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Reference model for distribution application for microgrids

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European foreword

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Introduction

The current and future distribution networks have to face the fact that there is no more a unidirectional power flow in their lines. The increasing of the installed power within Distributed Energy Resources raises potential problems in the grid (overvoltage, congestion, imbalance…). It is also noteworthy that the deployment of more and more Electric Vehicles (EVs) on European roads will mean an increase in electricity demand as never seen before.

Moreover, the increasing share of Renewable Energy Sources in the European Power Systems implies the need for more accurate forecasting tools to better calculate the energy that these sources will deliver. The intermittence and uncertainty of the weather phenomena which mobilize these energy sources mean an increase of the uncertainties for network operation purposes.

In order to avoid these potential problems, some strategies are being developed during the last years. These strategies are mainly focused not only on reducing the operating problems of the Demand Energy Response (DER) and Renewable Energy Sources (RES) but even in taking advantage of these kinds of sources and use them to improve safety and secure operation of the distribution networks. One of the strategies with the highest potential is the performing of Demand Response (DR) campaigns. Thanks to the modulation of the energy consumption of small and medium users, it is possible to produce beneficial services to the distribution grid. Furthermore, the increase of storage solutions such as domestic or industrial batteries and the batteries of the EVs, due to Vehicle to Grid (V2G) activities, can be used to improve the quality of the Medium Voltage MV and Low Voltage LV grids.

These activities must go hand in hand with the development of new technologies such as smart meters, power electronics, big data analytics, or the establishment of new algorithms that helps to ensure the reliability of the grid.

WiseGRID project directly tackled these facts with the development through a methodology a tool addressed to small Distribution System Operators (DSOs) and Microgrid Operators. This development led to propose a reference model and a methodology that could be used to develop similar solutions in different small and medium smart grids. These solutions would help them to better control and monitor their MV and LV networks without forgetting the decarbonization goals of the European Commission and also taking advantage of the technological and conceptual improvements above mentioned.

The first approach for developing a Distribution Management System (DMS) is to define the modules that would compose it. The experience and results of WiseGRID project recommend clustering the modules into different categories:

a) Real-Time monitoring

This section deals with the modules which collect data from different meter sources (such as Unbundled Smart Meters, AMIs or SCADAs. Inside this section monitors all these data sources and provide the necessary KPI calculations in order to correctly assess the performance of the tool.

b) Off-Line processes

In this cluster are included the tools which do not need permanently Real-Time data to work. These are the modules dealing with the topology and geographical information of the monitored grid, a power quality assessment of the distribution lines and an assistant for planning future grid improvements.

c) Problem detection and reaction

These modules are focused on the control of the distribution grid. These modules will detect the possible problems of the network (incidents) and will establish the best strategies that will solve those incidents.

d) User Interface

The WG Cockpit User Interface will be the interaction point with the DSO operator. Therefore, it must show all relevant information compiled by all other modules present in the architecture of the application.

1 Scope

This document aims to describe and explain a methodology used for the design of requirements, use cases, scenarios and key performance indicators for planning a Distribution Management System (DMS) of small Distribution System Operators (DSOs) and Microgrid Operators. It is focused on the needs that the DMS must address to provide valuable functionalities.

This document explains the background needed to collate and understand the methodology. The annexes contain the practical example of the application of this methodology to define the WiseGRID tool.

This document will not define either requirement related to safety aspects or consist on a management system.

2 Normative references

IEC 62559-2:2015, *Use case methodology – Part 2: Definition of the templates for use cases, actor list and requirements list*

3 Terms and definitions

Actor name	Description	Actor type
Aggregator	Accumulates flexibility from Prosumers and Consumers and sells it to the Supplier, the DSO or the TSO.	Organization
AMI	*Advanced Metering Infrastructure*. A set of systems that monitor, collect and analyse electricity consumption, and have two-way communication capabilities.	System
Balance Responsible Party	A party that has a contract proving financial security and identifying balance responsibility with the Market Operator entitling the party to operate in the market. [The meaning of the word “balance” in this context signifies that the quantity contracted to provide or to consume must be equal to the real quantity provided or consumed.]	Organization
Battery Operator	Entity responsible for operating a set of Storage Units connected to the electricity grid.	Organization
Data Provider	Independent entity responsible for undertaking and coordinating the information exchange and translation of the data of various sources into a common data model.	Organization

