measure of how the information gathered in the smart grid is being used for real applications giving value and justifying the smart grids deployment.

All demos are addressing sub-functionalities to enhance the data characterization for different purposes:

- LV customer consumption characterization.
- Consumption characterization of EV charging points.
- Visualisation of data from LV Network Management System.
- Define a sound LV network.
- Integration of measurement data to support state estimation in LV Network Management System.
- Integration of measurement data to support power flow analyses in LV Network Management System.
- Algorithm to determine connectivity of smart meters to the grid.
- Load and distributed generation forecasting.

This KPI will be calculated for all UPGRID demos as all of them are going to increase the total amount of characterized data volume. It will be the sum of the information used for different purposes (behaviour characterization or algorithm feeding). If a demo is not addressing i.e. load and DER forecasting, this demo will only consider the remaining characterization purposes.

Characterized data volume will be calculated using the following formula:

$$CDV(\%) = \frac{CD_{R\&I} - CD_{BAU}}{CD_{BAU}} \qquad (18)$$

where:

CD_{BAU}	Total characterized data according with count criterion in BAU scenario.
$CD_{R\&I}$	Total characterized data according with count criterion in R&I scenario.

Characterized data volume will be measured as the sum of data volume use to characterize behaviours and to feed algorithms, taking also into account the time period.

Example *(only and example, it may has not correspondence with any demo):*

Before the UPGRID project, a demo was using the active power, current and voltage of 10 secondary substations every 15 minutes during one month (30 days) to feed the state estimation algorithm.

After the UPGRID project, the demo will use the same parameters but of 20 secondary substations and for one month (30 days). In addition, the demo will use the hourly active power of 5 charging station recorded during 8 months (240 days) to feed charging station forecasting algorithms.

The KPI calculation will be as follows:

$$CD_{BAU} = 10\ (ss)\ x\ 3\ (parameters)\ x\ 4\ \left(\frac{measures}{day}\right)\ x\ 24\ \left(\frac{hours}{day}\right) x\ 30\ (days) = 86.400$$

$$CD_{R\&I} = \left[20\ (ss)\ x\ 3\ (parameters)\ x\ 4\ \left(\frac{measures}{hour}\right)\ x\ 24\ \left(\frac{hours}{day}\right) x\ 30\ (days)\right] + \left[5\ (charging\ stations)\ x\ 1\ (parameter)\ x\ 1\ \left(\frac{measure}{day}\right)\ x\ 240\ (days)\right] = 172.800 + 1.200 = 174.000$$

$$CDV(\%) = \frac{CD_{R\&I} - CD_{BAU}}{CD_{BAU}} = \frac{174.000 - 86.400}{86.400} = 101\%$$

This KPI has been defined specifically for UPGRID project as no references where found in any other European EEGI labelled projects regarding characterized data volume indicators.

5.13 AVAILABILITY OF INTELLIGENT NETWORK COMPONENTS

The availability of intelligent network components evaluates the increase of the total amount of intelligent network components (smart meters, smart transformers, new intelligent protection, etc.) deployed in the scope of each demo. UPGRID project is addressing several actions to be implemented in the demo areas which will increase the availability of intelligent network components. Some of these actions regard the deployment of new devices such as smart meters, concentrator, smart transformer or new fault detectors. Other actions are related to making smarter some of the already deployed devices, i.e. concept test of PLC-PRIME advanced queries in the deployed smart metering infrastructure.

This KPI will be calculated for all UPGRID demos as all of them are deploying new intelligent components or enhancing the functionalities of the existing ones. This KPI will be calculated for each UPGRID demo as the sum of the amount of new intelligent network components and/or the intelligent components with new and advanced functionalities.

The intelligent components to be deployed that will provide information to the LV and MV SCADAs are:

- Smart meters, data concentrators, base nodes and RTU (PRIME).
- Smart plugs and gateways.
- Fault passage indicators (FPI).
- Smart transformers.
- Advanced LV supervisors (SS).
- DER controllers.

The availability of intelligent network components will be calculated using the following formula:

$$AV(\%) = \frac{IC_{R\&I} - IC_{BAU}}{IC_{BAU}} \quad (19)$$

where:

$IC_{R\&I}$	Amount of the intelligent components deployed in R&I scenario and/or intelligent components with enhanced functionalities.
IC_{BAU}	Amount of the intelligent components deployed in BAU scenario.

In the former formula, the intelligent components will be weighted as is not the same installing a smart meter than installing an advanced LV supervisor in terms of investment but also in terms of amount and quality of the gathered information. As not all the UPGRID demos are deploying the same components, each demo will have its own matrix. The intelligent components weight matrix will be:

INTELLIGENT COMPONENT	DEMO SPAIN	DEMO PORTUGAL	DEMO SWEDEN	DEMO POLAND
Smart Meters	10 %	15 %		
Data Concentrators	10 %	15 %		
Base Nodes		15 %		
Service Nodes				
RTU	5 %	15 %	34 %	20 %
Smart plugs		20 %		
Gateways		20 %		
Fault passage indicators (FPI)			33 %	20 %
Smart transformers			33 %	
Advanced LV supervisors (SS)	20 %			30%
DER controllers				30 %
LV network management system	40 %			
PRIME NMS	15 %			
	100 %	*100 %*	*100 %*	*100 %*

In addition, this KPI will consider the new components to be installed in the scope of the UPGRID project but also the components in which new functionalities are enabled. The count criterion for the intelligent components will be:

- **IC = 0,5**: if the intelligent component has been modified to included new functionalities during the UPGRID project.
- **IC = 1**: if the intelligent component has been installed during the UPGRID project.

Other European EEGI labelled projects such as DISCERN have also considered characterized data volume indicators.

5.14 SUCCESS INDEX IN METER READING

Success index in meter reading determines the success index in meter reading in BAU and R&I scenarios. As it has been already mentioned before, one of the main objectives of UPGRID project is the integral deployment of the smart metering infrastructure. The success in meter reading is a simple indicator to evaluate the performance of the metering infrastructure and it may be the result of simple (i.e. load profile) and more complex queries to request meter data.

Success index in meter reading will be calculated using the following formula:

$$SIMR(\%) = SI_{R\&I} - SI_{BAU} \qquad (20)$$

$$SI(\%) = \frac{C_{Success}}{C_{Total}} \qquad (21)$$

where:

$C_{Success}$	Total number of measurements and actions that are correct and successfully performed by the first data retrieval and can be used for the respective process.
C_{Total}	Total number of triggered measurements and actions with the relevant period of time

Other European EEGI labelled projects such as DISCERN and IDE4L have also considered success index in meter reading indicators.

5.15 SUCCESS INDEX IN EVENTS READING

In the scope of UPGRID project, some demos will gather the grid events information registered by the smart meters in order to use it in the network operation processes. This objective was summarized in the sub-functionality “Queries to request advanced meter data to support operation”. For this reason a specific KPI has been defined to analyse if all the meters are sending correctly their registered grid events in BAU and R&I scenario.

It is important to mention here that a meter only registers an event (and therefore sends it) when an event happens. For this reason, to calculate this KPI only a group of meters that the DSO knows that should be sending and event (i.e. after a loss of energy supply) will be taken into account. This means that maybe not all the meters in the scope of the demo will be used to calculate this KPI.

Success index in events reading will be calculated using the following formula:

$$SIER(\%) = SI_{R\&I} - SI_{BAU} \quad (22)$$

$$SI(\%) = \frac{C_{Success}}{C_{Total}} \quad (23)$$

where:

$C_{Success}$	Number of meters sending correctly their events after a grid issue.
C_{Total}	Number of meters that the DSO knows that should be sending their events after a grid issue (i.e. after a loss of energy supply).

This KPI has been defined specifically for UPGRID project as no references where found in any other European EEGI labelled projects regarding success index in meter events reading.

5.16 SUCCESS INDEX IN ADVANCED FUNCTIONALITIES

In the scope of UPGRID project, some demos will use the advanced metering infrastructure to telecontrol other grid components such us PV installation controllers. This objective was summarized in the sub-functionality "Operation (control and multiservice) of LV grid devices using PLC-PRIME for different telecontrol applications (concept test)". For this reason a specific KPI has been defined to analyse the success in the communications with these grid devices.

This KPI will measure the latency in communications calculating the percentage of successful communications with grid devices in less than the delay objective. Each demo will fix the maximum delay between the stimulation and the response.

Success index in advanced functionalities will be calculated using the following formula:

$$SIAF(\%) = \frac{C_{Success}}{C_{Total}} \quad (24)$$

where:

$C_{Success}$	Successful communication attempts (lower latency than the target).
C_{Total}	Total number of communication attempts.

This KPI has been defined specifically for UPGRID project as no references where found in any other European EEGI labelled projects regarding success index in meter events reading.

5.17 SUCCES INDEX IN METERS CONNECTIVITY

In the scope of UPGRID project, some demos will enhance the connection between the LV network management system and the advanced metering infrastructure adding an improving the information about the meters connectivity available for the DSO. In example, this objective was summarized in the sub-functionality "Algorithm to determine connectivity of SM to the grid (identification of phase and line to which each SM is connected to".

This KPI will evaluate this improvement combining the DSO ability to know the location of the meter (customer) regarding the associated protection box and the phase and line to which each meter is connected.

Success index in meters connectivity will be calculated using the following formula:

$$SIMC(\%) = \mathrm{C_{PB}} \cdot \Delta\mathrm{SI_{PB}} + \mathrm{C_{PHL}} \cdot \Delta\mathrm{SI_{PHL}} \quad (25)$$

$$\Delta SI = SI_{R\&I} - SI_{BAU} \quad (26)$$

$$SI(\%) = \frac{C_{Success}}{C_{Total}} \quad (27)$$

where:

$\mathrm{C_{PB}}$	Weight factor for the ability to know the location of the meter regarding the associated protection box.
$\mathrm{C_{PHL}}$	Weight factor for the ability to know the phase and line to which the meter is connected.
$\Delta\mathrm{SI_{PB}}$	Improvement in the ability to know the location of the meter regarding the associated protection box between the BAU and R&I scenarios.
$\Delta\mathrm{SI_{PHL}}$	Improvement in the ability to know the phase and line to which the meter is connected between the BAU and R&I scenarios.
$C_{Success}$	Number of meter which protection box or phase and line is known.
C_{Total}	Total number of meters in the scope of the demo.

This KPI has been defined specifically for UPGRID project as no references where found in any other European EEGI labelled projects regarding success index in meter events reading.

5.18 CONSUMERS BEING METERED AUTOMATICALLY

Consumers being metered automatically states the quota of consumers which have their meter information remotely gathered by the distribution system operator, i.e. with smart meters connected via communication network to the data collection system in BAU and R&I scenarios. As it has been already mentioned before, one of the main objectives of UPGRID project is the integral deployment of the smart metering infrastructure. The number of consumers being metered automatically is a simple indicator to evaluate the evolution of the metering infrastructure together with the Success in index meter reading KPI.

Consumers being metered automatically will be calculated using the following formula:

$$Quota(\%) = \left(\frac{SMAR}{SM}\right)_{R\&I} - \left(\frac{SMAR}{SM}\right)_{BAU} \tag{28}$$

where:

$SMAR$	Total number of smart meters installed on field (meters connected to the communication network and able to be remotely accessed and read).
SM	Total number of smart meters (meters connected to the communication network and able to be remotely accessed and read).

Other European EEGI labelled projects such as DISCERN have also considered consumers being metered automatically indicators.

5.19 IMPROVED LIFE-TIME OF TRANSFORMERS

Power transformer load it is an indicator of the electrical stress that this equipment might be subjected to. The life span of the power transformers is reduced dramatically in case of exceeding the nominal values during a long time period or after having very accentuated peaks. This is much related to the excess of current circulating in the internal transformer winding (i.e. deterioration of the insulation due to the over heat generated by the current). It is worth noting that the overload of a transformer might be due to a continue increase of demand or for some network management operation (i.e. switching loads from one transformer to another or laying out new lines).

Before the deployment of supervision meters in the SSs, overloaded power transformers were only detected when the equipment fail. This means not only the impact of changing the unit but also the impact that might have on the surrounding infrastructure, on the customers (i.e. power cut) and the corresponding penalties. However, thanks to the leveraging data collected by supervision meters at SS and the processing of it, it is possible that the network management responsible have at its' disposal reports for transformer load. Then it is feasible to identified potential risk of equipment failure before it happen triggering work orders to change them by other of higher capacity. This can be schedule limiting the impact to the customers.

This KPI will be calculated based on the work orders resulted for the analysis of data retrieved from the supervisor meters in SS. It is considered that each time an overloaded power transformer is detected a work order for replacing them will be launched. This is the scenario for R&I.

Improved life-time of transformers will be calculated using the following formula:

$$\Delta \mathrm{Tr}_{life}(\%) = \frac{Nchanges_{BAU} - Nchanges_{R\&I}}{N_{transf}} \qquad \textbf{(29)}$$

where:

$Nchanges_{BAU}$	Number of power transformers changed in the BaU time period
$Nchanges_{R\&I}$	Number of power transformers changed in the R&I time period
N_{transf}	Number of total transformer in the selected area of the demo

This KPI is much related to KPI 9 – Energy losses and KPI 27 – Reduction in greenhouse gas emissions.

This KPI has been defied specifically for UPGRID project as no references where found in any other European EEGI labeled projects regarding improved life-time of transformers.

5.20 PARTICIPANT RECRUITMENT

Recruitment is an indication of the fraction of consumers accepting participation in the different demos. UPGRID project is addressing several actions to be implemented in the demo areas which require the participation of consumers and producers. Some of these actions regard demand side management. Other actions are related to the implementation of a web portal for customers awareness.

This KPI will be calculated for each UPGRID demo as the sum of the amount of consumers participating in the UPGRID demos (weighted in function of diversification of stakeholders) in relation with the total contacted to be part of them. It will only measure if the user decides to join, another KPI will measure if the user's participation is active or not (section 5.21). This KPI will be only calculated for an UPGRID demo if the demo is addressing sub-functionalities which require consumers or producers participation.

Recruitment will be calculated using the following formula:

$$R(\%) = \frac{n_{accept}}{n_{total}} \tag{30}$$

where:

n_{accept}	Number of users that finally accepted to be part of the demo.
n_{total}	Number of users contacted to be part of the demo.

Other European EEGI labelled projects such as GRID4EU have also considered recruitment indicators.

5.21 ACTIVE PARTICIPATION

Active participation is an indication of the fraction of consumers actively taking part in the different demos. UPGRID project is addressing several actions to be implemented in the demo areas which require the participation of users. Some of these actions regard demand side management. Other actions are related to the implementation of a web portal for customer awareness.

This KPI will be calculated for each UPGRID demo as the sum of the amount of users actively participating in the UPGRID demos in relation with the total that accepted participating. This KPI will be only calculated for an UPGRID demo if the demo is addressing sub-functionalities which require consumers or producers participation.

Active participation will be calculated using the following formula:

$$A(\%) = \frac{N_A}{N_P} \qquad (31)$$

where:

N_A	Number of consumers that have an active participation in the UPGRID demo.
N_P	Number of consumers that accepted participating in the demo.

A precise definition of “active participation” is required for consumers participating in the DSM service or accessing the web portal. The “active participation” criterion will be defined for the DSM service and for the web portal by each demo.

Other European EEGI labelled projects such as GRID4EU have also considered active participation indicators.

5.22 LOAD CURVE VALLEY FILLING

Load curve valley filling is an indication of the change in kWh used at valley or through time due to technical signal to increase consumption (DSO order). UPGRID project is addressing demand side management actions to be implemented in the demo areas which will impact positively in the valley filling of the aggregated demand of the customers included in the demo area.

This KPI will be only calculated for an UPGRID demo if the demo is addressing sub-functionalities related to demand side management.

Valley filling will be calculated using the following formula:

$$VF(\%) = \frac{\overline{kWh_1} - \overline{kWh_0}}{\overline{kWh_0}} \quad (32)$$

where:

kWh_p	Average hourly kWh used at valley times in period p (p=0 for the reference period, p=1 for the treatment period) by participant after a technical signal.

The reference period is defined as the average hourly kWh used by the same participant prior to the intervention (p=0) during the same hours, on the same day of the week (Monday, Tuesday, Wednesday, Thursday, Friday, Saturday, Sunday+holidays) over a surrounding 6-week period and corrected for temperature.

Other European projects such as ADVANCED have also considered valley filling indicators.

5.23 USE OF EQUIPMENT STANDARDS

Use of equipment standards is an indication of the effective use of standards with respect to the declared use. Task 1.3 of UPGRID project gathered how the four demos were considering the implementation of standardized solutions regarding equipment and thus how to improve some of the proposed demo projects by maximizing the use of interoperable and standardized protocols.

Specifically, the equipment standards were divided into the standards already being used in the demo and the standards to be developed or extended under UPGRID project. Tables 7, 11, 14 and 19 of UPGRID deliverable D1.3 contain all this information for the Spanish, Portuguese, Swedish and Polish demos respectively.

This KPI will be calculated for all UPGRID demos as all of them are considering the implementation of standards.

Use of protocol standards will be calculated using the following formula:

$$UES(\%) = \frac{ESEU}{ESDU} \quad (33)$$

where:

$ESEU$	Equipment standards effectively used according to the count criterion.
$ESDU$	Equipment standards declared to be used in D1.3 of UPGRID project.

The count criterion for the equipment standards will be:

- **ESEU = 0**: if there is no change between the status of the equipment standard before and after the UPGRID project.
- **ESEU = 0,5**: if the equipment standard application has been extended during the UPGRID project.
- **ESEU = 1**: if the equipment standard has been implemented during the UPGRID project.

Other European EEGI labelled projects such as GRID4EU have also considered use of standards indicators.

5.24 USE OF PROTOCOL STANDARDS

Use of protocols standards is an indication of the effective use of standards with respect to the declared use. Task 1.3 of UPGRID project tries gathered how the four demos were considering the implementation of standardized solutions regarding protocols and thus how to improve some of the proposed demo projects by maximizing the use of interoperable and standardized equipment.

Specifically, the protocol standards were divided into the standards already being used in the demo and the standards to be developed or extended under UPGRID project. Tables 6, 10, 13 and 18 of UPGRID deliverable D1.3 contain all this information for the Spanish, Portuguese, Swedish and Polish demos respectively.

This KPI will be calculated for all UPGRID demos as all of them are considering the implementation of standards.

Use of protocol standards will be calculated using the following formula:

$$\mathrm{UPS}(\%) = \frac{PSEU}{PSDU} \qquad (34)$$

where:

$PSEU$	Protocols standards effectively used according to the count criterion.
$PSDU$	Protocols standards declared to be used in D1.3 of UPGRID project.

The count criterion for the equipment standards will be:

- **PSEU = 0**: if there is no change between the status of the protocol standard before and after the UPGRID project.
- **PSEU = 0,5**: if the protocol standard application has been extended during the UPGRID project.
- **PSEU = 1**: if the protocol standard has been implemented during the UPGRID project.

Other European EEGI labelled projects such as GRID4EU have also considered use of standards indicators.

5.25 REDUCTION IN GREENHOUSE GAS EMISSIONS

The reduction in greenhouse gas emissions is an indication of the difference between total amounts of CO_2 emissions calculated respectively for BAU and R&I scenarios taking into account conventional generators, network automation, energy storage, import/export of electricity, need of additional power plants, modifications of the network and changes in the energy supply mix.

The greenhouse gas (GHG) emissions calculation associated to each demo in BAU and R&I scenarios is almost an unapproachable calculation because many information will be needed about generation, transmission, distribution and consumption. Nevertheless the calculation of the non-emitted CO_2 is an accessible problem. This difference can be compared with a reference value to evaluate the UPGRID contribution to the GHG emission reduction. This reference value may be the International Energy Agency (IEA) current values per country or even the EU targets.

This KPI will be only calculated for an UPGRID demo if the demo is addressing sub-functionalities which impact positively in the reduction of greenhouse gas emissions. These sub-functionalities mainly are:

- Demand Side Management service (Demand shifting from peak to valley as hourly energy mix is different).
- RES integration.
- Technical energy losses reduction.

Reduction in greenhouse gas emissions will be calculated using the following formula:

$$GHG(\%) = \frac{(CO_2)_{BAU} - (CO_2)_{R\&I}}{(CO_2)_R} \qquad (35)$$

where:

$(CO_2)_{BAU} - (CO_2)_{R\&I}$	Will be the sum of: • CO2 reduction thanks to RES production. • CO2 reduction thanks to demand shifting (DSM). • CO2 reduction thanks to technical losses reduction.
$(CO_2)_R$	Reference value (target) for each country (IEA, EU objectives, etc.)

Other European EEGI labelled projects such as IGREENGrid have also considered reduction in greenhouse gas emissions indicators.

6. UPGRID HIGH LEVEL KPIS DEFINTION

This section includes the definition of the UPGRID high level KPIs as the weighted sum of the detailed KPIs defined in the previous section of this document (section 5). Each high level KPI has been summarised in a table that includes the associated detailed KPIs and the weigh matrix for each UPGRID demo at the moment of closing the present document.

6.1 INTEGRATION OF SMART CUSTOMERS

TABLE 6: WEIGH MATRIX FOR HIGH LEVEL KPI D1 (ACTIVE DEMAND FOR INCREASED NETWORK FLEXIBILITY).

SOURCE: UPGRID PROJECT

CLUSTER OBJECTIVE		Integration of smart customers							
FUNCTIONAL OBJECTIVE		D1		Active Demand for increased network flexibility					
UPGRID KPI		*Spain*		*Portugal*		*Sweden*		*Poland*	
U1	Demand flexibility			x	*20 %*				
U12	Characterized information categories			x	*15 %*				
U13	Availability of intelligent network components			x	*10 %*				
U20	Participant recruitment			x	*10 %*				
U21	Active participation			x	*15 %*				
U22	Load curve valley filling			x	*20 %*				
U25	Reduction in greenhouse gas emissions			x	*10 %*				
			0%		*100 %*		*0%*		*0%*

TABLE 7: WEIGH MATRIX FOR HIGH LEVEL KPI D2 (ENABLING MAXIMUM ENERGY EFFICIENCY IN NEW OR REFURBISHED URBAN USING SMART DISTRIBUTION GRIDS).

SOURCE: UPGRID PROJECT

CLUSTER OBJECTIVE		Integration of smart customers							
FUNCTIONAL OBJECTIVE		D2		Enabling maximum energy efficiency in new or refurbished urban using smart distribution grids					
UPGRID KPI		*Spain*		*Portugal*		*Sweden*		*Poland*	
0	0								
			0%		*0%*		*0%*		*0%*

6.2 INTEGRATION OF DER AND NEW USES

TABLE 8: WEIGH MATRIX FOR HIGH LEVEL KPI D3 (INTEGRAITON OF DER AT LOW VOLTAGE).

SOURCE: UPGRID PROJECT

CLUSTER OBJECTIVE		Integration of DER and new uses							
FUNCTIONAL OBJECTIVE		D3		Integration of DER at low voltage					
UPGRID KPI		*Spain*		*Portugal*		*Sweden*		*Poland*	
U2	Generation flexibility							x	*100 %*
U4	Fulfilment of voltage limits								
U9	Energy losses								
U25	Reduction in greenhouse gas emissions								
			0%		*0%*		*0%*		*100 %*

TABLE 9: WEIGH MATRIX FOR HIGH LEVEL KPI D4 (INTEGRATION OF DER AT MEDIUM VOLTAGE / HIGH VOLTAGE).

SOURCE: UPGRID PROJECT

CLUSTER OBJECTIVE		Integration of DER and new uses							
FUNCTIONAL OBJECTIVE		D4		Integration of DER at medium voltage / high voltage					
UPGRID KPI		*Spain*		*Portugal*		*Sweden*		*Poland*	
			0%		*0%*		*0%*		*0%*

TABLE 10: WEIGH MATRIX FOR HIGH LEVEL KPI D5 (INTEGRATION OF STORAGE IN NETWORK MANAGEMENT).

SOURCE: UPGRID PROJECT

CLUSTER OBJECTIVE		Integration of DER and new uses							
FUNCTIONAL OBJECTIVE		D5		Integration of storage in network management					
UPGRID KPI		*Spain*		*Portugal*		*Sweden*		*Poland*	
			0%		*0%*		*0%*		*0%*

TABLE 11: WEIGH MATRIX FOR HIGH LEVEL KPI D6 (INTEGRATION OF INFRASTRUCTURE TO HOST ELECTRICAL VEHICLES).

SOURCE: UPGRID PROJECT

CLUSTER OBJECTIVE		Integration of DER and new uses							
FUNCTIONAL OBJECTIVE		D6		Integration of infrastructure to host Electrical Vehicles					
UPGRID KPI		*Spain*		*Portugal*		*Sweden*		*Poland*	
U3	Hosting Capacity of Electric Vehicles			x	*30 %*				
U10	Monitored information categories			x	*25 %*				
U12	Characterized information categories			x	*25 %*				
U13	Availability of intelligent network components			x	*20 %*				
			0%		*100 %*		*0%*		*0%*

6.3 NETWORK OPERATIONS

TABLE 12: WEIGH MATRIX FOR HIGH LEVEL KPI D7 (MONITORING AND CONTROL OF LV NETWORK).

SOURCE: UPGRID PROJECT

CLUSTER OBJECTIVE		Network operations							
FUNCTIONAL OBJECTIVE		D7	Monitoring and control of LV network						
UPGRID KPI		*Spain*		*Portugal*		*Sweden*		*Poland*	
U4	Fulfilment of voltage limits	x	*4 %*	x	*15 %*	x	*10 %*	x	*10 %*
U5	Average time for LV faults	x	*20 %*	x	*15 %*				
U9	Energy losses			x	*5 %*			x	*20 %*
U10	Monitored information categories	x	*10 %*	x	*15 %*	x	*20 %*	x	*10 %*
U11	Available information categories	x	*10 %*	x	*10 %*			x	*10 %*
U12	Characterized information categories	x	*10 %*	x	*10 %*			x	*10 %*
U13	Availability of intelligent network components	x	*5 %*	x	*10 %*	x	*35 %*	x	*10 %*
U15	Success index in events reading	x	*15 %*			x	*10 %*	x	*10 %*
U16	Success index in PRIME advanced functionalities	x	*15 %*						
U18	Consumers being metered automatically	x	*5 %*	x	*10 %*	x	*5 %*		
U23	Use of equipment standards	x	*3 %*	x	*5 %*	x	*10 %*	x	*10 %*
U24	Use of protocol standards	x	*3 %*	x	*5 %*	x	*10 %*	x	*10 %*
			100 %		*100 %*		*100 %*		*100 %*

TABLE 13: WEIGH MATRIX FOR HIGH LEVEL KPI D8 (AUTOMATION AND CONTROL OF MV NETWORK).

SOURCE: UPGRID PROJECT

CLUSTER OBJECTIVE		Network operations							
FUNCTIONAL OBJECTIVE		D8		Automation and control of MV network					
UPGRID KPI		Spain		Portugal		Sweden		Poland	
U6	Average time needed for fault location in MV					x	50 %	x	35 %
U8	Quality of Supply Improvement in MV							x	25 %
U10	Monitored information categories					x	30 %	x	15 %
U13	Availability of intelligent network components					x	20 %	x	25 %
			0%		0%		100 %		100 %

TABLE 14: WEIGH MATRIX FOR HIGH LEVEL KPI D9 (NETWORK MANAGEMENT METHODOLOGIES FOR NETWORK OPERATION).

SOURCE: UPGRID PROJECT

CLUSTER OBJECTIVE		Network operations							
FUNCTIONAL OBJECTIVE		D9		Network management methodologies for network operation					
UPGRID KPI		Spain		Portugal		Sweden		Poland	
U5	Average time for LV faults	x	30 %						
U7	Quality of Supply Improvement in LV	x	30 %						
U10	Monitored information categories	x	10 %						
U11	Available information categories	x	12 %					x	30 %
U12	Characterized information categories	x	12 %					x	20 %
U23	Use of equipment standards	x	3 %			x	50 %		
U24	Use of protocol standards	x	3 %			x	50 %	x	50 %
			100 %		0%		100 %		100 %

TABLE 15: WEIGH MATRIX FOR HIGH LEVEL KPI D10 (SMART METERING DATA UTILIZATION).

SOURCE: UPGRID PROJECT

CLUSTER OBJECTIVE		Network operations							
FUNCTIONAL OBJECTIVE		D10	Smart metering data utilization						
UPGRID KPI		*Spain*		*Portugal*		*Sweden*		*Poland*	
U5	Average time for LV faults	x	*25 %*	x	*10 %*	x	*30 %*	x	*25 %*
U8	Quality of Supply Improvement in MV							x	*25%*
U10	Monitored information categories	x	*15 %*	x	*20 %*	x	*20 %*	x	*15 %*
U11	Available information categories	x	*15 %*	x	*20 %*			x	*15 %*
U12	Characterized information categories	x	*15 %*	x	*20 %*			x	*20 %*
U13	Availability of intelligent network components			x	*10 %*				
U14	Success index in meter reading	x	*5 %*	x	*20 %*	x	*20 %*		
U15	Success index in events reading	x	*20 %*						
U17	Success index in meter connectivity	x	*5 %*			x	*30 %*		
			100 %		*100 %*		*100 %*		*100 %*

6.4 NETWORK PLANNING AND ASSET MANAGEMENT

TABLE 16: WEIGH MATRIX FOR HIGH LEVEL KPI D11 (NEW PLANNNG APPROACHES FOR DISTRIBUTION NETWORKS).

SOURCE: UPGRID PROJECT

CLUSTER OBJECTIVE		Network planning and asset management							
FUNCTIONAL OBJECTIVE		D11	New planning approaches for distribution networks						
UPGRID KPI		*Spain*		*Portugal*		*Sweden*		*Poland*	
U12	Characterized information categories	x	*50 %*						
U19	Improved Life-time of Transformers	x	*50 %*						
			100 %		*0%*		*0%*		*0%*

TABLE 17: WEIGH MATRIX FOR HIGH LEVEL KPI D12 (NOVEL APPROACHES TO ASSET MANAGEMENT). SOURCE: UPGRID PROJECT

CLUSTER OBJECTIVE		Network planning and asset management							
FUNCTIONAL OBJECTIVE		D12	Novel approaches to asset management						
UPGRID KPI		Spain		Portugal		Sweden		Poland	
U5	Average time for LV faults	x	5 %	x	20 %				
U9	Energy losses	x	10 %	x	20 %			x	100 %
U11	Available information categories	x	10 %	x	20 %				
U12	Characterized information categories	x	10 %	x	20 %				
U13	Availability of intelligent network components	x	10 %	x	15 %				
U19	Improved Life-time of Transformers	x	45 %						
U25	Reduction in greenhouse gas emissions	x	10 %	x	5 %				
			100 %		100 %		0%		100 %

6.5 MARKET DESIGN

TABLE 18: WEIGH MATRIX FOR HIGH LEVEL KPI D13 (NOVEL APPROACHES FOR MARKET DESIGN). SOURCE: UPGRID PROJECT

CLUSTER OBJECTIVE		Market design							
FUNCTIONAL OBJECTIVE		D13	Novel approaches for market design						
UPGRID KPI		Spain		Portugal		Sweden		Poland	
U1	Demand flexibility			x	20 %				
U11	Available information categories	x	15 %	x	15 %			x	30 %
U12	Characterized information categories	x	15 %	x	15 %			x	30 %
U20	Participant recruitment	x	35 %	x	10 %			x	20 %
U21	Active participation	x	35 %	x	15 %			x	20 %
U23	Use of equipment standards			x	10 %				
U24	Use of protocol standards			x	10 %				
U25	Reduction in greenhouse gas emissions			x	5 %				
			100 %		100 %		0%		100 %

REFERENCES

[1] “European Electricity Grid Initiative (EEGI) web page,” [Online]. Available: http://www.gridplus.eu/eegi.

[2] (EEGI), European Electricity Grid Initiative, “Research and Innovation Roadmap 2013-2022,” 2012. [Online]. Available: http://www.gridplus.eu/Documents/20130228_EEGI%20Roadmap%202013-2022_to%20print.pdf.

[3] E. E. G. I. (EEGI9, “Research and Innovation Roadmap 2013 - 2022,” January 2013. [Online]. Available: http://www.gridplus.eu/Documents/20130228_EEGI%20Roadmap%202013-2022_to%20print.pdf.

[4] “UPGRID Project deliverable D1.1: Report on Technical Specifications”.

[5] E. C. t. F. f. s. grids., “Expert Group 1: Functionalities of smart grids and smart meters,” December 2020. [Online]. Available: http://www.gt-engineering.it/uploads/allegati/25expert_group1.pdf.

[6] “GRID+ Project web page,” [Online]. Available: http://www.gridplus.eu/.

[7] “GRID+ Project deliverable D3.4: Define EEGI Project and Programme KPIs,” [Online]. Available: http://www.gridplus.eu/Documents/Deliverables/GRID+_D3%204b_r0.pdf.

[8] «EEGI Labelled projects list,» [En línea]. Available: http://www.gridplus.eu/node/172.

[9] “Labelling of EEGI projects web page,” [Online]. Available: http://www.gridplus.eu/eegi/eegi-project-labelling-started#4.

[10] “IGREENGrid project web page,” [Online]. Available: http://www.igreengrid-fp7.eu/.

[11] “IGREENGrid project deliverable D4.1 "Report listing selected KPIs and precise recommendations to EEGIt team for improvement of list of EEGI KPIs",” [Online]. Available: http://www.igreengrid-fp7.eu/deliverables .

[12] “GRID4EU Project web page,” [Online]. Available: http://www.grid4eu.eu/.

[13] «GRID4EU project deliverable D2.2 "Project KPIs definition and measurement methods",» [En línea]. Available: http://www.grid4eu.eu/project-demonstrators/deliverables.aspx .

[14] «DISCERN project web page,» [En línea]. Available: http://www.discern.eu/ .

[15] “DISCERN project deliverables D2.2 "Intermediate demonstration projects KPI fulfilment report. Definition and calculation methodology of DISCERN KPIs",” [Online]. Available: http://www.discern.eu/project_output/deliverables.html.

[16] «IDE4L project web page,» [En línea]. Available: http://ide4l.eu/.

[17] “IDE4L project deliverable D7.1 "KPI Definition",” [Online]. Available: http://ide4l.eu/results/.

[18] “ADVANCED Project web page,” [Online]. Available: http://www.advancedfp7.eu/.

[19] «UPGRID Project deliverable D1.3: Report on standards and potential synergies.».

Annex I. DETAILED KPI TEMPLATE

This template will be filled out for each detailed KPI defined in the UPGRID project. As this deliverable includes the KPI definition, most of the fields of this template will be completed. In deliverable D8.1 *Report about KPIs analysis and methods of comparison* in the scope of WP8 *Monitoring and Impact Assessment of demo results* this templates will be used as reference to calculate the KPIs from the information provided by the demos. This means that this template is aimed at being detailed enough to calculate the KPIs once the demo information is available without needing any other document with further description of the KPI calculation.

<table>
<tr><th colspan="5">BASIC KPI INFORMATION[5]</th></tr>
<tr><td>KPI Name</td><td colspan="2"></td><td>KPI ID</td><td></td></tr>
<tr><td>Main Objective</td><td colspan="4"></td></tr>
<tr><td>KPI Description</td><td colspan="4"></td></tr>
<tr><td>KPI Formula</td><td colspan="4"></td></tr>
<tr><td>Unit of measurement</td><td colspan="4"></td></tr>
<tr><td>Connection/Link with other relevant projects KPI</td><td colspan="4"></td></tr>
<tr><td>Project sites to be calculated</td><td>Demo Spain
☐</td><td>Demo Portugal
☐</td><td>Demo Sweden
☐</td><td>Demo Poland
☐</td></tr>
<tr><th colspan="5">KPI CALCULATION METHODOLOGY[6]</th></tr>
<tr><td>KPI Step Methodology ID [KPI ID #]</td><td colspan="3">Step</td><td>Responsible</td></tr>
<tr><td></td><td colspan="3"></td><td></td></tr>
<tr><td></td><td colspan="3"></td><td></td></tr>
<tr><td></td><td colspan="3"></td><td></td></tr>
<tr><td></td><td colspan="3"></td><td></td></tr>
<tr><th colspan="5">KPI SCENARIOS[7]</th></tr>
</table>

[5] **BASIC KPI INFORMATION**. The fields included in this category are filled out in the D1.4. This category provides the main KPI characteristics including the KPI formula, the relation of the KPI with other EEGI labelled projects and in which of the four demos will be applied. This section contains common information for all UPGRID demos. The subsequent sections of the table will be adapted to each demo characteristics.

[6] **KPI CALCULATION METHODOLOGY**. This category includes the step by step description of how each parameter of the KPI formula will be calculated from the measured or estimated demos' information (in close relation with the BaU and R&D scenarios). In Annex II this section is detailed for each demo to adapt the general formula to each demo characteristic, data availability and data gathering tools.

[7] **KPI SCENARIOS**. This category defines which scenario (baseline or reference, BaU and R&D) will be taken into account for the KPI. In Annex II this section is particularised for each demo characteristics.

Scenarios to be measured	Baseline ☐			Business as usual (BaU) ☐		R&D ☐	
KPI DATA COLLECTION[8]							
Data	**Data ID**	**Methodology for data collection**	**Source/Tools/ Instruments for Data collection**	**Location of Data collection**	**Frequency of data collection**	**Minimum monitoring period**	**Data collection responsible**
GENERAL COMMENTS[9]							

[8] **KPI DATA COLLECTION**. For each parameter of the KPI formula, the fields included in this category describe how this information will be collected and aggregated to be used for the KPI calculation. It includes the methodology to be followed, the tools or instruments for the data collection and the data responsible provider, among others. In Annex II this section is particularised for each demo to adapt the general formula to each demo characteristic, data availability and data gathering tools.

[9] **GENERAL COMMENTS**. This category has been included to collect important information about the KPI which does not fit in the previous fields including the contextual information. In Annex II this section is particularised for each demo.

Annex II. UPGRID DETAILED KPIS

This annex contains the templates defined in Annex I fulfilled for the UPGRID detailed KPIs at the stage of closing the present deliverable. For each detailed KPI there is a common definition for basic information and a per demo description regarding the calculation methodology and the KPI data collection.

A II. 1. DEMAND FLEXIBILITY

BASIC KPI INFORMATION				
KPI Name	Demand Flexibility		**KPI ID**	P_{DSM}
Main Objective	To measure the ability of the electricity system to respond to –and balance – supply and demand in real time			
KPI Description	Demand flexibility is mainly measured through demand response capabilities. This KPI will be calculated for each UPGRID demo as the sum of the amount of load capacity participating in demand side management.			
KPI Formula	$P_{DSM}(\%) = \frac{(P_{DSM})_{R\&I} - (P_{DSM})_{BAU}}{P_{peak}}$			
Unit of measurement	%			
Connection/Link with other relevant projects KPI	GRID+, DISCERN and ADVANCED			
Project sites to be calculated	Demo Spain [ ]	Demo Portugal [X]	Demo Sweden [ ]	Demo Poland [ ]

DEMO PORTUGAL

KPI CALCULATION METHODOLOGY		
KPI Step Methodology ID [KPI ID #]	**Step**	**Responsible**
P_DSM_R&I	Once the DSM infrastructure is working. Sum of the percentage (40%) of DSM service participating customers contracted power (kW).	EDP
P_DSM_BAU	DSM capabilities before UPGRID. (As there were not DSM capabilities before UPGRID, this value will be zero for the Portuguese demo).	EDP
P_peak	Sum of DSM service participating customers maximum power in a period (period=year).	EDP

KPI SCENARIOS			
Scenarios to be measured	Baseline [ ]	Business as usual (BaU) [X]	R&D [X]

KPI DATA COLLECTION							
Data	**Data ID**	**Methodology for data collection**	**Source/Tools/ Instruments for Data collection**	**Location of Data collection**	**Frequency of data collection**	**Minimum monitoring period**	**Data collection responsible**
P_DSM_R&I					Once	-	EDP
P_DSM_BAU			n.a.		Once	n.a.	EDP
P_peak			Smart Meters	AMI	Once	1 year	EDP
GENERAL COMMENTS							

A II. 2. GENERATION FLEXIBILITY

BASIC KPI INFORMATION				
KPI Name	Generation Flexibility		**KPI ID**	P_{DER}
Main Objective	To measure the ability of the electricity system to respond – and balance – supply and demand in real time.			
KPI Description	Generation flexibility is mainly measured through generation response capabilities. Nevertheless other grid initiatives may also enhance the generation flexibility of the grid, such as the integration of storage resources and specifically the integration of their operation in the distribution network operation. This KPI will be calculated for each UPGRID demo as the sum of the amount of generation and/or storage capacity managed by the distribution network operator.			
KPI Formula	$P_{DER}(\%) = \frac{(P_{DER})_{R\&I}}{\sum(P_R)_{R\&I}} - \frac{(P_{DER})_{BAU}}{\sum(P_R)_{BAU}}$			
Unit of measurement	%			
Connection/Link with other relevant projects KPI	GRID+, DISCERN and ADVANCED			
Project sites to be calculated	Demo Spain ☐	Demo Portugal ☐	Demo Sweden ☐	Demo Poland X

DEMO POLAND

KPI CALCULATION METHODOLOGY		
KPI Step Methodology ID [KPI ID #]	**Step**	**Responsible**
P_DER_BAU	Sum of nominal power of controllable DER if only ON/OFF capability is implemented or variable power range of controllable DER if regulation capabilities are implemented in BAU scenario.	ENERGA
P_R_BAU	Sum of nominal power of DER connected to the distribution network (also downstream customer's meter) in BAU scenario.	ENERGA
P_DER_R&I	Sum of nominal power of controllable DER if only ON/OFF capability is implemented or variable power range of controllable DER if regulation capabilities are implemented in R&I scenario.	ENERGA
P_R_R&I	Sum of nominal power of DER connected to the distribution network (also downstream customer's meter) in R&I scenario.	ENERGA

KPI SCENARIOS			
Scenarios to be measured	Baseline ☐	Business as usual (BaU) X	R&D X

KPI DATA COLLECTION							
Data	**Data ID**	**Methodology for data collection**	**Source/Tools/ Instruments for Data collection**	**Location of Data collection**	**Frequency of data collection**	**Minimum monitoring period**	**Data collection responsible**
P_DER_BAU	P_DER_BAU		Inventory of the Demo area		Once	-	ENERGA
P_R_BAU	P_R_BAU		Inventory of the Demo area		Once	-	ENERGA

P_DER_R&I	P_DER_R&I		Inventory of the Demo area		Once	-	ENERGA
P_R_R&I	P_R_R&I		Inventory of the Demo area		Once	-	ENERGA
GENERAL COMMENTS							
BAU scenario corresponds with a moment in time before the UPGRID project or in the future with a natural evolution. Therefore BAU calculation will be only performed if some generators are already being controlled by the DSO before the project, as by natural evolution, is not feasible an increase of generation flexibility as it requires (at least) the deployment of an ICT system. R&I scenario corresponds with a moment in time after the UPGRID project (once DER control centre is operative).							