Actor name	Description	Actor type
Distributed Energy Resource	Any type of generation units, storage units and load flexibility resources connected to the distribution network.	System
DMS	*Distribution Management System*. A system that monitors, controls and analyses in real-time or near real-time the electricity distribution system.	System
DSO	*Distribution System Operator*. The entity responsible for: the distribution network planning and development; the safe and secure operation and management of the distribution system; for data management associated with the use of the distribution system; for procurement of flexibility services.	Organization
Electronic Meter	A physical device containing one or more registers.	Device
Energy Management System	A system that monitors, controls and optimizes the operation of the energy system under supervision.	System
EVSE Operator	*Electric Vehicle Supply Equipment Operator*. Entity responsible for managing and operating the EV charging infrastructure.	Organization
Forecast Provider	The organization that provides, upon demand, forecasts regarding certain variables (e.g. electricity demand, RES production, weather conditions, etc.)	Organization
GIS	*Geographical Information System.*	System
Harbour Operator	An organization that manages and operates the harbour infrastructure.	Organization
Market Operator	The unique power exchange of trades for the actual delivery of energy that receives the bids from the Balance Responsible Parties that have a contract to bid. Determines the market energy price taking into account the technical constraints from the Transmission System Operator.	Organization
PDC	*Phasor Data Concentrator*. Receives and time-synchronized phasor data from multiple phasor measurement units (PMUs) to produce a real-time, time-aligned output data stream.	Device
Producer	An entity connected to the grid that injects electricity to the grid.	Person
RES Unit	*Renewable Energy Source Unit*. A type of Producer that transforms energy from	Device

Actor name	Description	Actor type
	renewable energy sources (e.g. sun, wind, etc.) to electricity and injects it to the grid.	
SCADA	*Supervisory Control And Data Acquisition* system	Device
Smart Meter	An Electronic Meter with two-way communication capabilities.	Device
Supplier	Supplies and invoices energy to its customers.	Organization
TSO	*Transmission System Operator*. A party that is responsible for a stable power system operation (including the organization of physical balance) through a transmission grid in a geographical area. The System Operator will also determine and be responsible for cross border capacity and exchanges. If necessary, he may reduce the allocated capacity to ensure operational stability.	Organization
VPP Operator	*Virtual Power Plant Operator.*	Organization

4 Methodology

This section gives an overview of the methodological approach to specifying the requirements needed for achieving the objectives, to identify specific Use Cases and to define measurable indicators of the impact of the proposed innovative technological solutions.

1) *Requirement analysis*

Through the requirement analysis, it is possible to identify all necessary attributes, capabilities, characteristics, or qualities of a system that cover the needs of its users. To this end, each requirement describes measurable conditions the fulfilment of which is possible to be evaluated. The methodology assists in the description, formalization and tracking of the DMS requirements explicitly and unambiguously.

For better organization of the work, classification groups are identified. Each requirement is characterized by its priority (5: high; 4-3: medium; 2-1: low). High priority is assigned to requirements that either realizes a key feature or are needed to realize it.

After a requirement is initially specified, the information is validated and any conflicts and dependencies identified, suggesting specific changes or objections. A revision process follows, to improve each requirement, while at the same time new requirements can be added. By repeating the aforementioned process, the optimal set of requirements is produced.

2) *Use Case definition*

Even though the Use Case methodology defined in IEC 62559-2:2015 originally derives from the software engineering discipline, the straightforward manner it offers for describing the intended functionalities (static as well as dynamic) of the system under study renders it also appropriate for application in the smart grid. Actually, the Use Case Methodology is the basis upon which the Smart Grid Architecture Model (SGAM) framework builds. Three levels of Use Cases are employed, each one with a different level of abstraction and –by extension– a different level of granularity:

— High-level use case (HL-UC): describes a general idea of a function;

— Primary use case (PUC): use case implemented in a specific system characterized by a defined boundary;

— Secondary use case (SUC): describes core functionalities that are used by multiple PUCs.

These Use Cases are formulated using a specific template that supports the process of mapping each characteristic of the Use Case to the SGAM layers.

One important part of the Use Cases is the identification of the actors involved in each one of them.