A II. 3. HOSTING CAPACITY OF ELECTRIC VEHICLES

BASIC KPI INFORMATION				
KPI Name	Hosting Capacity of EV		**KPI ID**	HC_{EV}
Main Objective	To measure the contribution that UPGRID project has in increasing the capacity of the distribution network to host EVs.			
KPI Description	A direct contribution to this KPI may be enhancing the grid capacity (lines and transformers) or even the allocation of new charging points in the demo area. An indirect contribution may be the management or the analysis of the usage information of the existing charging points to characterise the user's behaviour and host more charging points with the same grid capability. Regarding this topic, UPGRID project is mainly addressing indirect actions to enhance the hosting capacity of electric vehicles. This KPI will be calculated for each UPGRID demo as the sum of the available power of the characterized EV charging points.			
KPI Formula	$HC_{EV}(\%) = \frac{(HC_{EV})_{R\&I} - (HC_{EV})_{BAU}}{P_{EV}}$			
Unit of measurement	%			
Connection/Link with other relevant projects KPI	GRID+			
Project sites to be calculated	Demo Spain [ ]	Demo Portugal [X]	Demo Sweden [ ]	Demo Poland [ ]

DEMO PORTUGAL

KPI CALCULATION METHODOLOGY		
KPI Step Methodology ID [KPI ID #]	**Step**	**Responsible**
HC_EV_BAU	Sum of mean power in a period (year) of characterized EV charging stations in BAU scenarios.	EDP
HC_EV_R&I	Sum of mean power in a period (year) of characterized EV charging stations in R&I scenarios.	EDP
P_EV	Nominal power of EV charging stations connected to EDP network.	EDP

KPI SCENARIOS			
Scenarios to be measured	Baseline [ ]	Business as usual (BaU) [X]	R&D [X]

KPI DATA COLLECTION							
Data	**Data ID**	**Methodology for data collection**	**Source/Tools/ Instruments for Data collection**	**Location of Data collection**	**Frequency of data collection**	**Minimum monitoring period**	**Data collection responsible**
HC_EV_BAU	HC_EV _BAU	Hourly data collection during a year to calculate the mean value	Smart meter	AMI	Hourly	One year	EDP

HC_EV_R&I	HC_EV_R&I	Hourly data collection during a year to calculate the mean value	Smart meter	AMI	Hourly	One year	EDP
P_EV	P_EV				Once	-	EDP
GENERAL COMMENTS							

A II. 4. FULFILMENT OF VOLTAGE LIMITS

BASIC KPI INFORMATION				
KPI Name	Fulfilment of Voltage Limits		**KPI ID**	VL
Main Objective	To evaluate the power quality of distribution networks.			
KPI Description	UPGRID project is addressing some actions to be implemented in the demo areas which will impact positively in the fulfilment of voltage limits. Some of these actions regard the remote management of DER. Other actions are related to the implementation of new algorithms to identify the optimum topological configuration of the distribution grid or even its remote reconfiguration after a fault. In addition, new regulation guidelines will be implemented using smart devices. This KPI will be calculated for all UPGRID demos as all of them are considering the implementation of actions that will impact on the voltage limits fulfilment			
KPI Formula	$$V(\%) = \frac{V_{BAU} - V_{R\&I}}{V_{BAU}}$$ Each UPGRID demo will select the most suitable indicator to calculate V_{BAU} and $V_{R\&I}$ depending on their information availability. (V_{max} , $V_{95\%}$ or others)			
Unit of measurement	%			
Connection/Link with other relevant projects KPI	GRID+, IGREENGRID, DISCERN, and GRID4EU			
Project sites to be calculated	Demo Spain X	Demo Portugal X	Demo Sweden X	Demo Portugal X

DEMO SPAIN

KPI CALCULATION METHODOLOGY		
KPI Step Methodology ID [KPI ID #]	**Step**	**Responsible**
V_BAU	Number of customers in a year basis that the voltage level for customers is out of limits in BAU scenario.	IBERDROLA
V_R&I	Number of customers in year basis that the voltage level for customers is out of limits in R&I scenario.	IBERDROLA

KPI SCENARIOS			
Scenarios to be measured	Baseline ☐	Business as usual (BaU) X	R&D X

KPI DATA COLLECTION							
Data	**Data ID**	**Methodology for data collection**	**Source/Tools/ Instruments for Data collection**	**Location of Data collection**	**Frequency of data collection**	**Minimum monitoring period**	**Data collection responsible**

V_BAU	V_BAU	Analysis of SM events collected in the STG	STG[10]	STG data base	Once	One year	IBERDROLA
V_R&I	V_R&I	Analysis of SM events collected in the STG	STG	STG data base	Once	One year	IBERDROLA
GENERAL COMMENTS							
Only focused on LV. Based on event received from SMs. According to the Spanish regulation (Royal Decree 1955/2000) the maximum allowed supply voltage variation is ±7% of the nominal voltage. The KPI will be calculated for all the Spanish demo customers. This means that V_BAU and V_R&I will be the average value of all these customers.							

DEMO PORTUGAL

KPI CALCULATION METHODOLOGY		
KPI Step Methodology ID [KPI ID #]	**Step**	**Responsible**
V_BAU	$V_{95\%}$: The 95% percentage voltage value during monitoring period (six months), the value for which 95% of all voltage line measurements fall below in BAU scenario.	EDP
V_R&I	$V_{95\%}$: The 95% percentage voltage value during monitoring period (six months), the value for which 95% of all voltage line measurements fall below in BAU scenario in R&I scenario.	EDP

KPI SCENARIOS			
Scenarios to be measured	Baseline ☐	Business as usual (BaU) X	R&D X

KPI DATA COLLECTION							
Data	**Data ID**	**Methodology for data collection**	**Source/Tools/ Instruments for Data collection**	**Location of Data collection**	**Frequency of data collection**	**Minimum monitoring period**	**Data collection responsible**
V_BAU	V_BAU		Smart Meters, DTC	AMI	15 min average data values	Six months	EDP
V_R&I	V_R&I		Smart Meters, DTC	AMI	15 min average data values	Six months	EDP
GENERAL COMMENTS							
According to NP 50160, the maximum allowed supply voltage variation for each 10 minutes cycle is ± 10% of nominal in 95% of the measures.							

[10] STG stands for "Sistema de Telegestion"

DEMO SWEDEN

KPI CALCULATION METHODOLOGY		
KPI Step Methodology ID [KPI ID #]	**Step**	**Responsible**
BAU	Measure voltage level prior voltage regulation, using a “smart transformer” in secondary substation	VFT / SE
R&I	Measure voltage level after voltage regulation by a “smart transformer”	VFT / SE

KPI SCENARIOS			
Scenarios to be measured	Baseline	Business as usual (BaU)	R&D
	☐	X	X

KPI DATA COLLECTION							
Data	**Data ID**	**Methodology for data collection**	**Source/Tools/ Instruments for Data collection**	**Location of Data collection**	**Frequency of data collection**	**Minimum monitoring period**	**Data collection responsible**
V_BAU	V_BAU				Month	6 months	VFT
V_R&I	V_R&I				Month	6 months	VFT

GENERAL COMMENTS

A voltage measurement in BAU scenario is not possible for Vattenfall to retrieve.
For the Swedish Demo this KPI is only applicable for the line where we are going to install a smart transformer from SE (that is still the ambition). If also GE SCADA/DMS system will hold functionality for optimized operation of asset for the best voltage profile that could also support an improvement.
(The smart meters installed at Vattenfall cannot be used, since they do not register voltage, the meters only register an event if a voltage threshold is violated, e.g. the event type “SAG”, under voltage, or when voltage drops >10% the rated voltage to be recorded as an event).

DEMO POLAND

KPI CALCULATION METHODOLOGY		
KPI Step Methodology ID [KPI ID #]	**Step**	**Responsible**
V_BAU	$V_{95\%}$ in selected critical point in LV network for BAU scenario.	ENERGA
V_R&I	$V_{95\%}$ in selected critical point in LV network for R&I scenario.	ENERGA

KPI SCENARIOS			
Scenarios to be measured	Baseline	Business as usual (BaU)	R&D
	☐	X	X

KPI DATA COLLECTION							
Data	**Data ID**	**Methodology for data collection**	**Source/Tools/ Instruments for Data collection**	**Location of Data collection**	**Frequency of data collection**	**Minimum monitoring period**	**Data collection responsible**
V_BAU	V_BAU	Analysis of data from AMI	Smart Meters	AMI	15 min average data values	One month	ENERGA
V_R&I	V_R&I	Analysis of data from AMI	Smart Meters	AMI	15 min average data values	One month	ENERGA

GENERAL COMMENTS

BAU scenario corresponds with a moment in time before the UPGRID is deployed. In the same way, R&I scenario corresponds with a moment in time after the UPGRID project new tools, procedures and devices are deployed.

A II. 5. AVERAGE TIME FOR LV FAULTS

BASIC KPI INFORMATION				
KPI Name	Average time for LV faults		**KPI ID**	ΔT_{LV}
Main Objective	To evaluate the quality of supply of LV distribution networks in terms of reduction in time required for fault awareness, location and isolation.			
KPI Description	This KPI represents the percentage of reduction in time required for fault awareness, location and isolation (the last affected customer recovers supply). One of the main objectives of UPGRID project is to enhance the tools to reduce the average time needed for fault location in LV like the integration of processing meter event or/and other sources in the outage management process.			
KPI Formula	$$\Delta T_{LV}(\%) = \frac{\left(\Delta T_{fault}\right)_{BAU} - \left(\Delta T_{fault}\right)_{R\&I}}{\left(\Delta T_{fault}\right)_{BAU}}$$			
Unit of measurement	%			
Connection/Link with other relevant projects KPI	GRID+, DISCERN and GRID4EU			
Project sites to be calculated	Demo Spain X	Demo Portugal X	Demo Sweden X	Demo Poland X

DEMO SPAIN

KPI CALCULATION METHODOLOGY		
KPI Step Methodology ID [KPI ID #]	**Step**	**Responsible**
ΔT_fault_BAU	Time needed to restore the electrical service since the first user calls to notify an incidence in BAU scenario. Mean value of LV faults that occur during the BAU scenario monitoring period.	IBERDROLA
ΔT_fault_R&I	Time needed to restore the electrical service since the first user calls to notify an incidence in R&I scenario. Mean value of LV faults that occur during the R&I scenario monitoring period.	IBERDROLA

KPI SCENARIOS			
Scenarios to be measured	Baseline ☐	Business as usual (BaU) X	R&D X

KPI DATA COLLECTION							
Data	**Data ID**	**Methodology for data collection**	**Source/Tools/ Instruments for Data collection**	**Location of Data collection**	**Frequency of data collection**	**Minimum monitoring period**	**Data collection responsible**
ΔT_fault_BAU	ΔT_fault_BAU	Taken data from the REPOS (SPECTRUM) – CDS system applying the appropriate filters and analysing them	REPOS (SPECTRUM)	REPOS (SPECTRUM) data base	Once	One month	IBERDROLA

ΔT_fault_R&I	ΔT_fault_R&I	Taken data from the LV Network Management system used in UPGRID, PowerON. Appropriate will. Be applied and date retrieved could be analysed.	PowerOn	PowerOn data base	Once	One month	IBERDROLA
GENERAL COMMENTS							

DEMO PORTUGAL

KPI CALCULATION METHODOLOGY		
KPI Step Methodology ID [KPI ID #]	**Step**	**Responsible**
ΔT_fault_BAU	Time needed to restore the electrical service since the first user calls to notify an incidence in BAU scenario. Mean value of LV faults that occur during the BAU scenario monitoring period.	EDP
ΔT_fault_R&I	Time needed to restore the electrical service since the first user calls to notify an incidence in R&I scenario. Mean value of LV faults that occur during the R&I scenario monitoring period.	EDP

KPI SCENARIOS			
Scenarios to be measured	Baseline ☐	Business as usual (BaU) X	R&D X

KPI DATA COLLECTION							
Data	**Data ID**	**Methodology for data collection**	**Source/Tools/ Instruments for Data collection**	**Location of Data collection**	**Frequency of data collection**	**Minimum monitoring period**	**Data collection responsible**
ΔT_fault_BAU	ΔT_fault_BAU			OMS	After every fault	Six months	EDP
ΔT_fault_R&I	ΔT_fault_R&I			OMS	After every fault	Six months	EDP
GENERAL COMMENTS							

DEMO SWEDEN

KPI CALCULATION METHODOLOGY		
KPI Step Methodology ID [KPI ID #]	**Step**	**Responsible**
BAU	Estimated time from fault to restoration in LV network	VFT
R&I	Estimated time needed to restore a fault in LV network taking into account outage improvement in LV Management system for fault awareness	VFT / GE / Powel

KPI SCENARIOS			
Scenarios to be measured	Baseline [ ]	Business as usual (BaU) [X]	R&D [X]

KPI DATA COLLECTION							
Data	**Data ID**	**Methodology for data collection**	**Source/Tools/ Instruments for Data collection**	**Location of Data collection**	**Frequency of data collection**	**Minimum monitoring period**	**Data collection responsible**
V_BAU	V_BAU	Estimates*	Records in Control Centre systems		Once	Months	VFT
V_R&I	V_R&I		RTU / IED	SCADA	Month	Months	VFT

GENERAL COMMENTS
The Swedish Demo will not include the field work. The improvement will only estimate the time gained for fault awareness in the Control Centre. For the Swedish Demo, the technical solution will not be able to detect all type of faults, since we are only measuring on the outgoing LV lines in the secondary substation. A fault occurring downstream a street cabinet, may not be identified by the deployed solution *An estimate will be calculated in BAU scenario for how long time it takes, on average, for fault awareness, location, isolation and restoration. Fault awareness today is made by customer calls for the LV network.

DEMO POLAND

KPI CALCULATION METHODOLOGY		
KPI Step Methodology ID [KPI ID #]	**Step**	**Responsible**
ΔT_fault_BAU	Time needed to restore the electrical service since the user calls to notify an incidence in BAU scenario. Mean value of all the faults that occur during the BAU scenario monitoring period.	ENERGA
ΔT_fault_R&I	Time needed to restore the electrical service since the user calls to notify an incidence in R&I scenario. Mean value of all the faults that occur during the R&I scenario monitoring period.	ENERGA

KPI SCENARIOS			
Scenarios to be measured	Baseline [ ]	Business as usual (BaU) [X]	R&D [X]

KPI DATA COLLECTION							
Data	**Data ID**	**Methodology for data collection**	**Source/Tools/ Instruments for Data collection**	**Location of Data collection**	**Frequency of data collection**	**Minimum monitoring period**	**Data collection responsible**
ΔT_fault_BAU	ΔT_fault_BAU	Analysis of data from IT systems	SID (existing Information System of Distribution), AMI,	SID, AMI	After every fault	One year	ENERGA
ΔT_fault_R&I	ΔT_fault_R&I	Analysis of data from IT systems	SID (existing Information System of Distribution), AMI, OMS	SID, AMI, OMS	After every fault	One year	ENERGA

GENERAL COMMENTS

A II. 6. AVERAGE TIME NEEDED FOR FAULT LOCATION IN MV

BASIC KPI INFORMATION				
KPI Name	Average time needed for fault location		**KPI ID**	ΔT_{MV}
Main Objective	To evaluate the quality of supply of MV distribution networks in terms of reduction in time required for fault awareness, location and isolation.			
KPI Description	This KPI represents the percentage of reduction in time required for fault awareness, location and isolation. UPGRID project is addressing several actions to be implemented in the demo areas which will reduce the average time needed for fault location. Some of these actions regard the revision and implementation of the DSO business processes in relation with the outage management integrating and processing meter events or/and other sources. In addition, new smart devices will be deployed and tested to detect the fault and to support the maintenance grid crews. Although all demos are considering the implementation of actions regarding the outage management optimization in LV, only some demos are also addressing actions in MV. Only these demos will calculate this KPI.			
KPI Formula	$\Delta T_{MV}(\%) = \frac{(\Delta T_{fault})_{BAU} - (\Delta T_{fault})_{R\&I}}{(\Delta T_{fault})_{BAU}}$			
Unit of measurement	%			
Connection/Link with other relevant projects KPI	GRID+, DISCERN and GRID4EU			

Project sites to be calculated	Demo Spain	Demo Portugal	Demo Sweden	Demo Poland
	[ ]	[ ]	[X]	[X]

DEMO SWEDEN

KPI CALCULATION METHODOLOGY		
KPI Step Methodology ID [KPI ID #]	**Step**	**Responsible**
BAU	Estimated time from fault to restoration in MV network	VFT
R&I	Estimated time needed to restore a fault in MV network taking into account outage improvement in MV SCADA/DMS for fault awareness, e.g. by using Fault Passage Indicators (FPI)	VFT / Partners

KPI SCENARIOS			
Scenarios to be measured	Baseline [ ]	Business as usual (BaU) [X]	R&D [X]

KPI DATA COLLECTION							
Data	**Data ID**	**Methodology for data collection**	**Source/Tools/ Instruments for Data collection**	**Location of Data collection**	**Frequency of data collection**	**Minimum monitoring period**	**Data collection responsible**
V_BAU	V_BAU			MV SCADA	Once	Months	VFT
V_R&I	V_R&I		FPI	MV SCADA	Month	Months	VFT / Partners

GENERAL COMMENTS

For fault identification which will result in the opening of the MV breaker, our intention will be to calculate the time between the opening of the breaker to the time when all customers are powered on again. Depending on the reporting from field, eventually it will also be possible to reconstruct the time it takes for different activities in the process. For faults occurring that do not make the MV breaker to open, e.g. the HV fuse is broken, these types of faults today require the customer to call. If we get the functionality we would like to be implemented on the Demo Site feeders, then we will be able to detect those faults by ourselves, but we will also be able to locate the fault, (pin point the fault between two secondary substations). In this case we will perhaps be able to make an evaluation of the time for localisation

DEMO POLAND

KPI CALCULATION METHODOLOGY		
KPI Step Methodology ID [KPI ID #]	**Step**	**Responsible**
ΔT_fault_BAU	Time needed to restore the electrical service since the user calls to notify an incidence in BAU scenario. Mean value of all the faults that occur during the BAU scenario monitoring period.	ENERGA
ΔT_fault_R&I	Time needed to restore the electrical service since the user calls to notify an incidence in R&I scenario. Mean value of all the faults that occur during the R&I scenario monitoring period.	ENERGA

KPI SCENARIOS			
Scenarios to be measured	Baseline ☐	Business as usual (BaU) X	R&D X

KPI DATA COLLECTION							
Data	**Data ID**	**Methodology for data collection**	**Source/Tools/ Instruments for Data collection**	**Location of Data collection**	**Frequency of data collection**	**Minimum monitoring period**	**Data collection responsible**
ΔT_fault_BAU	ΔT_fault_BAU	Analysis of data from SID	SID (existing Information System of Distribution),	SID	After every fault	One year	ENERGA
ΔT_fault_R&I	ΔT_fault_R&I	Analysis of data from SID	SID (existing Information System of Distribution),	SID	After every fault	One year	ENERGA

GENERAL COMMENTS

A II. 7. QUALITY OF SUPPLY IMPROVEMENT IN LV

BASIC KPI INFORMATION				
KPI Name	Quality of Supply Improvement in LV		**KPI ID**	QS_{LV}
Main Objective	To evaluate the improvement in the frequency and duration of interruption in LV distribution networks.			
KPI Description	Although other KPIs have been defined in the scope of UPGRID project to evaluate the quality of supply of distribution networks, also a general quality of supply improvement KPI has been considered to evaluate the improvement in the frequency and duration of interruptions in LV.			
KPI Formula	$QS_{LV}(\%) = \frac{CML_{BAU} - CML_{R\&I}}{CML_{BAU}}$			
Unit of measurement	%			
Connection/Link with other relevant projects KPI	GRID+, DISCERN and IDE4L			
Project sites to be calculated	Demo Spain: X	Demo Portugal:	Demo Sweden:	Demo Poland: X

DEMO SPAIN

KPI CALCULATION METHODOLOGY		
KPI Step Methodology ID [KPI ID #]	**Step**	**Responsible**
CML_BAU	Customer Minutes Lost in BAU scenario.	IBERDROLA
CML_R&I	Customer Minutes Lost in R&I scenario	IBERDROLA

KPI SCENARIOS			
Scenarios to be measured	Baseline:	Business as usual (BaU): X	R&D: X

KPI DATA COLLECTION							
Data	**Data ID**	**Methodology for data collection**	**Source/Tools/ Instruments for Data collection**	**Location of Data collection**	**Frequency of data collection**	**Minimum monitoring period**	**Data collection responsible**
CML_BAU	CML_BAU	Taken data from the REPOS (SPECTRUM) – CDS system applying the appropriate filters and analysing them	REPOS (SPECTRUM) – CDS	REPOS (SPECTRUM) – CDS data base	Once	One month	IBERDROLA

CML_R&I	CML_R&I	Taken data from the LV Network Management system used in UPGRID, PowerON. Appropriate will. Be applied and date retrieved could be analysed.	PowerOn	PowerOn data base	Once	One month	IBERDROLA
GENERAL COMMENTS							
BAU scenario corresponds with a moment in time before the UPGRID is deployed. In the same way, R&I scenario corresponds with a moment in time after the UPGRID project (once outage management improvement sub-functionalities are implemented). Customer Minutes Lost (CML) is calculated by taking the sum of the customer minutes lost for all restoration stages for all incidents during the monitoring period and dividing by the number of connected customer.							

DEMO POLAND

KPI CALCULATION METHODOLOGY		
KPI Step Methodology ID [KPI ID #]	**Step**	**Responsible**
CML_BAU	Customer Minutes Lost in BAU scenario.	ENERGA
CML_R&I	Customer Minutes Lost in R&I scenario	ENERGA

KPI SCENARIOS			
Scenarios to be measured	Baseline ☐	Business as usual (BaU) X	R&D X

KPI DATA COLLECTION							
Data	**Data ID**	**Methodology for data collection**	**Source/Tools/ Instruments for Data collection**	**Location of Data collection**	**Frequency of data collection**	**Minimum monitoring period**	**Data collection responsible**
CML_BAU	CML_BAU		SID (existing Information System of Distribution), AMI,	SID, AMI	After every fault	One year	ENERGA
CML_R&I	CML_R&I		SID (existing Information System of Distribution), AMI, OMS	SID,AMI, OMS	After every fault	One year	ENERGA
GENERAL COMMENTS							
BAU scenario corresponds with a moment in time before the UPGRID is deployed. In the same way, R&I scenario corresponds with a moment in time after the UPGRID project (once outage management improvement sub-functionalities are implemented). Customer Minutes Lost (CML) is calculated by taking the sum of the customer minutes lost for all restoration stages for all incidents during the monitoring period and dividing by the number of connected customer.							

A II. 8. QUALITY OF SUPPLY IMPROVEMENT IN MV

BASIC KPI INFORMATION				
KPI Name	Quality of Supply Improvement in MV		**KPI ID**	QS_{MV}
Main Objective	To evaluate the improvement in the frequency and duration of interruption in MV distribution networks.			
KPI Description	UPGRID project is addressing several actions to be implemented in the demo areas which will impact positively in the reduction of duration and frequency of interruptions. Some of these actions regard the revision and implementation of the DSO business processes in relation with the outage management integrating and processing meter events or/and other sources. Other actions are related to the implementation of new algorithms to the remote reconfiguration of the distribution grid after a fault. In addition, new smart devices will be deployed and tested to detect the fault and to support the maintenance grid crews.			
KPI Formula	$QS_{MV}(\%) = \mathrm{C_{SAIFI}} \cdot \Delta_{\mathrm{SAIFI}} + \mathrm{C_{SAIDI}} \cdot \Delta_{\mathrm{SAIDI}}$ $\Delta_{\mathrm{SAIFI}} = \frac{\mathrm{SAIFI_{BAU}} - \mathrm{SAIFI}_{R\&I}}{\mathrm{SAIFI_{BAU}}}$ $SAIFI = \frac{\#interruptions}{\#customers}$ $\Delta_{\mathrm{SAIDI}} = \frac{\mathrm{SAIDI_{BAU}} - \mathrm{SAIDI}_{R\&I}}{\mathrm{SAIDI_{BAU}}}$ $SAIDI = \frac{\#duration\_interruptions}{\#customers}$			
Unit of measurement	%			
Connection/Link with other relevant projects KPI	GRID+, DISCERN and IDE4L			
Project sites to be calculated	Demo Spain ☐	Demo Portugal X	Demo Sweden X	Demo Poland X

DEMO PORTUGAL

KPI CALCULATION METHODOLOGY		
KPI Step Methodology ID [KPI ID #]	**Step**	**Responsible**
interrumptions_BAU	Total number of interruptions within the observed period (one year) in BAU scenario.	EDP
interruptions_R&I	Total number of interruptions within the observed period (six months) in R&I scenario.	EDP
duration_interruptions _BAU	Sum of all end customer interruptions duration within the observed period (one year) in BAU scenario.	EDP

duration_interruptions_R&I	Sum of all end customer interruptions duration within the observed period (six months) in R&I scenario.	EDP
customers_BAU	Total number of customers served (average within the period observed (one year) in BAU scenario.	EDP
customers_R&I	Total number of customers served (average within the period observed (six months)) in R&I scenario.	EDP
C_SAIDI	Weight factor for SAIDI (50%)	EDP
C_SAIFI	Weight factor for SAIFI (50%)	EDP

KPI SCENARIOS

Scenarios to be measured	Baseline	Business as usual (BaU)	R&D
	[ ]	[X]	[X]

KPI DATA COLLECTION

Data	Data ID	Methodology for data collection	Source/Tools/ Instruments for Data collection	Location of Data collection	Frequency of data collection	Minimum monitoring period	Data collection responsible
interrumptions_BAU	interrumptions_BAU			OMS	After each interruption	One year	EDP
interruptions_R&I	interruptions_R&I			OMS	After each interruption	Six months	EDP
duration_interruptions_BAU	duration_interruptions_BAU			OMS	After each interruption	One year	EDP
duration_interruptions_R&I	duration_interruptions_R&I			OMS	After each interruption	Six months	EDP
customers_BAU	customers_BAU				Once	One year	EDP
customers_R&I	customers_R&I				Once	Six months	EDP

GENERAL COMMENTS

BAU scenario corresponds with a moment in time before the UPGRID is deployed. In the same way, R&I scenario corresponds with a moment in time after the UPGRID project (once outage management improvement sub-functionalities are implemented).

DEMO SWEDEN

KPI CALCULATION METHODOLOGY

KPI Step Methodology ID [KPI ID #]	Step	Responsible
interrumptions_BAU	Total number of interruptions within the observed period (months) in BAU scenario.	VFT
interruptions_R&I	Total number of interruptions within the observed period (months) in R&I scenario.	VFT
duration_interruptions_BAU	Sum of all end customer interruptions duration within the observed period (months) in BAU scenario.	VFT
duration_interruptions_R&I	Sum of all end customer interruptions duration within the observed period (months) in R&I scenario.	VFT
customers_BAU	Total number of customers served (average within the period observed (months)) in BAU scenario.	VFT

customers_R&I	Total number of customers served (average within the period observed (months)) in R&I scenario.	VFT
C_SAIDI	Weight factor for SAIDI (50%)	VFT
C_SAIFI	Weight factor for SAIFI (50%)	VFT

Scenarios to be measured	Baseline	Business as usual (BaU)	R&D
	[ ]	[X]	[X]

KPI DATA COLLECTION							
Data	**Data ID**	**Methodology for data collection**	**Source/Tools/ Instruments for Data collection**	**Location of Data collection**	**Frequency of data collection**	**Minimum monitoring period**	**Data collection responsible**
interrumptions_BAU	interrumptions_BAU				Month	Months	VFT
interruptions_R&I	interruptions_R&I				Month	Months	VFT
duration_interruptions_BAU	duration_interruptions_BAU				Month	Months	VFT
duration_interruptions_R&I	duration_interruptions_R&I				Month	Months	VFT
customers_BAU	customers_BAU				Once	Months	VFT
customers_R&I	customers_R&I				Once	Months	VFT

GENERAL COMMENTS

BAU scenario corresponds with a moment in time before the UPGRID is deployed. In the same way, R&I scenario corresponds with a moment in time after the UPGRID project (once outage management improvement sub-functionalities are implemented).

Uncertainty on what information that will be available from the ordinary line organisation regarding fault management, i.e. SAIDI, SAIFI data and restorations times etc.
This KPI will only be calculated for the MV feeder (s) included in the Upgrid Demo Site Area, i.e. those MV feeders where the Swedish Demo plan to deploy FPI's in MV network.
The R&I scenario will be estimated, using the new tools for calculating the improved awareness time. Real impact on the MV outage management process will not be evaluated and calculated.

DEMO POLAND

KPI CALCULATION METHODOLOGY		
KPI Step Methodology ID [KPI ID #]	**Step**	**Responsible**
interrumptions_BAU	Total number of interruptions within the observed period (six months) in BAU scenario.	ENERGA

interruptions_R&I	Total number of interruptions within the observed period (six months) in R&I scenario.	ENERGA
duration_interruptions_BAU	Sum of all end customer interruptions duration within the observed period (six months) in BAU scenario.	ENERGA
duration_interruptions_R&I	Sum of all end customer interruptions duration within the observed period (six months) in R&I scenario.	ENERGA
customers_BAU	Total number of customers served (average within the period observed (six months)) in BAU scenario.	ENERGA
customers_R&I	Total number of customers served (average within the period observed (six months)) in R&I scenario.	ENERGA
C_SAIDI	Weight factor for SAIDI (50%)	ENERGA
C_SAIFI	Weight factor for SAIFI (50%)	ENERGA

KPI SCENARIOS

Scenarios to be measured	Baseline	Business as usual (BaU)	R&D
	[ ]	[X]	[X]

KPI DATA COLLECTION

Data	Data ID	Methodology for data collection	Source/Tools/ Instruments for Data collection	Location of Data collection	Frequency of data collection	Minimum monitoring period	Data collection responsible
interruptions_BAU	interruptions_BAU	Analysis of data from SID	SID (existing Information System of Distribution),	SID	After each interruption	Six months	ENERGA
interruptions_R&I	interruptions_R&I	Analysis of data from SID	SID (existing Information System of Distribution),	SID	After each interruption	Six months	ENERGA
duration_interruptions_BAU	duration_interruptions_BAU	Analysis of data from SID	SID (existing Information System of Distribution),	SID	After each interruption	Six months	ENERGA
duration_interruptions_R&I	duration_interruptions_R&I	Analysis of data from SID	SID (existing Information System of Distribution),	SID	After each interruption	Six months	ENERGA
customers_BAU	customers_BAU	Analysis of data from SID	SID (existing Information System of Distribution),	SID	Once	Six months	ENERGA
customers_R&I	customers_R&I	Analysis of data from SID	SID (existing Information System of Distribution),	SID	Once	Six months	ENERGA

GENERAL COMMENTS

BAU scenario corresponds with a moment in time before the UPGRID is deployed. In the same way, R&I scenario corresponds with a moment in time after the UPGRID project (once outage management improvement sub-functionalities are implemented).

A II. 9. ENERGY LOSSES

BASIC KPI INFORMATION				
KPI Name	Energy Losses		**KPI ID**	ΔE
Main Objective	To evaluate the reduction of energy technical losses in the distribution network.			
KPI Description	This KPI will be calculated in order to know the total reduction of technical energy losses as a result of the combination of the different implemented R&I actions. This KPI will be only calculated for an UPGRID demo if the demo is addressing sub-functionalities focused on reducing energy losses.			
KPI Formula	$\Delta E(\%) = \frac{E_{BAU} - E_{R\&I}}{E_{BAU}}$			
Unit of measurement	%			
Connection/Link with other relevant projects KPI	GRID4EU, DISCERN and IDE4L			
Project sites to be calculated	Demo Spain X	Demo Portugal X	Demo Sweden	Demo Poland X

DEMO SPAIN

KPI CALCULATION METHODOLOGY		
KPI Step Methodology ID [KPI ID #]	**Step**	**Responsible**
E_BAU	Technical losses in the scope of the demo in the BAU scenario within the observed period (six months).	IBERDROLA
E_R&I	Technical losses in the scope of the demo in the R&I scenario within the observed period (six months).	IBERDROLA

KPI SCENARIOS			
Scenarios to be measured	Baseline	Business as usual (BaU) X	R&D X

KPI DATA COLLECTION							
Data	**Data ID**	**Methodology for data collection**	**Source/Tools/ Instruments for Data collection**	**Location of Data collection**	**Frequency of data collection**	**Minimum monitoring period**	**Data collection responsible**
E_BAU	E_BAU	Assuming that the work orders indicated in the R&I would not exist and then those power transformers are kept with certain overload.	STG (data from supervision meters)	STG	Once	Based on the number of work orders	IBERDROLA

E_R&I	E_R&I	Based on the work orders to substitute power transformers in SSs based on the information collected by the STG (from supervision meters)	STG (data from supervision meters)	STG	Once	Based on the number of work orders	IBERDROLA

GENERAL COMMENTS
BAU scenario corresponds with a moment in time before the UPGRID is deployed. In the same way, R&I scenario corresponds with a moment in time after the UPGRID project new tools, procedures and devices are deployed. Technical losses related to I^2R. This is related to the load of the power transformers in SS.

DEMO PORTUGAL

KPI CALCULATION METHODOLOGY		
KPI Step Methodology ID [KPI ID #]	**Step**	**Responsible**
E_BAU	Energy losses in the scope of the demo in the BAU scenario within the observed period (six months).	EDP
E_R&I	Energy losses in the scope of the demo in the R&I scenario within the observed period (six months).	EDP

KPI SCENARIOS			
Scenarios to be measured	Baseline ☐	Business as usual (BaU) X	R&D X

KPI DATA COLLECTION							
Data	**Data ID**	**Methodology for data collection**	**Source/Tools/ Instruments for Data collection**	**Location of Data collection**	**Frequency of data collection**	**Minimum monitoring period**	**Data collection responsible**
E_BAU	E_BAU		n.a.			Six months	EDP
E_R&I	E_R&I		Smart Meters	AMI	Monthly	Six months	EDP

GENERAL COMMENTS
BAU scenario corresponds with a moment in time before the UPGRID is deployed. In the same way, R&I scenario corresponds with a moment in time after the UPGRID project new tools, procedures and devices are deployed. The Portuguese demo will use the overall energy losses (technical and commercial losses) to evaluate this KPI.

DEMO POLAND

KPI CALCULATION METHODOLOGY		
KPI Step Methodology ID [KPI ID #]	**Step**	**Responsible**
E_BAU	Technical losses in the scope of the demo in the BAU scenario within the observed period (six months).	ENERGA

<table>
<tr><td colspan="2">E_R&I</td><td colspan="4">Technical losses in the scope of the demo in the R&I scenario within the observed period (six months).</td><td colspan="2">ENERGA</td></tr>
<tr><th colspan="8">KPI SCENARIOS</th></tr>
<tr><th colspan="2">Scenarios to be measured</th><td colspan="2">Baseline
[ ]</td><td colspan="2">Business as usual (BaU)
X</td><td colspan="2">R&D
X</td></tr>
<tr><th colspan="8">KPI DATA COLLECTION</th></tr>
<tr><th>Data</th><th>Data ID</th><th>Methodology for data collection</th><th>Source/Tools/ Instruments for Data collection</th><th>Location of Data collection</th><th>Frequency of data collection</th><th>Minimum monitoring period</th><th>Data collection responsible</th></tr>
<tr><td>E_BAU</td><td>E_BAU</td><td>Technical calculations</td><td>DMS LV</td><td>DMS LV</td><td></td><td>One month</td><td>ENERGA</td></tr>
<tr><td>E_R&I</td><td>E_R&I</td><td>Technical calculations</td><td>DMS LV</td><td>DMS LV</td><td></td><td>One month</td><td>ENERGA</td></tr>
<tr><th colspan="8">GENERAL COMMENTS</th></tr>
<tr><td colspan="8">BAU scenario corresponds with a moment in time before the UPGRID is deployed. In the same way, R&I scenario corresponds with a moment in time after the UPGRID project new tools, procedures and devices are deployed.</td></tr>
</table>

A II. 10. MONITORING INFORMATION CATEGORIES

BASIC KPI INFORMATION				
KPI Name	Monitoring Information Categories		**KPI ID**	MIC
Main Objective	To evaluate the amount of new data monitored.			
KPI Description	Monitoring data volume is an indication of the increase of data amount for new monitored currents, powers or voltages in primary substations, secondary substation or customer level. One of the main objectives of UPGRID project is the integration of measurement data for low voltage network control tools, for supporting state estimation and power flow algorithms or for the outage management procedures, among others			
KPI Formula	$MIC(\%) = \frac{MD_{R\&I} - MD_{BAU}}{MD_{BAU}}$			
Unit of measurement	%			
Connection/Link with other relevant projects KPI	IDE4L			
Project sites to be calculated	Demo Spain X	Demo Portugal X	Demo Sweden X	Demo Poland X

DEMO SPAIN

KPI CALCULATION METHODOLOGY		
KPI Step Methodology ID [KPI ID #]	**Step**	**Responsible**
MD_{BAU}	Consolidation of the table of information categories for the following equipment: • Smart meters, data concentrators, based nodes and RTU (PRIME) • Advanced LV supervisors (SS)	IBERDROLA - ZIV
$MD_{R\&I}$	Consolidation of the table of information categories for the following equipment: • Smart meters, data concentrators, based nodes and RTU (PRIME) • Advanced LV supervisors (SS)	IBERDROLA - ZIV

KPI SCENARIOS			
Scenarios to be measured	Baseline	Business as usual (BaU) X	R&D X

KPI DATA COLLECTION							
Data	**Data ID**	**Methodology for data collection**	**Source/Tools/ Instruments for Data collection**	**Location of Data collection**	**Frequency of data collection**	**Minimum monitoring period**	**Data collection responsible**
MD_{BAU}	MD_{BAU}	Filling the monitored data (yes/no) column before UPGRID and count each case	Demo equipment inventory	Based on companion s	Once	n/a	IBERDROLA - ZIV

$MD_{R\&I}$	$MD_{R\&I}$	Filling the monitored data (yes/no) column after UPGRID and count each case	Demo equipment inventory	Based on companions	Once	n/a	IBERDROLA - ZIV
GENERAL COMMENTS							
Count criterion 2 has been selected for this demo.							

DEMO PORTUGAL

KPI CALCULATION METHODOLOGY		
KPI Step Methodology ID [KPI ID #]	**Step**	**Responsible**
MD_{BAU}	Consolidation of the table of information categories for the following equipment: • Smart meters, data concentrators, based nodes and RTU (PRIME). • Smart plugs and gateways.	EDP
$MD_{R\&I}$	Consolidation of the table of information categories for the following equipment: • Smart meters, data concentrators, based nodes and RTU (PRIME). • Smart plugs and gateways.	EDP

KPI SCENARIOS			
Scenarios to be measured	Baseline ☐	Business as usual (BaU) X	R&D X

KPI DATA COLLECTION							
Data	**Data ID**	**Methodology for data collection**	**Source/Tools/ Instruments for Data collection**	**Location of Data collection**	**Frequency of data collection**	**Minimum monitoring period**	**Data collection responsible**
MD_{BAU}	MD_{BAU}	Filling the monitored data (yes/no) column before UPGRID and count each case	Demo equipment inventory	Based on companions	Once	n/a	EDP
$MD_{R\&I}$	$MD_{R\&I}$	Filling the monitored data (yes/no) column after UPGRID and count each case	Demo equipment inventory	Based on companions	Once	n/a	EDP
GENERAL COMMENTS							
For Portuguese demo it should be considered the second count criterion.							

DEMO SWEDEN

KPI CALCULATION METHODOLOGY		
KPI Step Methodology ID [KPI ID #]	**Step**	**Responsible**

BAU	In BAU scenario count each information category available in each LV measuring point	VFT
R&I	In R&I scenario count each information category available in each LV measuring point	VFT

KPI SCENARIOS			
Scenarios to be measured	Baseline ☐	Business as usual (BaU) X	R&D X

KPI DATA COLLECTION							
Data	**Data ID**	**Methodology for data collection**	**Source/Tools/ Instruments for Data collection**	**Location of Data collection**	**Frequency of data collection**	**Minimum monitoring period**	**Data collection responsible**
V_BAU	V_BAU				Once	Year	VFT
V_R&I	V_R&I				Once	Year	VFT

GENERAL COMMENTS
Count criterion 2 has been selected for this demo. For this KPI the R&I scenario will be based on the deployment made in the Demo Site Area, and compared with the situation prior the Upgrid deployment. This KPI will not be scaled up for a larger area/region.

DEMO POLAND

KPI CALCULATION METHODOLOGY		
KPI Step Methodology ID [KPI ID #]	**Step**	**Responsible**
MD_{BAU}	Consolidation of the table of information categories for the following equipment: • Smart meters, data concentrators, based nodes and RTU (PRIME). • Advanced LV supervisors (SS). • DER controllers by nodes by nodes and RTU (PRIME).	ENERGA, Atende
$MD_{R\&I}$	Consolidation of the table of information categories for the following equipment: • Smart meters, data concentrators, based nodes and RTU (PRIME). • Advanced LV supervisors (SS). DER controllers by nodes by nodes and RTU (PRIME).	ENERGA, Atende

KPI SCENARIOS			
Scenarios to be measured	Baseline ☐	Business as usual (BaU) X	R&D X

KPI DATA COLLECTION							
Data	**Data ID**	**Methodology for data collection**	**Source/Tools/ Instruments for Data collection**	**Location of Data collection**	**Frequency of data collection**	**Minimum monitoring period**	**Data collection responsible**
MD_{BAU}	MD_{BAU}	Filling the monitored data (yes/no) column before UPGRID and count each case	Demo equipment inventory	Based on companion s	once		ENERGA, Atende

$MD_{R\&I}$	$MD_{R\&I}$	Filling the monitored data (yes/no) column after UPGRID and count each case	Demo equipment inventory	Based on companion s	once		ENERGA, Atende
GENERAL COMMENTS							
Count criterion 2 has been selected for this demo.							