3) *Key Performance Indicators*

In order to evaluate the results of the solutions proposed and implemented in the DMS, it is necessary to quantify the tangible and measurable impacts which contribute to specific EU policy goals. To this end, the methodology proposed by GRID+ [1] for defining the Key Performance Indicators (KPIs) is followed. In order to ensure compliance with the methodology and produce *meaningful*, *understandable* and *quantifiable* indices, the KPIs are defined according to the identified needs of the PUCs and are categorized as "Specific" KPIs or "Project" KPIs. Consequently, each PUC could use more than one KPIs, while one KPI could be appropriate for more than one PUCs. Apart from the essential information of the description, the formula and the unit of measurement, each KPI is also mapped to the specific European energy policy goals (*Sustainability*, *Market competitiveness* and/or *Security of supply*) to the attainment of which the DMS contributes.

5 Requirements

5.1 Requirements analysis

The analysis of the requirement is the first step. These requirements identify all necessary attributes, capabilities, characteristics, or qualities of the system that cover the needs of its users. To this end, each requirement describes measurable conditions the fulfilment of which is possible to be evaluated.

Several options and methodologies exist for defining requirements. The aim of using a methodology for this analysis is to describe, formalize and track the management requirements in an explicit and unambiguous manner. The following principles need to be ensured by the chosen methodology and the consequent analysis:

— It is needed that the methodology and the analysis follow simple steps to identify and formalize the requirements in an unambiguous manner.

— It should provide an easy process to track and evaluate the progress of the solution.

It could be better to use known methodologies to easier perform the analysis.

The requirements shall specify a reference point for the later stages. During the use case analysis, for example, different use cases shall cover different aspects of the requirements and all important requirements shall be covered by them.

Another function that will easier the requirements' analysis is to use a mechanism for all involved parties to specify the requirements in a standard format. Thereby, specifying the additional context of a requirement such as a rationale and the acceptance criteria for every requirement helps to build a common understanding of the overall system. Furthermore, defining priorities helps to clarify the focus of the project.

The overall process consists of the following steps:

— Initial definition of requirements.

— Prioritization of requirements.

— Validation: identifying conflicts, dependencies and objections.

— Revision: Iteratively revise the specification and identify additional issues until it is free of conflicts, dependencies and objections.

The result will constitute the final list of requirements.

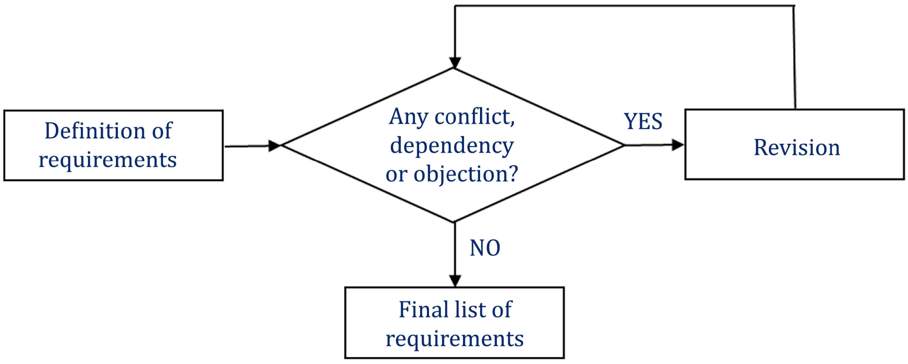

Figure 1 — Requirement Specification and Validation Process

5.2 Requirements definition

In this first stage all the requirements needed to accomplish the objectives shell be defined. They will be refined in future stages.

If a software tool is used to manage this process, a set of functionalities that help on the process and the information to be available at this stage can be the following:

— List of requirements: The list of requirements with some additional options.

  — Filtering options: The list of requirements filtered per id., type and/or filtered per author.

  — Expand table: Show/hide some columns, displaying more or less information about the requirement.

— Requirements management: Modification options for requirements.

  — View a requirement.

  — Edit a requirement.

  — Delete a requirement.

  — Add a new requirement.

— Requirements tracing: keeping track of all the requirements history.

Minimum fields to be used to define the requirements can be:

— ID: This ID uniquely identifies each requirement.