A II. 11. AVAILABLE INFORMATION CATEGORIES

BASIC KPI INFORMATION				
KPI Name	Available Information Categories		**KPI ID**	ADIC
Main Objective	To evaluate the amount of available data in new visualization tools			
KPI Description	Available data volume is an indication of the increase of data amount for new visualized currents, powers or voltages in primary substations, secondary substation or customer level. One of the main objectives of UPGRID project is to enhance the availability of the information gathered by the smart metering infrastructure for the distribution system operator and also for the final customer. This information will be integrated in the low voltage management tools visualization for the distributed system operator. Also the consumption information will be available in a web portal for increasing the customer awareness. Finally, the information will be also depicted in smart mobile devices to support maintenance grid crews.			
KPI Formula	$$AIC(\%) = \frac{AD_{R\&I} - AD_{BAU}}{AD_{BAU}}$$			
Unit of measurement	%			
Connection/Link with other relevant projects KPI	-			
Project sites to be calculated	Demo Spain X	Demo Portugal X	Demo Sweden ☐	Demo Poland X

DEMO SPAIN

KPI CALCULATION METHODOLOGY		
KPI Step Methodology ID [KPI ID #]	**Step**	**Responsible**
AD_{BAU}	Consolidation of the table of information categories for the following equipment: • LV Network Management System (DSO) • Web portal (customers) • Mobile devices (grid crews)	IBERDROLA
$AD_{R\&I}$	Consolidation of the table of information categories for the following equipment: • LV Network Management System (DSO) • Web portal (customers) • Mobile devices (grid crews)	IBERDROLA

KPI SCENARIOS			
Scenarios to be measured	Baseline ☐	Business as usual (BaU) X	R&D X

KPI DATA COLLECTION							
Data	**Data ID**	**Methodology for data collection**	**Source/Tools/ Instruments for Data collection**	**Location of Data collection**	**Frequency of data collection**	**Minimum monitoring period**	**Data collection responsible**

AD_{BAU}	AD_{BAU}	Filling the available data (yes/no) column before UPGRID and count each case	Demo platform inventory	Based on platform specification	Once	n/a	IBERDROLA and partners involved in the platform
$AD_{R\&I}$	$AD_{R\&I}$	Filling the available data (yes/no) column after UPGRID and count each case	Demo platform inventory	Based on platform specification	Once	n/a	IBERDROLA and partners involved in the platform
GENERAL COMMENTS							
Count criterion 2 has been selected for this demo.							

DEMO PORTUGAL

KPI CALCULATION METHODOLOGY		
KPI Step Methodology ID [KPI ID #]	**Step**	**Responsible**
AD_{BAU}	Consolidation of the table of information categories for the following equipment: • LV Network Management System (DSO) • Web portal (customers)	EDP
$AD_{R\&I}$	Consolidation of the table of information categories for the following equipment: • LV Network Management System (DSO) • Web portal (customers)	EDP

KPI SCENARIOS			
Scenarios to be measured	Baseline [ ]	Business as usual (BaU) [X]	R&D [X]

KPI DATA COLLECTION							
Data	**Data ID**	**Methodology for data collection**	**Source/Tools/ Instruments for Data collection**	**Location of Data collection**	**Frequency of data collection**	**Minimum monitoring period**	**Data collection responsible**
AD_{BAU}	AD_{BAU}	Filling the available data (yes/no) column before UPGRID and count each case	Demo platform inventory	Based on platform specification	Once	n/a	EDP
$AD_{R\&I}$	$AD_{R\&I}$	Filling the available data (yes/no) column after UPGRID and count each case	Demo platform inventory	Based on platform specification	Once	n/a	EDP
GENERAL COMMENTS							
For Portuguese demo it should be considered the second count criterion.							

DEMO POLAND

KPI CALCULATION METHODOLOGY		
KPI Step Methodology ID [KPI ID #]	**Step**	**Responsible**
AD_{BAU}	Consolidation of the table of information categories for the following equipment: • Existing MV/LV SCADA/DMS • Web portal (customers) • AMI	ENERGA, ATENDE
$AD_{R\&I}$	Consolidation of the table of information categories for the following equipment: • LV Network Management System (DSO) • Existing MV/LV SCADA/DMS • Web portal (customers) • AMI	ENERGA, ATENDE

KPI SCENARIOS			
Scenarios to be measured	Baseline [ ]	Business as usual (BaU) [X]	R&D [X]

KPI DATA COLLECTION							
Data	**Data ID**	**Methodology for data collection**	**Source/Tools/ Instruments for Data collection**	**Location of Data collection**	**Frequency of data collection**	**Minimum monitoring period**	**Data collection responsible**
AD_{BAU}		Filling the available data (yes/no) column before UPGRID and count each case	IT systems	Based on IT systems specification	once		ENERGA, ATENDE
$AD_{R\&I}$		Filling the available data (yes/no) column before UPGRID and count each case	IT systems	Based on IT systems specification	once		ENERGA, ATENDE

GENERAL COMMENTS
Count criterion 2 has been selected for this demo.

A II. 12. CHARACTERIZED INFORMATION CATEGORIES

BASIC KPI INFORMATION				
KPI Name	Characterized Information Categories		**KPI ID**	CIC
Main Objective	To evaluate the amount of new data for characterization analysis.			
KPI Description	Characterized data volume is an indication of the increase of data amount for new characterization analysis of currents, powers or voltages in primary substations, secondary substation or customer level. UPGRID addresses the data analytic based on the information gathered by the smart metering infrastructure to characterize low voltage consumption, to characterize the EV charging points behaviour and the grid state data to assist network planning and maintenance.			
KPI Formula	$CIC(\%) = \frac{CD_{R\&I} - CD_{BAU}}{CD_{BAU}}$			
Unit of measurement	%			
Connection/Link with other relevant projects KPI	-			
Project sites to be calculated	Demo Spain [X]	Demo Portugal [X]	Demo Sweden [ ]	Demo Poland [X]

DEMO SPAIN

KPI CALCULATION METHODOLOGY		
KPI Step Methodology ID [KPI ID #]	**Step**	**Responsible**
#1	Refinement of the list of processes targeted by this KPI	IBERDROLA
#2	Identified key information categories for each process	IBERDROLA
#3	Evaluate the differences in term of for example granularity, time period and number of SS for each scenario BaU and R&I	IBERDROLA

KPI SCENARIOS			
Scenarios to be measured	Baseline [ ]	Business as usual (BaU) [X]	R&D [X]

KPI DATA COLLECTION							
Data	**Data ID**	**Methodology for data collection**	**Source/Tools/ Instruments for Data collection**	**Location of Data collection**	**Frequency of data collection**	**Minimum monitoring period**	**Data collection responsible**

CD_{BAU}	CD_{BAU}	Sum of a series of multiplication that take into account the most relevant pieces of information and the identified characterisation factors for each of them during the BaU period.	Project equipment inventory, equipment specifications, STG	Document and data bases associated to the indicated source of information	Once	-	IBERDROLA (with the support of demo partners)
$CD_{R\&I}$	$CD_{R\&I}$	Sum of a series of multiplication that take into account the most relevant pieces of information and the identified characterisation factors for each of them during the R&I period.	Project equipment inventory, equipment specifications, STG, PowerOn	Document and data bases associated to the indicated source of information	Once	-	IBERDROLA (with the support of demo partners)

GENERAL COMMENTS

The Spanish demo will be mainly focused on the following points derived from the selected list of demo sub-functionalities:

- Data used by the LV Management Network System
- Define a sound LV network
- Integration of measurement data to support power flow analyses in LV Network Management System

This will be translated into:

- Volume of data uploaded in the LV management system (e.g. % of SS and General boxes)
- New data capture from the LV advanced supervisor
- Events which reception, as happened has been, reviewed
- Data approach regarding performing power flow

The KPI will be quantified counting the differences in terms of: granularity of the information category / parameter, time period and number of SS involved.

DEMO PORTUGAL

KPI CALCULATION METHODOLOGY

KPI Step Methodology ID [KPI ID #]	Step	Responsible
#1	Refinement of the list of processes targeted by this KPI	EDP
#2	Identified key information categories for each process	EDP
#3	Evaluate the differences in term of for example granularity, time period and number of SS for each scenario BaU and R&I	EDP

KPI SCENARIOS

Scenarios to be measured	Baseline	Business as usual (BaU)	R&D
	[ ]	[X]	[X]

KPI DATA COLLECTION

Data	Data ID	Methodology for data collection	Source/Tools/ Instruments for Data collection	Location of Data collection	Frequency of data collection	Minimum monitoring period	Data collection responsible
CD_{BAU}	CD_{BAU}	Sum of a series of multiplication that take into account the most relevant pieces of information and the identified characterisation factors for each of them during the BaU period.	Project equipment inventory, equipment specifications, STG	Document and data bases associated to the indicated source of information	Once	-	EDP
$CD_{R\&I}$	$CD_{R\&I}$	Sum of a series of multiplication that take into account the most relevant pieces of information and the identified characterisation factors for each of them during the R&I period.	Project equipment inventory, equipment specifications, STG, PowerOn	Document and data bases associated to the indicated source of information	Once	-	EDP

GENERAL COMMENTS

The Portuguese demo will be mainly focused on the following points derived from the selected list of demo sub-functionalities:

- LV customer consumption characterization.
- Consumption characterization of EV charging points.
- Integration of measurement data to support power flow analysis in LV Network Management System.

DEMO POLAND

KPI CALCULATION METHODOLOGY		
KPI Step Methodology ID [KPI ID #]	**Step**	**Responsible**
#1	Refinement of the list of processes targeted by this KPI	ENERGA, Atende
#2	Identified key information categories for each process	ENERGA, Atende
#3	Evaluate the differences in term of for example granularity, time period and number of SS for each scenario BaU and R&I	ENERGA, Atende
#4	Refinement of the list of processes targeted by this KPI	ENERGA, Atende

KPI SCENARIOS			
Scenarios to be measured	Baseline ☐	Business as usual (BaU) X	R&D X

KPI DATA COLLECTION							
Data	**Data ID**	**Methodology for data collection**	**Source/Tools/ Instruments for Data collection**	**Location of Data collection**	**Frequency of data collection**	**Minimum monitoring period**	**Data collection responsible**
CD_{BAU}	CD_{BAU}	Sum of a series of multiplication that take into account the most relevant pieces of information and the identified characterisation factors for each of them during the BaU period.	Project equipment inventory, equipment specifications,	Document and data bases associated to the indicated source of information	Once		ENERGA, Atende
$CD_{R\&I}$	$CD_{R\&I}$	Sum of a series of multiplication that take into account the most relevant pieces of information and the identified characterisation factors for each of them during the R&I period.	Project equipment inventory, equipment specifications,	Document and data bases associated to the indicated source of information	Once		ENERGA, Atende

GENERAL COMMENTS

A II. 13. AVAILABILITY OF INTELLIGENT NETWORK COMPONENTS

BASIC KPI INFORMATION				
KPI Name	Availability of Intelligent Network		**KPI ID**	AV
Main Objective	To evaluate the increase of the total amount of intelligent network components (smart meters, smart transformers, new intelligent protection, etc.) deployed in the scope of each demo.			
KPI Description	The availability of intelligent network components evaluates the increase of the total amount of intelligent network components (smart meters, smart transformers, new intelligent protection, etc.) deployed in the scope of each demo. UPGRID project is addressing several actions to be implemented in the demo areas which will increase the availability of intelligent network components. Some of these actions regard the deployment of new devices such as smart meters, concentrator, smart transformer or new fault detectors. Other actions are related to making smarter some of the already deployed devices, i.e. concept test of PLC-PRIME advanced queries in the deployed smart metering infrastructure.			
KPI Formula	$AV(\%) = \frac{IC_{R\&I} - IC_{BAU}}{IC_{BAU}}$			
Unit of measurement	%			
Connection/Link with other relevant projects KPI	DISCERN			
Project sites to be calculated	Demo Spain [X]	Demo Portugal [X]	Demo Sweden [X]	Demo Poland [X]

DEMO SPAIN

KPI CALCULATION METHODOLOGY		
KPI Step Methodology ID [KPI ID #]	**Step**	**Responsible**
#1	Identified the most relevant intelligent component in the demo	IBERDROLA
#2	Select a weight factor to measure the relative importance within the demo	IBERDROLA
#3	Identified in which cases new functionalities or modifications have been added into each component to apply the 0,5 or 1 coefficient in each case	IBERDROLA

KPI SCENARIOS			
Scenarios to be measured	Baseline [ ]	Business as usual (BaU) [X]	R&D [X]

KPI DATA COLLECTION							
Data	**Data ID**	**Methodology for data collection**	**Source/Tools/ Instruments for Data collection**	**Location of Data collection**	**Frequency of data collection**	**Minimum monitoring period**	**Data collection responsible**

IC_{BAU}	IC_{BAU}	Based on a consolidated table of intelligent components, relative weight and count of possible changes on component in BaU	Project equipment inventory, equipment specifications, STG	Document and data bases associated to the indicated source of informatio n	Once	-	IBERDROLA (with the support of demo partners)
$IC_{R\&I}$	$IC_{R\&I}$	Based on a consolidated table of intelligent components, relative weight and count of possible changes on component during UPGRID (R&I)	Project equipment inventory, equipment specifications, STG, PowerOn	Document and data bases associated to the indicated source of informatio n	Once	-	IBERDROLA (with the support of demo partners)

GENERAL COMMENTS

This KPI will be based on the table presented in section 5.15.

It is important to note that not all the indicated components in that table will be installed during the UPGRID project but some of them were deployed in the demo base. For this reason the weight % has been selected to give higher importance to those more related to the work done in the Spanish demo in particular.

DEMO PORTUGAL

KPI CALCULATION METHODOLOGY

KPI Step Methodology ID [KPI ID #]	Step	Responsible
#1	Identified the most relevant intelligent component in the demo	EDP
#2	Select a weight factor to measure the relative importance within the demo	EDP
#3	Identified in which cases new functionalities or modifications have been added into each component to apply the 0,5 or 1 coefficient in each case	EDP

KPI SCENARIOS

Scenarios to be measured	Baseline	Business as usual (BaU)	R&D
		X	X

KPI DATA COLLECTION

Data	Data ID	Methodology for data collection	Source/Tools/ Instruments for Data collection	Location of Data collection	Frequency of data collection	Minimum monitoring period	Data collection responsible

IC_{BAU}	IC_{BAU}	Based on a consolidated table of intelligent components, relative weight and count of possible changes on component in BaU	n.a.	Document and data bases associated to the indicated source of information	Once	-	EDP
$IC_{R\&I}$	$IC_{R\&I}$	Based on a consolidated table of intelligent components, relative weight and count of possible changes on component during UPGRID (R&I)	AMI	Document and data bases associated to the indicated source of information	Once	-	EDP
GENERAL COMMENTS							

DEMO SWEDEN

KPI CALCULATION METHODOLOGY		
KPI Step Methodology ID [KPI ID #]	**Step**	**Responsible**
BAU	In BAU scenario, (existing components prior the Upgrid deployment), count the number of components, e.g. smart meters, data concentrators, system applications	VFT
R&I	In R&I scenario, (existing components after the Upgrid deployment), count the number of components, e.g. smart meters, data concentrators, IEDs, FPIs, system applications etc	VFT

KPI SCENARIOS			
Scenarios to be measured	Baseline ☐	Business as usual (BaU) ☒	R&D ☒

KPI DATA COLLECTION							
Data	**Data ID**	**Methodology for data collection**	**Source/Tools/ Instruments for Data collection**	**Location of Data collection**	**Frequency of data collection**	**Minimum monitoring period**	**Data collection responsible**
V_BAU	V_BAU				Once	6 month	VFT
V_R&I	V_R&I				Once	6 month	VFT
GENERAL COMMENTS							

The components are suggested to be weighed as follows: Smart meters: 10% Data concentrators: 10% RTU: 15% Gateways: 5% FPI: 15% Smart transformer: 15% LV network management system: 30%

DEMO POLAND

KPI CALCULATION METHODOLOGY		
KPI Step Methodology ID [KPI ID #]	**Step**	**Responsible**
#1	Analysis of the availability of intelligent network components (analyse "as-is")	ENERGA
#2	Evaluates the increase of the total amount of intelligent network components in BAU scenario.	ENERGA
#3	the total of new network components built for the project UPGRID	ENERGA

KPI SCENARIOS			
Scenarios to be measured	Baseline ☐	Business as usual (BaU) X	R&D X

KPI DATA COLLECTION							
Data	**Data ID**	**Methodology for data collection**	**Source/Tools/ Instruments for Data collection**	**Location of Data collection**	**Frequency of data collection**	**Minimum monitoring period**	**Data collection responsible**
IC_{BAU}	IC_{BAU}	The total amount of intelligent network components in BAU scenario.	Technical documentation of network		Once		ENERGA
$IC_{R\&I}$	$IC_{R\&I}$	Amount of the intelligent components deployed in R&I scenario and/or intelligent components with enhanced functionalities.	Demo system design		Once		ENERGA

GENERAL COMMENTS

A II. 14. SUCCESS INDEX IN METER READING

BASIC KPI INFORMATION			
KPI Name	Success index in meter Reading	**KPI ID**	SIMR
Main Objective	To measure the success index in meter reading		
KPI Description	The success in meter reading is a simple indicator to evaluate the performance of the metering infrastructure and it may be the result of simple (i.e. load profile) and more complex queries to request meter data.		
KPI Formula	$SIMR(\%) = SI_{R\&I} - SI_{BAU}$ $SI(\%) = \frac{C_{Success}}{C_{Total}}$		
Unit of measurement	%		
Connection/Link with other relevant projects KPI	DISCERN and IDE4L		

Project sites to be calculated	Demo Spain	Demo Portugal	Demo Sweden	Demo Poland
	X	X	X	

DEMO SPAIN

KPI CALCULATION METHODOLOGY		
KPI Step Methodology ID [KPI ID #]	**Step**	**Responsible**
SI_{BAU}	The success in meter reading based on the index retrieved directly from the STG before UPGRID	IBERDROLA
$SI_{R\&I}$	The success in meter reading based on the index retrieved directly from the STG after UPGRID	IBERDROLA

KPI SCENARIOS			
Scenarios to be measured	Baseline	Business as usual (BaU)	R&D
		X	X

KPI DATA COLLECTION							
Data	**Data ID**	**Methodology for data collection**	**Source/Tools/ Instruments for Data collection**	**Location of Data collection**	**Frequency of data collection**	**Minimum monitoring period**	**Data collection responsible**
SI_{BAU}	SI_{BAU}	Check indexes shown in the STG	STG	STG data base	Once	One month	IBERDROLA
$SI_{R\&I}$	$SI_{R\&I}$	Check indexes shown in the STG	STG	STG data base	Once	One month	IBERDROLA

GENERAL COMMENTS

Values are calculated directly in the STG. In the Spanish demonstrator no SMs are installed (all Type 5 are already installed) The area selected from the system will be the one as much closer as possible to the demo area.

DEMO PORTUGAL

KPI CALCULATION METHODOLOGY		
KPI Step Methodology ID [KPI ID #]	**Step**	**Responsible**
SI_{BAU}	The success in meter reading based on the index retrieved directly from the STG before UPGRID	EDP
$SI_{R\&I}$	The success in meter reading based on the index retrieved directly from the STG after UPGRID	EDP

KPI SCENARIOS			
Scenarios to be measured	Baseline ☐	Business as usual (BaU) X	R&D X

KPI DATA COLLECTION							
Data	**Data ID**	**Methodology for data collection**	**Source/Tools/ Instruments for Data collection**	**Location of Data collection**	**Frequency of data collection**	**Minimum monitoring period**	**Data collection responsible**
SI_{BAU}	SI_{BAU}			AMI	Daily	Six months	EDP
$SI_{R\&I}$	$SI_{R\&I}$			AMI	daily	Six months	EDP

GENERAL COMMENTS
The Portuguese demo will start the deployment of smart meters during the UPGRID project. For this reason, BAU scenario will correspond to six months the UPGRID project finishes (when some of the smart meters will be already installed) and the R&I will correspond to the end of UPGRID project (when most of the smart meters will be installed).