— Description: The scope of this requirement. A one sentence statement which describes the intention of the requirement.

— Type: The type of the requirement as defined in the process.

— Rationale: A justification of the requirement.

— Acceptance criteria: A measurement of the requirement for further verification that the solution matches the original requirement.

— Priority: The importance of successfully implementing the requirement for the customer.

5.3 Requirements prioritization

Several motivations can lead to prioritize the requirements of the capabilities of the solution. For example, the innovation degree that introduced the requirement can be a factor to prioritize the implementation of the requirement. Other factors could be critical business parameters control, economic reasons, etc.

To prioritize requirements, five different classes of priorities are defined, ranging from one (lowest priority) to five (highest priority). The definition of this classes range is as follows:

— **5- High**: Requirements in this class are either realizing a key factor (innovation) or they are needed to realize it. These requirements are necessary to achieve the goals of the management solution.

— **4-3 Medium**: Requirements in this class are not necessary to realize a key factor (innovation) but they are necessary or very helpful to develop application prototypes.

— **2-1 Low**: Requirements in this class are neither realizing a key factor (innovation) nor necessary for application prototypes. However, in a broader context possibly they may be important.

As a consequence, for the success of the solution, it is essential to fulfil the requirements with high priority. Concerning providing thorough support for application developers, it is important to realize the requirements with medium priority as well. The requirements with low priority, however, are not of immediate relevance but their realization may provide additional features or benefits that should be considered after all requirements of the other two classes have been successfully implemented.

In order to give all stakeholders and interested parties an insight into the prioritization process, it is recommended not only to assign categories to each requirement but also decide to include the main rationale for this classification in the resulting document. Besides from being informative, this can be helpful in later stages where unforeseeable issues may require including new requirements or revising the existing ones.

5.4 Requirements validation

After the initial definition of requirements, the validation process begins. All the requirements should be approved by all the participants. At this stage, conflicts and dependencies between requirements must be detected. Furthermore, any objection must be pointed out:

— **Dependency**: Requirements that have some dependency on other requirements.

— **Conflict**: Requirements that cannot be implemented if another requirement is implemented or conflict due to an insufficient definition of the requirement.

— **Objection**: A reason or argument offered in disagreement, opposition, refusal or disapproval of the requirement.

5.5 Requirements revision

All the dependencies, conflicts and objections highlighted by the participants during the validation stage must be revised and solved.

The revision can have two outcomes:

— modify or delete the requirement or,

— clarify the requirement with a better explanation or justify the intention of the requirement.

All involved parties should be aware of the revised requirements and approve the actions taken for resolving the dependency/conflict/objection.

The used software should allow every participant to review the history of a requirement.

6 Use cases

6.1 Definition of the Use Cases

The Use Case definition is a relevant step in the development of the DMS. It is recommended to follow the Use Case (UC) Methodology which was originally defined in IEC 62559-2:2015 to cover the needs of the software engineering. However, its advantages render it also appropriate for application in the smart grid. More specifically:

— It offers a systematical manner for gathering all necessary information regarding functionalities, processes and respective actors;

— It facilitates the coordination among various stakeholders as it ensures the common understanding of complex processes;

— It forms the basis for further development of the functionalities of the system under study.

This Use Case Methodology includes a template where all necessary information for a specific process is described: from high-level information, such as the name of the UC, to a detailed step-by-step analysis of the realization of the UC as well as the actors involved. The use of standardized templates and questionnaires through the whole development process provides higher efficiency.

Use Cases shall be categorized depending on the amount of information and level of detail included in the Use Case, with different levels of abstraction and different levels of granularity (Figure 2):

— High-level use case (HL-UC): describes a general idea of a function;

— Primary use case (PUC): use case implemented in a specific system characterized by a defined boundary;

— Secondary use case (SUC): describes core functionalities that are used by multiple PUCs.