DEMO SWEDEN

KPI CALCULATION METHODOLOGY		
KPI Step Methodology ID [KPI ID #]	**Step**	**Responsible**
BAU	Calculate the success index in meter reading in BAU scenario (The number of meters that we successfully retrieve measurement data from after X hours divided by the total number of meters).	SE (VFT)
R&I	Calculate the success index in meter reading in R&I scenario (The number of meters that we successfully retrieve measurement data from after X hours divided by the total number of meters).	SE (VFT)

KPI SCENARIOS			
Scenarios to be measured	Baseline ☐	Business as usual (BaU) X	R&D X

KPI DATA COLLECTION							
Data	**Data ID**	**Methodology for data collection**	**Source/Tools/ Instruments for Data collection**	**Location of Data collection**	**Frequency of data collection**	**Minimum monitoring period**	**Data collection responsible**

V_BAU	V_BAU			AMM system	Month	6 months	SE
V_R&I	V_R&I			AMM system	Month	6 months	SE
GENERAL COMMENTS							
There will be no difference in BAU and R&I scenario for the Swedish Demo. The Smart Meters were deployed in Sweden for several years ago and is today managed by the ordinary business, and operated on a daily basis by sub-contractors (VSN and SE) to Vattenfall Distribution. The project will only leverage on the smart meter functionalities. The scope does not include exchanging anything in this technology. Hence, this KPI for the Swedish Demo will use the same principle in calculation as being used by Distribution in following up the performance by the sub-contractors. For example: The process used within Vattenfall, (operated by SE), to calculate this is to compare the number of meters we have retrieved measurement information from with the total number of meters installed. This “KPI” is usually complied for different time periods, e.g. after 12 hours, after 24 hours, after 5 working days, after 30 day from the turn of the months etc. Example: - The total number of meters for one (small) area is 534 pcs - The number of meters that we successfully retrieve measurement data from after 24 hours are 530. - The “KPI” would then be the collection performance after 24h, i.e. 530/534=99,3%							

A II. 15. SUCCESS INDEX IN EVENT READING

BASIC KPI INFORMATION			
KPI Name	Success index in event Reading	**KPI ID**	SIER
Main Objective	To measure the success index in meter events reading		
KPI Description	In the scope of UPGRID project, some demos will gather the grid events information registered by the smart meters in order to use it in the network operation processes. This objective was summarized in the sub-functionality "Queries to request advanced meter data to support operation". For this reason a specific KPI has been defined to analyse if all the meters are sending correctly their registered grid events in BAU and R&I scenario.		
KPI Formula	$SIER(\%) = SI_{R\&I} - SI_{BAU}$ $SI(\%) = \frac{C_{Success}}{C_{Total}}$		
Unit of measurement	%		
Connection/Link with other relevant projects KPI	-		

Project sites to be calculated	Demo Spain	Demo Portugal	Demo Sweden	Demo Poland
	X			X

DEMO SPAIN

KPI CALCULATION METHODOLOGY		
KPI Step Methodology ID [KPI ID #]	**Step**	**Responsible**
C_success_BAU	Number of meter sending correctly their events after a grid issue in BAU scenario.	IBERDROLA
C_total_BAU	Number of meters that the DSO knows that should be sending their events after a grid issue in BAU scenario.	IBERDROLA
C_success_R&I	Number of meter sending correctly their events after a grid issue in R&I scenario.	IBERDROLA
C_total_R&I	Number of meters that the DSO knows that should be sending their events after a grid issue in R&I scenario.	IBERDROLA

KPI SCENARIOS			
Scenarios to be measured	Baseline	Business as usual (BaU)	R&D
		X	X

KPI DATA COLLECTION							
Data	**Data ID**	**Methodology for data collection**	**Source/Tools/ Instruments for Data collection**	**Location of Data collection**	**Frequency of data collection**	**Minimum monitoring period**	**Data collection responsible**
C_success_BAU	C_success_BAU	Count the SMs that have sent events after a power cut.	STG (collecting events from SMs)	STG data base	Once after each grid event	Based on the number of known issues	IBERDROLA

C_total_BAU	C_total_BAU	Number of SMs affected by the power cut (same number of the SMs that should have sent the event).	STG (data base of SMs)	STG data base	Once after each grid event	Based on the number of known issues	IBERDROLA
C_success_R&I	C_success_R&I	Count the SMs that have sent events after a power cut.	STG (collecting events from SMs)	STG data base	Once after each grid event	Based on the number of known issues	IBERDROLA
C_total_R&I	C_total_R&I	Number of SMs affected by the power cut (same number of the SMs that should have sent the event).	STG (data base of SMs)	STG data base	Once after each grid event	Based on the number of known issues	IBERDROLA

GENERAL COMMENTS

BAU scenario corresponds with a moment in time before the UPGRID is deployed. In the same way, R&I scenario corresponds with a moment in time after the UPGRID project new tools, procedures and devices are deployed.

This KPI will be the mean value of the precedent indicator (SI) in BAU and R&I scenarios if more than one grid event that should generate events in the meter occurs during the monitoring period.

The demo only will be focused in one case of study: power cuts.

DEMO POLAND

KPI CALCULATION METHODOLOGY

KPI Step Methodology ID [KPI ID #]	Step	Responsible
C_success_BAU	Number of meter sending correctly their events after a grid issue in BAU scenario.	ENERGA
C_total_BAU	Number of meters that the DSO knows that should be sending their events after a grid issue in BAU scenario.	ENERGA
EC_success_R&I	Number of meter sending correctly their events after a grid issue in R&I scenario.	ENERGA
C_total_R&I	Number of meters that the DSO knows that should be sending their events after a grid issue in R&I scenario.	ENERGA

KPI SCENARIOS

Scenarios to be measured	Baseline	Business as usual (BaU)	R&D
		X	X

KPI DATA COLLECTION

Data	Data ID	Methodology for data collection	Source/Tools/ Instruments for Data collection	Location of Data collection	Frequency of data collection	Minimum monitoring period	Data collection responsible
C_success_BAU	C_success_BAU	Count the SMs that have sent events after a power cut.	AMI	AMI	Once after each grid event	One month	ENERGA

C_total_BAU	C_total _BAU	Number of SMs affected by the power cut (same number of the SMs that should have sent the event).	AMI	AMI	Once after each grid event	One month	ENERGA
C_success_R &I	C_succ ess_R& I	Count the SMs that have sent events after a power cut.	AMI	AMI	Once after each grid event	One month	ENERGA
C_total_R&I	C_total _R&I	Number of SMs affected by the power cut (same number of the SMs that should have sent the event).	AMI	AMI	Once after each grid event	One month	ENERGA

GENERAL COMMENTS

BAU scenario corresponds with a moment in time before the UPGRID is deployed. In the same way, R&I scenario corresponds with a moment in time after the UPGRID project new tools, procedures and devices are deployed.

This KPI will be the mean value of the precedent indicator (SI) in BAU and R&I scenarios if more than one grid event that should generate events in the meter occurs during the monitoring period.

A II. 16. SUCCES INDEX IN ADVANCED FUNCTIONALITIES

BASIC KPI INFORMATION				
KPI Name	Success index in advanced functionalities		**KPI ID**	SIAF
Main Objective	To analyse the success in the communications with grid devices in an advanced metering infrastructure environment.			
KPI Description	This KPI will measure the latency in communications calculating the percentage of successful communications with grid devices in less than the delay objective. Each demo will fix the maximum delay between the stimulation and the response.			
KPI Formula	$SIAF(\%) = \frac{C_{Success}}{C_{Total}}$			
Unit of measurement	%			
Connection/Link with other relevant projects KPI	-			
Project sites to be calculated	Demo Spain X	Demo Portugal ☐	Demo Sweden ☐	Demo Poland ☐

DEMO SPAIN

KPI CALCULATION METHODOLOGY		
KPI Step Methodology ID [KPI ID #]	**Step**	**Responsible**
C_success_R&I	Success communication attempts (lower latency than the target) in R&I scenario.	IBERDROLA
C_total_R&I	Total number of communication attempts in R&I scenario.	IBERDROLA

KPI SCENARIOS			
Scenarios to be measured	Baseline ☐	Business as usual (BaU) X	R&D X

KPI DATA COLLECTION							
Data	**Data ID**	**Methodology for data collection**	**Source/Tools/ Instruments for Data collection**	**Location of Data collection**	**Frequency of data collection**	**Minimum monitoring period**	**Data collection responsible**

C_success_R&I	C_success_R&I	Send a series of orders (different times along the day to cover different status of the network) using a SCADA simulator to a PRIME controllable device (e.g. RTU). Then, the time registers (send and receive) will be compared. Those cases under the decided threshold will be considered successful.	SCADA simulator (WinPCPau)	WinPCPau time registers	aprox. 50 signals for each test with an interval of 5 min. in different period of the day	-aprox. 5 -10	ZIV
C_total_R&I	C_total_R&I	Count of number of orders sent	SCADA simulator (WinPCPau)	WinPCPau time registers	50 signals for each test with an interval of 5 min. in different period of the day)	--aprox. 5 - 10	ZIV

GENERAL COMMENTS
In this case, there is not BAU since this sub-functionality (control equipments over PRIME) does not exist before UPGRID. The R&I scenario corresponds with a moment in time after the UPGRID project new tools, procedures and devices are deployed. The UPGRID sub-functionality linked with this KPI ("Operation (control and multiservice) of LV grid devices using PLC-PRIME for different telecontrol applications") will not be a permanent component or development in the demo, but a concept test. This means that a given number of attempts will be performed to calculate the KPI. The Spanish demo has fixed the latency target in 10 seconds.

A II. 17. SUCCES INDEX IN METER CONNECTIVITY

BASIC KPI INFORMATION				
KPI Name	Success index in meter connectivity		**KPI ID**	SIMC
Main Objective	To measure the improvement combining the DSO ability to know the location of the meter (customer) regarding the associated protection box and the phase and line to which each meter is connected			
KPI Description	In the scope of UPGRID project, some demos will enhance the connection between the LV network management system and the advanced metering infrastructure adding an improving the information about the meters connectivity available for the DSO. In example, this objective was summarized in the sub-functionality "Algorithm to determine connectivity of SM to the grid (identification of phase and line to which each SM is connected to". This KPI will evaluate this improvement combining the DSO ability to know the location of the meter (customer) regarding the associated protection box and the phase and line to which each meter is connected.			
KPI Formula	$SIMC(\%) = \mathrm{C_{PB}} \cdot \Delta\mathrm{SI_{PB}} + \mathrm{C_{PHL}} \cdot \Delta\mathrm{SI_{PHL}}$ $\Delta SI = SI_{R\&I} - SI_{BAU}$ $SI(\%) = \frac{C_{Success}}{C_{Total}}$			
Unit of measurement	%			
Connection/Link with other relevant projects KPI	-			
Project sites to be calculated	Demo Spain X	Demo Portugal ☐	Demo Sweden X	Demo Poland ☐

DEMO SPAIN

KPI CALCULATION METHODOLOGY		
KPI Step Methodology ID [KPI ID #]	**Step**	**Responsible**
C_success_BAU_PB	Number of meter which protection box or phase and line is known in BAU scenario.	IBERDROLA
C_success_R&I_PB	Number of meter which protection box or phase and line is known in R&I scenario.	IBERDROLA
C_success_BAU_PHL	Number of meter which phase and line is known in BAU scenario.	IBERDROLA
C_success_R&I_PHL	Number of meter which phase and line is known in R&I scenario.	IBERDROLA
C_total_BAU	Total number of meters in the scope of the demo in BAU scenario.	IBERDROLA
C_total_R&I	Total number of meters in the scope of the demo in R&I scenario.	IBERDROLA
C_PB	Weight factor for the ability to know the location of the meter regarding the associated protection box.	IBERDROLA
C_R&I	Weight factor for the ability to know the phase and line to which the meter is connected.	IBERDROLA
KPI SCENARIOS		

Scenarios to be measured	Baseline	Business as usual (BaU)	R&D
	[ ]	X	X

KPI DATA COLLECTION							
Data	**Data ID**	**Methodology for data collection**	**Source/Tools/ Instruments for Data collection**	**Location of Data collection**	**Frequency of data collection**	**Minimum monitoring period**	**Data collection responsible**
C_success_BAU_PB	C_success_BAU_PB	Analysis of data before UPGRID using the previous version of the LV management tool	PowerOn and STG	PowerOn and STG data bases	Once	-	IBERDROLA - GE
C_success_R&I_PB	C_success_R&I_PB	Analysis of data after UPGRID using the new version of the LV management tool	PowerOn and STG	PowerOn and STG data bases	Once	-	IBERDROLA - GE
C_success_BAU_PHL	C_success_BAU_PHL	Analysis of data before UPGRID using the previous version of the LV management tool	PowerOn and STG	PowerOn and STG data bases	Once	-	IBERDROLA - GE
C_success_R&I_PHL	C_success_R&I_PHL	Analysis of data after UPGRID using the new version of the LV management tool	PowerOn and STG	PowerOn and STG data bases	Once	-	IBERDROLA - GE
C_total_BAU	C_total_BAU	Count number of supply points that should be represented	PowerOn and STG	PowerOn and STG data bases	Once	-	IBERDROLA - GE
C_total_R&I	C_total_R&I	Count number of supply points that should be represented	PowerOn and STG	PowerOn and STG data bases	Once	-	IBERDROLA - GE
GENERAL COMMENTS							

BAU scenario corresponds with a moment in time before the UPGRID is deployed. In the same way, R&I scenario corresponds with a moment in time after the UPGRID project new tools, procedures and devices are deployed. The Spanish demo has fixed the weight factors in 50% for the connection between the meter and the protection box and in 50% for the phase and line of each meter. The background behind this KPI is the following one. Before the UPGRID project, it is considered that around of 2% of the Secondary Substations and 10% of the protection boxes approximately have not been uploaded in the demo base version of the PowerOn (the LV management system). During UPGRID thanks to the development that will be done in the LV management system, it is expected to upload all of them.

DEMO SWEDEN

KPI CALCULATION METHODOLOGY		
KPI Step Methodology ID [KPI ID #]	**Step**	**Responsible**
C_success_BAU_PB	Number of meter which phase and line is known in BAU scenario.	SE / VFT
C_success_R&I_PB	Number of meter phase and line is known in R&I scenario.	SE / VFT
C_success_BAU_PHL	Number of meter which phase and line is known in BAU scenario.	SE / VFT
C_success_R&I_PHL	Number of meter which phase and line is known in R&I scenario.	SE / VFT
C_total_BAU	Total number of meters in the scope of the demo in BAU scenario.	SE / VFT
C_total_R&I	Total number of meters in the scope of the demo in R&I scenario.	SE / VFT

KPI SCENARIOS			
Scenarios to be measured	Baseline [ ]	Business as usual (BaU) X	R&D X

KPI DATA COLLECTION							
Data	**Data ID**	**Methodology for data collection**	**Source/Tools/ Instruments for Data collection**	**Location of Data collection**	**Frequency of data collection**	**Minimum monitoring period**	**Data collection responsible**
C_success_BAU_PB	C_success_BAU_PB				Once	-	SE / VFT
C_success_R&I_PB	C_success_R&I_PB				Once	-	SE / VFT
C_success_BAU_PHL	C_success_BAU_PHL				Once	-	SE / VFT
C_success_R&I_PHL	C_success_R&I_PHL				Once	-	SE / VFT
C_total_BAU	C_total_BAU				Once	-	SE / VFT
C_total_R&I	C_total_R&I				Once	-	SE / VFT

GENERAL COMMENTS

BAU scenario corresponds with a moment in time before the UPGRID is deployed. In the same way, R&I scenario corresponds with a moment in time after the UPGRID project new tools, procedures and devices are deployed. The Swedish Demo may take part in this KPI, with main support from Upgrid partner Schneider Electric and the use of their LV Monitoring application.

A II. 18. CONSUMERS BEING METERED AUTOMATICALLY

BASIC KPI INFORMATION				
KPI Name	Consumers being metered automatically		**KPI ID**	Quota
Main Objective	To measure the number of consumers which have their metering information remotely gathered by the DSO.			
KPI Description	The number of consumers being metered automatically is a simple indicator to evaluate the evolution of the metering infrastructure together with the success in index meter reading KPI.			
KPI Formula	$Quota(\%) = \left(\frac{SMAR}{SM}\right)_{R\&I} - \left(\frac{SMAR}{SM}\right)_{BAU}$			
Unit of measurement	%			
Connection/Link with other relevant projects KPI	DISCERN			
Project sites to be calculated	Demo Spain X	Demo Portugal X	Demo Sweden X	Demo Poland ☐

DEMO SPAIN

KPI CALCULATION METHODOLOGY		
KPI Step Methodology ID [KPI ID #]	**Step**	**Responsible**
SMAR_BAU	Total number of smart meters installed on field (meters connected to the communication network and able to be remotely accessed and read) in BAU scenario.	IBERDROLA
SM_BAU	Total number of customers in the scope of the demo in BAU scenario	IBERDROLA
SMAR_R&I	Total number of smart meters installed on field (meters connected to the communication network and able to be remotely accessed and read) in R&I scenario.	IBERDROLA
SM_R&I	Total number of customers in the scope of the demo in R&I scenario	IBERDROLA

KPI SCENARIOS			
Scenarios to be measured	Baseline ☐	Business as usual (BaU) X	R&D X

KPI DATA COLLECTION							
Data	**Data ID**	**Methodology for data collection**	**Source/Tools/ Instruments for Data collection**	**Location of Data collection**	**Frequency of data collection**	**Minimum monitoring period**	**Data collection responsible**
SMAR_BAU	SMAR_BAU	Check the STG	STG	STG data base	Once	-	IBERDROLA
SM_BAU	SM_BAU	Check the STG	STG	STG data base	Once	-	IBERDROLA
SMAR_R&I	SMAR_R&I	Check the STG	STG	STG data base	Once	-	IBERDROLA
SM_R&I	SM_R&I	Check the STG	STG	STG data base	Once	-	IBERDROLA
GENERAL COMMENTS							

BAU scenario corresponds with a moment in time before the UPGRID is deployed. In the same way, R&I scenario corresponds with a moment in time after the UPGRID project devices and tools are implemented.

DEMO PORTUGAL

KPI CALCULATION METHODOLOGY		
KPI Step Methodology ID [KPI ID #]	**Step**	**Responsible**
SMAR_BAU	Total number of smart meters installed on field (meters connected to the communication network and able to be remotely accessed and read) in BAU scenario.	EDP
SM_BAU	Total number of customers in the scope of the demo in BAU scenario	EDP
SMAR_R&I	Total number of smart meters installed on field (meters connected to the communication network and able to be remotely accessed and read) in R&I scenario.	EDP
SM_R&I	Total number of customers in the scope of the demo in R&I scenario	EDP

KPI SCENARIOS			
Scenarios to be measured	Baseline [ ]	Business as usual (BaU) [X]	R&D [X]

KPI DATA COLLECTION							
Data	**Data ID**	**Methodology for data collection**	**Source/Tools/ Instruments for Data collection**	**Location of Data collection**	**Frequency of data collection**	**Minimum monitoring period**	**Data collection responsible**
SMAR_BAU	SMAR_ BAU			AMI	Once	-	EDP
SM_BAU	SM_BA U			Commercia l system	Once	-	EDP
SMAR_R&I	SMAR_ R&I			AMI	Once	-	EDP
SM_R&I	SM_R& I			Commercia l System	Once	-	EDP

GENERAL COMMENTS
BAU scenario corresponds with a moment in time before the UPGRID is deployed. In the same way, R&I scenario corresponds with a moment in time after the UPGRID project devices and tools are implemented. No SMs (type 5) will be installed during the Spanish demonstrator. All of them have been deployed before it and effectively integrated into the AMI. Then the KPI will show 100% of customers are been metered automatically in both scenarios.

DEMO SWEDEN

KPI CALCULATION METHODOLOGY		
KPI Step Methodology ID [KPI ID #]	**Step**	**Responsible**
SMAR_BAU	Total number of smart meters installed on field (meters connected to the communication network and able to be remotely accessed and read) in BAU scenario.	VFT
SM_BAU	Total number of customers in the scope of the demo in BAU scenario	VFT

SMAR_R&I	Total number of smart meters installed on field (meters connected to the communication network and able to be remotely accessed and read) in R&I scenario.	VFT
SM_R&I	Total number of customers in the scope of the demo in R&I scenario	VFT

KPI SCENARIOS

Scenarios to be measured	Baseline	Business as usual (BaU)	R&D
	[ ]	[X]	[X]

KPI DATA COLLECTION

Data	**Data ID**	**Methodology for data collection**	**Source/Tools/ Instruments for Data collection**	**Location of Data collection**	**Frequency of data collection**	**Minimum monitoring period**	**Data collection responsible**
SMAR_BAU	SMAR_BAU				Once	6 months	VFT
SM_BAU	SM_BAU				Once	6 months	VFT
SMAR_R&I	SMAR_R&I				Once	6 months	VFT
SM_R&I	SM_R&I				Once	6 months	VFT

GENERAL COMMENTS

BAU scenario corresponds with a moment in time before the UPGRID is deployed. In the same way, R&I scenario corresponds with a moment in time after the UPGRID project devices and tools are implemented.

In the Swedish Demo Site area all customers are equipped with smart meters. The majority (residential customers) has an Echelon AMR3 meters. Larger customers with a fuse >63A has high voltage meters, those being separated from the AMR3 meters and collected by another collection system.

A II. 19. IMPROVED LIFE-TIME OF TRANSFORMERS

BASIC KPI INFORMATION				
KPI Name	Improved life-time of transformers		**KPI ID**	ILTT
Main Objective	Replace overloaded power transformers in SS before the equipment fail creating a high impact on the network operation and the service provided to customers.			
KPI Description	Before the deployment of supervision meters in the SSs, overloaded power transformers were only detected when the equipment fail. This means not only the impact of changing the unit but also the impact that might have on the surrounding infrastructure, on the customers (e.g. power cut) and the corresponding penalties. However, thanks to the leveraging data collected by supervision meters at SS and the processing of it, it is possible that the network management responsible have at its' disposal reports for transformer load. Then it is feasible to identified potential risk of equipment failure before it happen triggering work orders to change them by other of higher capacity. This can be schedule limiting the impact to the customers.			
KPI Formula	$\Delta \mathrm{Tr}_{life}(\%) = \frac{Nchanges_{BAU} - Nchanges_{R\&I}}{N_{transf}}$			
Unit of measurement	%			
Connection/Link with other relevant projects KPI	GRID+			
Project sites to be calculated	Demo Spain X	Demo Portugal 	Demo Sweden 	Demo Poland

DEMO SPAIN

KPI CALCULATION METHODOLOGY		
KPI Step Methodology ID [KPI ID #]	**Step**	**Responsible**
$Nchanges_{BAU}$	Number of power transformers at SS changes before having the reports of transformer load	IBERDROLA
$Nchanges_{R6I}$	Number of power transformers at SS changes after having the reports of transformer load	IBERDROLA
N_{transf}	Total number of power transformers in the demo area	IBERDROLA

KPI SCENARIOS			
Scenarios to be measured	Baseline 	Business as usual (BaU) X	R&D X

KPI DATA COLLECTION							
Data	**Data ID**	**Methodology for data collection**	**Source/Tools/ Instruments for Data collection**	**Location of Data collection**	**Frequency of data collection**	**Minimum monitoring period**	**Data collection responsible**

$Nchanges_{BAU}$	$Nchanges_{BAU}$	Asking field crew about the number of power transformers at SS replace in the demo area before having the transformer load reports	Asking grid crew	Field crew	once	One year	IBERDROLA
$Nchanges_{R6I}$	$Nchanges_{R6I}$	Count the number of work order launched for transformer replacement.	STG	STG data base (reports of transform load)	once	One year	IBERDROLA
N_{transf}	N_{transf}						
GENERAL COMMENTS							

A II. 20. PARTICIPANT RECRUITMENT

BASIC KPI INFORMATION				
KPI Name	Participant Recruitment		**KPI ID**	R
Main Objective	To assess the consumers and producers acceptation to participate in the demos.			
KPI Description	Recruitment is an indication of the fraction of consumers accepting participation in the different demos. UPGRID project is addressing several actions to be implemented in the demo areas which require the participation of consumers and producers. Some of these actions regard demand side management. Other actions are related to the implementation of a web portal for customers awareness. This KPI will be calculated for each UPGRID demo as the sum of the amount of consumers participating in the UPGRID demos (weighted in function of diversification of stakeholders) in relation with the total contacted to be part of them. It will only measure if the user decides to join, another KPI will measure if the user's participation is active or not. This KPI will be only calculated for an UPGRID demo if the demo is addressing sub-functionalities which require consumers or producers participation.			
KPI Formula	$R(\%) = \frac{n_{accept}}{n_{total}}$			
Unit of measurement	%			
Connection/Link with other relevant projects KPI	GRID4EU			
Project sites to be calculated	Demo Spain [X]	Demo Portugal [X]	Demo Sweden [ ]	Demo Poland [X]

DEMO SPAIN

KPI CALCULATION METHODOLOGY		
KPI Step Methodology ID [KPI ID #]	**Step**	**Responsible**
n_accept	Number of users that finally accepted to be part of the demo.	IBERDROLA
n_total	Number of users contacted to be part of the demo.	IBERDROLA

KPI SCENARIOS			
Scenarios to be measured	Baseline [ ]	Business as usual (BaU) [ ]	R&D [X]

KPI DATA COLLECTION							
Data	**Data ID**	**Methodology for data collection**	**Source/Tools/ Instruments for Data collection**	**Location of Data collection**	**Frequency of data collection**	**Minimum monitoring period**	**Data collection responsible**
n_accept	n_accept	Check web portal registers	Web portal	Web portal registers data base	Once	-	EVE

n_total	n_total	Number of users contacted to be part of the demo	Register of people contacted	Web portal registers data base	Once	-	EVE
GENERAL COMMENTS							

DEMO PORTUGAL

KPI CALCULATION METHODOLOGY		
KPI Step Methodology ID [KPI ID #]	**Step**	**Responsible**
n_accept	Number of users that finally accepted to be part of the demo.	EDP
n_total	Number of users contacted to be part of the demo.	EDP

KPI SCENARIOS			
Scenarios to be measured	Baseline ☐	Business as usual (BaU) ☐	R&D X

KPI DATA COLLECTION							
Data	**Data ID**	**Methodology for data collection**	**Source/Tools/ Instruments for Data collection**	**Location of Data collection**	**Frequency of data collection**	**Minimum monitoring period**	**Data collection responsible**
n_accept	n_accept			Commercial system	Once	-	EDP
n_total	n_total			Commercial system	Once	-	EDP
GENERAL COMMENTS							

DEMO POLAND

KPI CALCULATION METHODOLOGY		
KPI Step Methodology ID [KPI ID #]	**Step**	**Responsible**
n_accept	Number of users that finally accepted to be part of the demo.	ENERGA
n_total	Number of users contacted to be part of the demo.	ENERGA

KPI SCENARIOS			
Scenarios to be measured	Baseline ☐	Business as usual (BaU) ☐	R&D X

KPI DATA COLLECTION							
Data	**Data ID**	**Methodology for data collection**	**Source/Tools/ Instruments for Data collection**	**Location of Data collection**	**Frequency of data collection**	**Minimum monitoring period**	**Data collection responsible**
n_accept	n_accept	Invitation send to customers	Sum of invitation send to customers	Web portal registers data base	Once	-	ENERGA

n_total	n_total	Confirmation of the invitation	Sum of confirmation of the invitation	Web portal registers data base	Once	-	ENERGA
GENERAL COMMENTS							

A II. 21. ACTIVE PARTICIPATION

BASIC KPI INFORMATION				
KPI Name	Active Participation		**KPI ID**	A
Main Objective	To evaluate the fraction of consumers actively participating in the demos.			
KPI Description	Active participation is an indication of the fraction of consumers actively taking part in the different demos. UPGRID project is addressing several actions to be implemented in the demo areas which require the participation of users. Some of these actions regard demand side management. Other actions are related to the implementation of a web portal for customer awareness. This KPI will be calculated for each UPGRID demo as the sum of the amount of users actively participating in the UPGRID demos in relation with the total that accepted participating. This KPI will be only calculated for an UPGRID demo if the demo is addressing sub-functionalities which require consumers or producers participation.			
KPI Formula	$A(\%) = \frac{N_A}{N_P}$			
Unit of measurement	%			
Connection/Link with other relevant projects KPI	GRID4EU			
Project sites to be calculated	Demo Spain X	Demo Portugal X	Demo Sweden ☐	Demo Poland X

DEMO SPAIN

KPI CALCULATION METHODOLOGY		
KPI Step Methodology ID [KPI ID #]	**Step**	**Responsible**
N_a	Number of consumers that have had an active participation in the demo.	EVE
N_p	Number of consumers that finally accepted to be part of the demo.	EVE

KPI SCENARIOS			
Scenarios to be measured	Baseline ☐	Business as usual (BaU) ☐	R&D X

KPI DATA COLLECTION							
Data	**Data ID**	**Methodology for data collection**	**Source/Tools/ Instruments for Data collection**	**Location of Data collection**	**Frequency of data collection**	**Minimum monitoring period**	**Data collection responsible**
N_a	N_a	Checking web portal activity	Web page registers	Web page	Once	-	EVE
N_p	N_p	Checking data base of consumers that finally accepted to be part of the demo (web page)	Registers of customers	Register data base	Once	-	EVE

GENERAL COMMENTS
The "active participation" criterion will be: • For the web portal, a user will be active if he visits the web page at least once a week and does not remain more than 3 minutes inactive (without clicking).

DEMO PORTUGAL

KPI CALCULATION METHODOLOGY		
KPI Step Methodology ID [KPI ID #]	**Step**	**Responsible**
N_a	Number of consumers that have had an active participation in the demo.	EDP
N_p	Number of consumers that finally accepted to be part of the demo.	EDP

KPI SCENARIOS			
Scenarios to be measured	Baseline [ ]	Business as usual (BaU) [ ]	R&D [X]

KPI DATA COLLECTION							
Data	**Data ID**	**Methodology for data collection**	**Source/Tools/ Instruments for Data collection**	**Location of Data collection**	**Frequency of data collection**	**Minimum monitoring period**	**Data collection responsible**
N_a	N_a				Once	-	EDP
N_p	N_p				Once	-	EDP

GENERAL COMMENTS
The "active participation" criterion will be: • For the DSM service, a user will be active if he answers to more than a 50 % of the signals sent by the DSO. • For the web portal, a user will be active if he visits the web page at least once a week and does not remain more than 3 minutes inactive (without clicking).

DEMO POLAND

KPI CALCULATION METHODOLOGY		
KPI Step Methodology ID [KPI ID #]	**Step**	**Responsible**
N_a	Number of consumers that have had an active participation in the demo.	ENERGA
N_p	Number of consumers that finally accepted to be part of the demo.	ENERGA

KPI SCENARIOS			
Scenarios to be measured	Baseline [ ]	Business as usual (BaU) [ ]	R&D [X]

KPI DATA COLLECTION							
Data	**Data ID**	**Methodology for data collection**	**Source/Tools/ Instruments for Data collection**	**Location of Data collection**	**Frequency of data collection**	**Minimum monitoring period**	**Data collection responsible**

N_a	N_a	N_a	Checking web portal activity	Web page registers	Web page	Once	ENERGA
N_p	N_p	N_p	Checking data base of consumers that finally accepted to be part of the demo (web page)	Registers of customers	Register data base	Once	ENERGA
GENERAL COMMENTS							
The "active participation" criterion will be: • For the web portal, a user will be active if he visits the web page at least once a month and does not remain more than 3 minutes inactive (without clicking).							

A II. 22. LOAD CURVE VALLEY FILLING

BASIC KPI INFORMATION				
KPI Name	Load Curve Valley filling		**KPI ID**	VF
Main Objective	To evaluate the modification of the Load curve from the consumers according to price/volume signal during valley periods evoke from a technical point of view			
KPI Description	UPGRID project is addressing demand side management actions to be implemented in the demo areas which will impact positively in the valley filling of the aggregated demand of the customers included in the demo area. Valley filling is an indication of the change in kWh used at valley or through time due to price volume signal to increase consumption.			
KPI Formula	$VF(\%) = \frac{\overline{kWh_1} - \overline{kWh_0}}{\overline{kWh_0}}$			
Unit of measurement	%			
Connection/Link with other relevant projects KPI	ADVANCED			
Project sites to be calculated	Demo Spain [ ]	Demo Portugal [X]	Demo Sweden [ ]	Demo Poland [ ]

DEMO PORTUGAL

KPI CALCULATION METHODOLOGY		
KPI Step Methodology ID [KPI ID #]	**Step**	**Responsible**
kWh_0	Average hourly kWh used at valley times in p=0 (per participant) during a six-week period prior to DSM signal.	EDP
kWh_1	Average hourly kWh used at valley times in p=1 (per participant) after each DSM signal.	EDP

KPI SCENARIOS			
Scenarios to be measured	Baseline [ ]	Business as usual (BaU) [ ]	R&D [X]

KPI DATA COLLECTION							
Data	**Data ID**	**Methodology for data collection**	**Source/Tools/ Instruments for Data collection**	**Location of Data collection**	**Frequency of data collection**	**Minimum monitoring period**	**Data collection responsible**
kWh_0	kWh_0		Smart Meters	AMI	Hourly	Six month	EDP
kWh_1	kWh_1		Smart Meters	AMI	Hourly	During the time stamp of each DSM signal	EDP

GENERAL COMMENTS

kWh_0 and kWh_1 refer to the same hour, same participant, same week-day and are enclosed in a 6-week period. This KPI will be calculated for each DSM signal carried out. The final value of the KPI will be the average value considering only the answered signals. Valley hours are from 00:00 to 11:00 and from 21:00 to 00:00.

A II. 23. USE OF EQUIPMENT STANDARDS

BASIC KPI INFORMATION				
KPI Name	Use of equipment standards		**KPI ID**	UES
Main Objective	To evaluate the use of equipment standards in the different demos regarding to the declared use initially.			
KPI Description	Specifically, the equipment standards were divided into the standards already being used in the demo and the standards to be developed or extended under UPGRID project. Tables 7, 11, 14 and 19 of UPGRID deliverable D1.3 contain all this information for the Spanish, Portuguese, Swedish and Polish demos respectively. This KPI will be calculated for all UPGRID demos as all of them are considering the implementation of standards.			
KPI Formula	$UES(\%) = \frac{ESEU}{ESDU}$			
Unit of measurement	%			
Connection/Link with other relevant projects KPI	GRID4EU			
Project sites to be calculated	Demo Spain X	Demo Portugal X	Demo Sweden X	Demo Poland X

DEMO SPAIN

KPI CALCULATION METHODOLOGY		
KPI Step Methodology ID [KPI ID #]	**Step**	**Responsible**
ESEU	Equipment standards effectively used according to the count criterion.	IBERDROLA
ESDU	Equipment standards declared to be used in D1.3 of UPGRID project.	IBERDROLA

KPI SCENARIOS			
Scenarios to be measured	Baseline ☐	Business as usual (BaU) ☐	R&D X

KPI DATA COLLECTION							
Data	**Data ID**	**Methodology for data collection**	**Source/Tools/ Instruments for Data collection**	**Location of Data collection**	**Frequency of data collection**	**Minimum monitoring period**	**Data collection responsible**
ESEU	ESEU	Review the demo equipment finally used in the demo and evaluate if they have been modified or not and count each case.	Demo inventory of equipment	Demo inventory of equipment	Once	-	IBERDROLA

ESDU	ESDU	Review what was said in D1.3 regarding equipment.	D1.3	D1.3	Once	-	IBERDROLA
GENERAL COMMENTS							
The count criterion for the equipment standards will be: • **ESEU = 0**: if there is no change between the status of the equipment standard before and after the UPGRID project. • **ESEU = 0,5**: if the equipment standard application has been extended during the UPGRID project. • **ESEU = 1**: if the equipment standard has been implemented during the UPGRID project.							

DEMO PORTUGAL

KPI CALCULATION METHODOLOGY		
KPI Step Methodology ID [KPI ID #]	**Step**	**Responsible**
ESEU	Equipment standards effectively used according to the count criterion.	EDP
ESDU	Equipment standards declared to be used in D1.3 of UPGRID project.	EDP

KPI SCENARIOS			
Scenarios to be measured	Baseline ☐	Business as usual (BaU) ☐	R&D X

KPI DATA COLLECTION							
Data	**Data ID**	**Methodology for data collection**	**Source/Tools/ Instruments for Data collection**	**Location of Data collection**	**Frequency of data collection**	**Minimum monitoring period**	**Data collection responsible**
ESEU	ESEU		Smart Meters	AMI	Once	-	EDP
ESDU	ESDU		Smart Meters	AMI	Once	-	EDP
GENERAL COMMENTS							
The count criterion for the equipment standards will be: • **ESEU = 0**: if there is no change between the status of the equipment standard before and after the UPGRID project. • **ESEU = 0,5**: if the equipment standard application has been extended during the UPGRID project. • **ESEU = 1**: if the equipment standard has been implemented during the UPGRID project.							

DEMO SWEDEN

KPI CALCULATION METHODOLOGY		
KPI Step Methodology ID [KPI ID #]	**Step**	**Responsible**
ESEU	Equipment standards effectively used according to the count criterion.	VFT
ESDU	Equipment standards declared to be used in D1.3 of UPGRID project.	VFT

KPI SCENARIOS			
Scenarios to be measured	Baseline ☐	Business as usual (BaU) ☐	R&D X

KPI DATA COLLECTION							
Data	**Data ID**	**Methodology for data collection**	**Source/Tools/ Instruments for Data collection**	**Location of Data collection**	**Frequency of data collection**	**Minimum monitoring period**	**Data collection responsible**

ESEU	ESEU				Once	-	VFT
ESDU	ESDU				Once	-	VFT

GENERAL COMMENTS

The count criterion for the equipment standards will be:

- **ESEU = 0**: if there is no change between the status of the equipment standard before and after the UPGRID project.
- **ESEU = 0,5**: if the equipment standard application has been extended during the UPGRID project.
- **ESEU = 1**: if the equipment standard has been implemented during the UPGRID project.

DEMO POLAND

KPI CALCULATION METHODOLOGY

KPI Step Methodology ID [KPI ID #]	Step	Responsible
ESEU	Equipment standards effectively used according to the count criterion.	ENERGA
ESDU	Equipment standards declared to be used in D1.3 of UPGRID project.	ENERGA

KPI SCENARIOS

Scenarios to be measured	Baseline	Business as usual (BaU)	R&D
	☐	☐	X

KPI DATA COLLECTION

Data	Data ID	Methodology for data collection	Source/Tools/ Instruments for Data collection	Location of Data collection	Frequency of data collection	Minimum monitoring period	Data collection responsible
ESEU	ESEU	Review the demo equipment finally used in the demo and evaluate if they have been modified or not and count each case.	Demo inventory of equipment	Demo inventory of equipment	Once	-	IBERDROLA
ESDU	ESDU	Review what was said in D1.3 regarding equipment.	D1.3	D1.3	Once	-	IBERDROLA

GENERAL COMMENTS

The count criterion for the equipment standards will be:

- **ESEU = 0**: if there is no change between the status of the equipment standard before and after the UPGRID project.
- **ESEU = 0,5**: if the equipment standard application has been extended during the UPGRID project.
- **ESEU = 1**: if the equipment standard has been implemented during the UPGRID project.

A II. 24. USE OF PROTOCOL STANDARDS

BASIC KPI INFORMATION				
KPI Name	Use of protocol standards		**KPI ID**	UPS
Main Objective	To evaluate the use of protocol standards in the different demos regarding to the declared use initially.			
KPI Description	Specifically, the protocol standards were divided into the standards already being used in the demo and the standards to be developed or extended under UPGRID project. Tables 6, 10, 13 and 18 of UPGRID deliverable D1.3 contain all this information for the Spanish, Portuguese, Swedish and Polish demos respectively. This KPI will be calculated for all UPGRID demos as all of them are considering the implementation of standards.			
KPI Formula	$UPS(\%) = \frac{PSEU}{PSDU}$			
Unit of measurement	%			
Connection/Link with other relevant projects KPI	GRID4EU			
Project sites to be calculated	Demo Spain X	Demo Portugal X	Demo Sweden X	Demo Poland X

DEMO SPAIN

KPI CALCULATION METHODOLOGY		
KPI Step Methodology ID [KPI ID #]	**Step**	**Responsible**
ESEU	Protocol standards effectively used according to the count criterion.	IBERDROLA
ESDU	Protocol standards declared to be used in D1.3 of UPGRID project.	IBERDROLA

KPI SCENARIOS			
Scenarios to be measured	Baseline ☐	Business as usual (BaU) ☐	R&D X

KPI DATA COLLECTION							
Data	**Data ID**	**Methodology for data collection**	**Source/Tools/ Instruments for Data collection**	**Location of Data collection**	**Frequency of data collection**	**Minimum monitoring period**	**Data collection responsible**
ESEU	ESEU				Once	-	IBERDROLA
ESDU	ESDU				Once	-	IBERDROLA

GENERAL COMMENTS

The count criterion for the protocol standards will be:

- **ESEU = 0**: if there is no change between the status of the protocol standard before and after the UPGRID project.
- **ESEU = 0,5**: if the protocol standard application has been extended during the UPGRID project.
- **ESEU = 1**: if the protocol standard has been implemented during the UPGRID project.

DEMO PORTUGAL

KPI CALCULATION METHODOLOGY		
KPI Step Methodology ID [KPI ID #]	**Step**	**Responsible**
ESEU	Protocol standards effectively used according to the count criterion.	EDP
ESDU	Protocol standards declared to be used in D1.3 of UPGRID project.	EDP

KPI SCENARIOS			
Scenarios to be measured	Baseline ☐	Business as usual (BaU) ☐	R&D ☒

KPI DATA COLLECTION							
Data	**Data ID**	**Methodology for data collection**	**Source/Tools/ Instruments for Data collection**	**Location of Data collection**	**Frequency of data collection**	**Minimum monitoring period**	**Data collection responsible**
ESEU	ESEU		Smart Meters	AMI	Once	-	EDP
ESDU	ESDU		Smart Meters	AMI	Once	-	EDP

GENERAL COMMENTS

The count criterion for the protocol standards will be:

- **ESEU = 0**: if there is no change between the status of the protocol standard before and after the UPGRID project.
- **ESEU = 0,5**: if the protocol standard application has been extended during the UPGRID project.
- **ESEU = 1**: if the protocol standard has been implemented during the UPGRID project.

DEMO SWEDEN

KPI CALCULATION METHODOLOGY		
KPI Step Methodology ID [KPI ID #]	**Step**	**Responsible**
ESEU	Protocol standards effectively used according to the count criterion.	VFT
ESDU	Protocol standards declared to be used in D1.3 of UPGRID project.	VFT

KPI SCENARIOS			
Scenarios to be measured	Baseline ☐	Business as usual (BaU) ☐	R&D ☒

KPI DATA COLLECTION							
Data	**Data ID**	**Methodology for data collection**	**Source/Tools/ Instruments for Data collection**	**Location of Data collection**	**Frequency of data collection**	**Minimum monitoring period**	**Data collection responsible**
ESEU	ESEU				Once	-	VFT
ESDU	ESDU				Once	-	VFT

GENERAL COMMENTS

The count criterion for the protocol standards will be:

- **ESEU = 0**: if there is no change between the status of the protocol standard before and after the UPGRID project.
- **ESEU = 0,5**: if the protocol standard application has been extended during the UPGRID project.
- **ESEU = 1**: if the protocol standard has been implemented during the UPGRID project.

DEMO POLAND

KPI CALCULATION METHODOLOGY		
KPI Step Methodology ID [KPI ID #]	**Step**	**Responsible**
ESEU	Protocol standards effectively used according to the count criterion.	ENERGA
ESDU	Protocol standards declared to be used in D1.3 of UPGRID project.	ENERGA

KPI SCENARIOS			
Scenarios to be measured	Baseline ☐	Business as usual (BaU) ☐	R&D X

KPI DATA COLLECTION							
Data	**Data ID**	**Methodology for data collection**	**Source/Tools/ Instruments for Data collection**	**Location of Data collection**	**Frequency of data collection**	**Minimum monitoring period**	**Data collection responsible**
ESEU	ESEU	Review the demo protocols finally used in the demo and evaluate if they have been modified or not and count each case.	Demo specifications	Demo specificatio ns	Once	-	IBERDROLA
ESDU	ESDU	Review what was said in D1.3 regarding protocols.	D1.3	D1.3	Once	-	IBERDROLA

GENERAL COMMENTS

A II. 25. REDUCTION IN GREENHOUSE GAS EMISSIONS

BASIC KPI INFORMATION				
KPI Name	Reduction in greenhouse gas emissions		**KPI ID**	GHG
Main Objective	To calculate the reduction of GHG emissions due to the developments implemented in the four demos respect to the original scenarios.			
KPI Description	The reduction in greenhouse gas emissions is an indication of the difference between total amounts of CO2 emissions calculated respectively for BAU and R&I scenarios taking into account conventional generators, network automation, energy storage, import/export of electricity, need of additional power plants, modifications of the network and changes in the energy supply mix.			
KPI Formula	$$GHG(\%) = \frac{(CO_2)_{BAU} - (CO_2)_{R\&I}}{(CO_2)_{BAU}}$$			
Unit of measurement	%			
Connection/Link with other relevant projects KPI	IGREENGRID			
Project sites to be calculated	Demo Spain [X]	Demo Portugal [X]	Demo Sweden [ ]	Demo Poland [ ]

DEMO SPAIN

KPI CALCULATION METHODOLOGY		
KPI Step Methodology ID [KPI ID #]	**Step**	**Responsible**
E (%)	Result from the reduction of technical losses (one on the previous KPIs)	IBERDROLA
$CO_{2\ emi\ coef}$	Equivalent coefficient of CO_2 emissions (ton CO_2 / kWh)	IBERDROLA

KPI SCENARIOS			
Scenarios to be measured	Baseline [ ]	Business as usual (BaU) [X]	R&D [X]

KPI DATA COLLECTION							
Data	**Data ID**	**Methodology for data collection**	**Source/Tools/ Instruments for Data collection**	**Location of Data collection**	**Frequency of data collection**	**Minimum monitoring period**	**Data collection responsible**
E (%)	E (%)	Calculation of the KPI about reduction of losses	KPI calculation	D8.1	once	-	IBERDROLA
$CO_{2\ emi\ coef}$	$CO_{2\ emi\ coef}$	Public values	Public values	Public values	once	-	IBERDROLA - ITE

GENERAL COMMENTS
Related to the reduction I^2R losses in the power transformer after decreasing the load lever on certain power transformers in SS

DEMO PORTUGAL

KPI CALCULATION METHODOLOGY		
KPI Step Methodology ID [KPI ID #]	**Step**	**Responsible**
E	Result from demand shifting	EDP
$C0_{2\ emi\ coef}$	Equivalent coefficient of CO_2 emissions (ton CO_2 / kWh)	EDP

KPI SCENARIOS			
Scenarios to be measured	Baseline ☐	Business as usual (BaU) X	R&D X

KPI DATA COLLECTION							
Data	**Data ID**	**Methodology for data collection**	**Source/Tools/ Instruments for Data collection**	**Location of Data collection**	**Frequency of data collection**	**Minimum monitoring period**	**Data collection responsible**
E	E	Calculation demand shifting	KPI calculation		once	-	EDP
$C0_{2\ emi\ coef}$	$C0_{2\ emi\ coef}$	Public values	Public values	Public values	once	-	EDP - ITE

GENERAL COMMENTS

Annex III. UPGRID SUB-FUNCTIONALITIES VS DETAILED KPIS

This annex includes the link between the UPGRID sub-functionalities defined in D1.1 – *Report on Technical Specifications* and the UPGRID detailed KPIs organised by EEGI functional objectives. These matrixes were checked with the UPGRID demo leaders and have been the basis to decide which detailed KPIs were selected to calculate each high level KPI.

A III. 1. INTEGRATION OF SMART CUSTOMERS

Function Objectives / UPGRID Sub-functionalities		UPGRID KPIs																								
		U_1	**U_2**	**U_3**	**U_4**	**U_5**	**U_6**	**U_7**	**U_8**	**U_9**	**U_10**	**U_11**	**U_12**	**U_13**	**U_14**	**U_15**	**U_16**	**U_17**	**U_18**	**U_19**	**U_20**	**U_21**	**U_22**	**U_23**	**U_24**	**U_25**
D1	**Active Demand for increased network flexibility**	**1**											**1**	**1**							**1**	**1**	**1**			**1**
	LV customer consumption characterisation												1	1												
	Home Energy management system to provide data to dynamic pricing simulator	1																			1	1				1
	End user engagement to improve distribution network operation	1																			1	1	1			1
D2	**Enabling maximum energy efficiency in new or refurbished urban using smart distribution grids**																									

A III. 2. Integration of DER and new uses

Function Objectives / UPGRID Sub-functionalities		UPGRID KPIs																								
		U_1	**U_2**	**U_3**	**U_4**	**U_5**	**U_6**	**U_7**	**U_8**	**U_9**	**U_10**	**U_11**	**U_12**	**U_13**	**U_14**	**U_15**	**U_16**	**U_17**	**U_18**	**U_19**	**U_20**	**U_21**	**U_22**	**U_23**	**U_24**	**U_25**
D3	**Integration of DER at low voltage**		**1**		**1**					**1**																**1**
	Remote management of DER		1		1					1																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**			**1**							**1**		**1**	**1**												
	Consumption characterisation of Electrical Vehicle (EV) charging points (street stations)			1							1		1	1												

A III. 3. NETWORKS OPERATIONS

Function Objectives / UPGRID Sub-functionalities		UPGRID KPIs																								
		U_1	U_2	U_3	U_4	U_5	U_6	U_7	U_8	U_9	U_10	U_11	U_12	U_13	U_14	U_15	U_16	U_17	U_18	U_19	U_20	U_21	U_22	U_23	U_24	U_25
D7	**Monitoring and control of LV network**				**1**	**1**			**1**	**1**	**1**	**1**		**1**		**1**	**1**		**1**					**1**	**1**	
	Operation (control and multiservice) of LV grid devices using PLC-PRIME for different telecontrol applications (Concept test)													1		1	1							1	1	
	Queries to request advanced meter data to support operation					1			1							1	1		1							
	Improvement the LV Network Management System visualisation by integrating data measurements from inside SS (e.g. transformer meter, advanced LV supervision)										1	1														
	Improvement the LV Network Management System visualisation by integrating data measurements from LV network devices (e.g. customers SM, EV charging points, DER)										1	1							1							
	Integration of the MV power transformer status from the MV systems to the LV Network Management System				1						1	1														
	Integration of measurement data to support state estimation in LV Network Management System										1		1													
	Integration of measurement data to support power flow analyses in LV Network Management System										1		1													
	Integration of LV power flow and MV power flow analyses				1				1	1																
	LV regulation at SS level using a new smart transformer				1				1					1												

	LV meshed / double feed network operation - Remote reconfiguration (no fully automatic) of the LV network (grid protection)				1				1	1																
	LV meshed / double feed network operation - identifying the optimum topological configuration				1				1	1																
	Interoperability test of the integration of LV Network Management System with equipment from different manufactures																							1	1	
D8	**Automation and control of MV network**						**1**		**1**		**1**			**1**												
	Monitoring MV network by fault detectors						1		1		1			1												
D9	**Network management methodologies for network operation**					**1**		**1**			**1**		**1**											**1**	**1**	
	Define a sound LV network (schematic diagrams and parameters of components)												1													
	Use CIM for LV network modelling and data exchange between e.g. AMI, GIS, MV SCADA, LV Network Management System																							1	1	
	Interface to manage PRIME subnetwork with Simple Network Management Protocol (SNMP)										1													1	1	
	Implementation of Network Management System (NMS) based on Simple Network Management Protocol (SNMP) at SS level										1													1	1	
	Visualisation of data from LV Management Network System in a geographical context											1														
	Internal DSO business processes review in relation with Outage Management					1		1																		
	Load and distributed generation forecasting																									
D10	**Smart metering data utilisation**					**1**			**1**		**1**	**1**	**1**			**1**		**1**								
	Integration and processing of meter events or/and other sources (e.g. telecom data) in the Outage Management System (OMS)					1			1		1	1	1			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)												1	1												
	Algorithm to determine connectivity of SM to the grid (identification of phase and line to which each SM is connected to)										1	1			1			1								
	Calculation of non-technical losses using data from metering devices both in SS and LV network										1															

A III. 4. NETWORK PLANNING AND ASSET MANAGEMENT

Function Objectives / UPGRID Sub-functionalities		UPGRID KPIs																								
		U_1	U_2	U_3	U_4	U_5	U_6	U_7	U_8	U_9	U_10	U_11	U_12	U_13	U_14	U_15	U_16	U_17	U_18	U_19	U_20	U_21	U_22	U_23	U_24	U_25
D11	**New Planning approaches for distribution network**												**1**							**1**						
	Data analytic based on historical network state data to assist network planning												1							1						
D12	**Novel approaches to asset management**					**1**			**1**	**1**		**1**	**1**	**1**						**1**						**1**
	Data analytic based on historical network state data to assist maintenance									1			1							1						1
	Transformer replacement optimisation based on historical data from meters inside SS												1													
	Life Cycle Cost (LCC) calculations of best technical / financial solution with new equipment (e.g. IED)																									
	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					1			1			1	1	1												

A III. 5. MARKET DESIGN

Function Objectives / UPGRID Sub-functionalities		UPGRID KPIs																								
		U_1	**U_2**	**U_3**	**U_4**	**U_5**	**U_6**	**U_7**	**U_8**	**U_9**	**U_10**	**U_11**	**U_12**	**U_13**	**U_14**	**U_15**	**U_16**	**U_17**	**U_18**	**U_19**	**U_20**	**U_21**	**U_22**	**U_23**	**U_24**	**U_25**
D13	**New approaches for market design**	**1**							**1**			**1**	**1**								**1**	**1**		**1**	**1**	**1**
	Web portal for increasing the consumer awareness in order to leverage their participation in electricity markets											1	1								1	1				
	Create market hub for relationship between DSO and Suppliers	1							1																	
	Dynamic / Real time pricing based on DSO services and infrastructure (DSM) (simulator)	1											1											1	1	1
	Dynamic contractual power control	1																								

Annex IV. MOST RELEVANT STANDARDS IN UPGRID DEMOS

This annex includes the classification of the most relevant protocols and equipment standards in the UPGRID demos. These tables have been directly borrowed from D1.3 – *Report on standards and potential synergies.* They will be used to calculate two detailed KPIs U_25 – *Use of equipment standards* (section 5.23) and U_26 – *Use of protocol standards* (section 5.24).

A IV. 1. DEMO SPAIN

TABLE 19: CLASSIFICATION OF THE MOST RELEVANT PROTOCOLS IN THE SPANISH DEMONSTRATOR.

SOURCE: [19].

DEMO BASE

Used standard protocols
DLMS COSEM ▸ Transport layer for SMs provided data 4-32/PRIME ▸ Transport layer for line monitoring units CTI hdlc/rs485 ▸ Data model for SMs: T5 Spanish Companion Specification ▸ Data model for line monitoring units CTI: CTI Companion Specification
PRIME 1.3.6 ▸ 4-32 convergence sub-layer ▸ SMs profile
ICCP / TASE2 (IEC 60870-6-503)
IEC 60870-5-104
CIM (IEC 61968, IEC 61970, IEC 62325)

DEMO DEVELOPED UNDER UPGRID

Proposed standard protocols to be used
PRIME 1.3.6 ▸ IP convergence sublayer
SNMPv3 for MIB collection
ICCP / TASE2 (IEC 60870-6-503)
IEC 60870-5-104

Used proprietary protocols
STG-DC 3.2 for SMs management

Development of new protocols / Development of extensions to a standard protocol / protocol profiles to be developed (and Possible standardization process)
DLMS COSEM Data model for line monitoring units CTI: CTI Companion
Extend STG 3.2 to include Line Supervision
Particular profile of CIM

TABLE 20: CLASSIFICATION OF THE MOST RELEVANT EQUIPMENT IN THE SPANISH DEMONSTRATOR.

SOURCE: [19].

DEMO BASE

Used standardised equipment
PRIME SM
Line Monitoring Units
Data concentrators
Used non-standardised equipment
N/A

DEMO DEVELOPED UNDER UPGRID

Proposed standardised equipment to be used
N/A
Development of new equipment (and possible standardization process)
PRIME Base node that supports both application, IP and SMs
PRIME service node for IP communications
SW system for PRIME Base Nodes MIB's query

A IV. 2. DEMO PORTUGAL

TABLE 21: CLASSIFICATION OF THE MOST RELEVANT PROTOCOLS IN THE PORTUGUESE DEMONSTRATOR.

SOURCE: [19].

DEMO BASE

Used standard protocols
IEC60870-5-104 ▸ Light Protocol Implementation Document (LPID) for IEC 60870-5-104 defined by EDP Distribuição
PRIME ▸ Version 1.3.6 established by PRIME Alliance ▸ PRIME MAC & PHY layers (PLC) ▸ PRIME 4-32 convergence sub-layer
DLMS/COSEM ▸ DLMS UA 1000-1: Blue book, COSEM Identification System and Interface Classes, 12th Edition ▸ DLMS UA 1000-2: Green book, DLMS/COSEM Architecture and Protocols, 8th Edition ▸ IEC 62056-42: Electricity metering – Data exchange for meter reading, tariff and load control - Part 42: Physical ▸ IEC 62056-46: Electricity metering – Data exchange for meter reading, tariff and load control – Part 46: HDLC ▸ IEC 62056-47: Electricity metering – Data exchange for meter reading, tariff and load control – Part 47: COSEM transport layer for IP networks (Wrapper for GPRS SMs)

DEMO DEVELOPED UNDER UPGRID

Proposed standard protocols to be used
IEC60870-5-104 ▸ Light Protocol Implementation Document (LPID) for IEC 60870-5-104 defined by EDP Distribuição
PRIME ▸ Version 1.3.6 established by PRIME Alliance ▸ PRIME MAC & PHY layers (PLC) ▸ PRIME 4-32 convergence sub-layer
DLMS/COSEM ▸ DLMS UA 1000-1: Blue book, COSEM Identification System and Interface Classes, 12th Edition ▸ DLMS UA 1000-2: Green book, DLMS/COSEM Architecture and Protocols, 8th Edition ▸ IEC 62056-42: Electricity metering – Data exchange for meter reading, tariff and load control - Part 42: Physical ▸ IEC 62056-46: Electricity metering – Data exchange for meter reading, tariff and load control – Part 46: HDLC ▸ IEC 62056-47: Electricity metering – Data exchange for meter reading, tariff and load control – Part 47: COSEM transport layer for IP networks (Wrapper for GPRS SMs)

▸ IEC 62056-53: Electricity metering – Data exchange for meter reading, tariff and load control – Part 53: COSEM application layer ▸ IEC 62056-62: Electricity metering – Data exchange for meter reading, tariff and load control – Part 61: Object identification system (OBIS) ▸ EDP Box data model – EDP companion for DLMS/COSEM
Web services SOAP (STG-DC 3.1.c) ▸ Central System – DTC interface based on DC INTERFACE SPECIFICATION , v3.1.c, authored by Iberdrola but currently under the responsibility of the Prime Alliance ▸ EDP profile with specific Orders (Bnn) and Reports (Snn) - WS_STG.DTC_perfil.EDP_v5.13
FTP (RFC959)
MODBUS over serial line ▸ MODBUS APPLICATION PROTOCOL SPECIFICATION, V1.1b for HAN interface of the EDP Box
Used proprietary protocols
HAN interface ▸ Data model and communication protocol for the HAN interface of the EDP Box

▸ IEC 62056-53: Electricity metering – Data exchange for meter reading, tariff and load control – Part 53: COSEM application layer ▸ IEC 62056-62: Electricity metering – Data exchange for meter reading, tariff and load control – Part 61: Object identification system (OBIS) ▸ EDP Box data model – EDP companion for DLMS/COSEM
Web services SOAP (STG-DC 3.1.c) ▸ Central System – DTC interface based on DC INTERFACE SPECIFICATION , v3.1.c, authored by Iberdrola but currently under the responsibility of the Prime Alliance ▸ EDP profile with specific Orders (Bnn) and Reports (Snn) - WS_STG.DTC_perfil.EDP_v5.13
FTP (RFC959)
MODBUS over serial line ▸ MODBUS APPLICATION PROTOCOL SPECIFICATION, V1.1b for HAN interface of the EDP Box
Development of new protocols / Development of extensions to a standard protocol / protocol profiles to be developed (and Possible standardization process)
N/A

TABLE 22: CLASSIFICATION OF THE MOST RELEVANT EQUIPMENT IN THE PORTUGUESE DEMONSTRATOR. SOURCE: [19].

DEMO BASE

Used standardised equipment
PRIME SM – EDP Box
DTC – Distribution Transformer Controller
Router
Used non-standardised equipment
N/A

DEMO DEVELOPED UNDER UPGRID

Proposed standardised equipment to be used
PRIME SM – EDP Box
DTC – Distribution Transformer Controller
Router
Development of new equipment (and possible standardization process)
HEMS (Gateway and Homeplug)

A IV. 3. DEMO SWEDEN

TABLE 23: CLASSIFICATION OF THE MOST RELEVANT PROTOCOLS IN THE SWEDISH DEMONSTRATOR.

SOURCE: [19].

DEMO BASE

Used standard protocols
OSGP ETSI GS OSG 001 - Open Smart Grid Protocol for both measurements and events between SM<->DC<->AMI Head End system
GS2* - Message based protocol for measurement values (meter stands and hourly values) between AMI Head End and Vattenfall (MDMS) *GS2 stands for "GränsSnitt2" or "Interface2", which is an object oriented data model, similar to XML, for handling metering and settlement information. The model was developed in Norway by SINTEF Energy Research during the 90's at the time for the de-regulation process in Sweden. Used today in Norway and Sweden.
XML - Message based protocol for events from SM from AMI Head End system and Vattenfall PER-system (PerformanceEventReport system)
PLC - Power Line Communication, using both A and C band, and different frequencies. Communication carrier between the SM and DC. A-band is for communication between SM and DC and C-band for communication between SM and in-home devices. In UPGRID project, just A-band will be used.
GPRS/3G - Communication between the field installed IED, e.g. DC, and telecommunication service provider hardware environment

DEMO DEVELOPED UNDER UPGRID

Proposed standard protocols to be used
OSGP
GS2
XML
PLC
GPRS/3G/CDMA

Used proprietary protocols
N/A

IEC-60870-5-104 - Communication between FPI and SCADA-DMS and/or fault analysis tool in MV substation
IEC-60870-5-104 - Communication between secondary substation (10-20/0.4 kV) and SCADA-DMS
DNP3 (IEEE Std. 1815) - Distributed Network Protocol might be used by one RTU manufacturer, while -104 implementation is finalized
ZigBee (IEEE 802.15.4) - Communication between wireless current sensor and RTU
CIM - Common Information Model for data exchange between Network Information System and LV SCADA
FTP (RFC959) over GPRS
Development of new protocols / Development of extensions to a standard protocol / protocol profiles to be developed (and Possible standardization process)
N/A

TABLE 24: CLASSIFICATION OF THE MOST RELEVANT EQUIPMENT IN THE SWEDISH DEMONSTRATOR.

SOURCE: [19].

DEMO BASE

Used standardised equipment
Echelon SMs (SM)
Echelon Data Concentrators (DC), (with built in GPRS communication modem or with Ethernet connection for an external modem/router)
Used non-standardised equipment
N/A

DEMO DEVELOPED UNDER UPGRID

Proposed standardised equipment to be used
SMs
Meter Data Concentrators, (with built in GPRS communication modem or with Ethernet connection for external modem/router)
Schneider Electric Smart Transformer
RTU devices (or equivalent IED) for MV and LV measurement in secondary substations (10-20/0.4 kV)
FPI - Fault passage Indicators for fault detection and localisation on MV network
Modem/router for GPRS/2G/3G or other secured communication
Re-closer/breaker for remote network operation/automation[11]
CT - Current Transformers in secondary substation. (Others, which may be tested are Rogowski Current Transformers, micro snap-on CT)
CT - Current Transformers for MV network FPIs
Development of new equipment (and possible standardization process)
N/A

[11] A re-closer/breaker is under discussions within the project to be included or not. This decision is partly dependent on IT security issues and the system set-up for the project

A IV. 4. DEMO POLAND

TABLE 25: CLASSIFICATION OF THE MOST RELEVANT PROTOCOLS IN THE POLISH DEMONSTRATOR

SOURCE: [19].

DEMO BASE

Used standard protocols
PRIME Specification revision 1.3.6. PRIME Alliance
DLMS/COSEM Architecture and Protocols. Green book – 8th edition. Technical report. DLMS User Association, 2014 COSEM Identification System and Interface Classes. Blue Book – 12th edition. Technical report. DLMS User Association, 2014.
STG-DC 3.1
Used proprietary protocols
DC-SAP (Data Concentrator - Simple Acquisition Protocol)

DEMO DEVELOPED UNDER UPGRID

Proposed standard protocols to be used
IEC 60870-5-104 Std.: Telecontrol equipment and systems – Part 5-104: Transmission protocols – Network access for IEC 60870-5-101 using standard transport profiles. Second edition, 2006
IEEE 1815 Std.: IEEE Standard for Electric Power Systems Communications—Distributed Network Protocol (DNP3). Revised edition, 2012
IEC 61970 Std.: Energy Management System Application Program Interfaces EMS-API
IEC 61968 Std.: Application Integrational Electric Utilities - System Interfaces for Distribution Management
IEC 61968-100 Std.: Application integration at electric utilities - System interfaces for distribution management - Part 100: Implementation profiles
IEC 62325-301 Std.: Framework for Energy Market Communication
Development of new protocols / Development of extensions to a standard protocol / protocol profiles to be developed (and Possible standardization process)
DLMS/COSEM Extensions for PRIME PLC LV monitoring and control unit

TABLE 26: CLASSIFICATION OF THE MOST RELEVANT EQUIPMENT IN THE POLISH DEMONSTRATOR.

SOURCE: [19].

DEMO BASE

Used standardised equipment
PRIME SMs
PRIME Data concentrators
Wireless GSM GPRS/EDGE/UMTS, CDMA modems/routers/switches for MV/LV substations
Used non-standardised equipment
N/A

DEMO DEVELOPED UNDER UPGRID

Proposed standardised equipment to be used
IEEE 60870-5-104 or IEEE 1815 Monitoring and control units for MV/LV substations
Development of new equipment (and possible standardization process)
DLMS/COSEM/PRIME Monitoring and control units for LV DER equipment