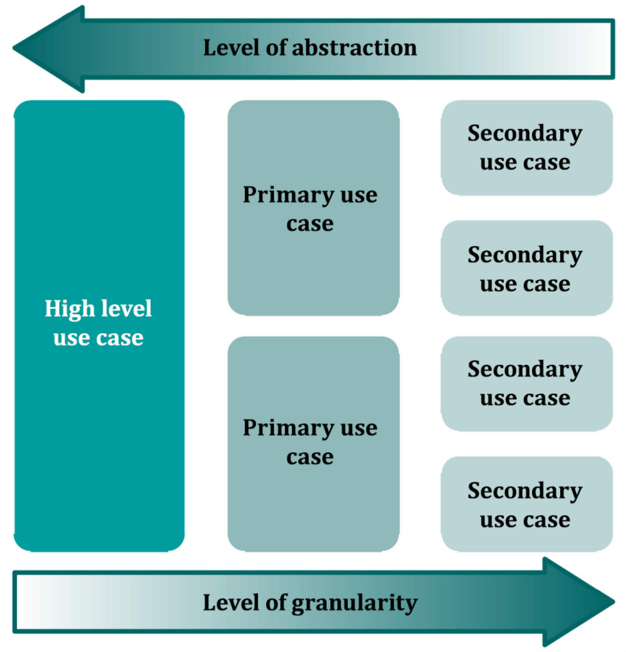

Figure 2 — Use case structure

6.2 Overview of SGAM (Smart Grid Architecture Model)

The Smart Grids Architecture Model (SGAM) framework can be described as the architectural structure of a practical methodology where each particular Use Case (UC) can be modelled and analysed from different aspects. The most important factor while modelling a UC is the coherency of the whole process, as well as the production of an analytic and easy to understand the model. As far as the general presentation of a UC is concerned, three main categories interoperate between each other, while various cross-cutting issues (referring to relationships between the categories) need to be taken into account (Figure 3).

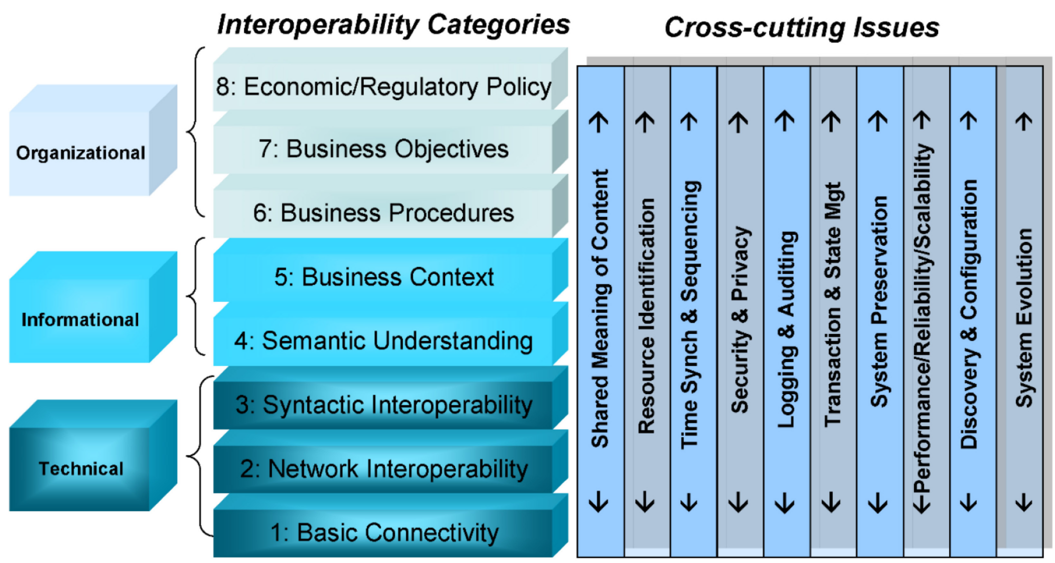

Figure 3 — Interoperability Categories and Cross-Cutting Issues

In the SGAM framework, these interoperability categories are aggregated into five different levels, the SGAM layers (Figure 4). As can be seen, each layer refers to a different aspect of every UC, starting from the Business layer (referring to the business usage of the smart grid information exchanged, the involved market partners, business objectives, constraints etc.), moving step by step to the Component layer (physical layer, including all entities of smart grid, such as the system equipment, the network infrastructure and the protection devices). Between these two, lie the Function, the Information and the Communication layer. These layers refer to the functions implemented (functionality of UC), the information object and data models exchanged between functions or actors (devices, applications, persons, organizations) and the protocols/mechanisms used for the exchange of information, respectively.

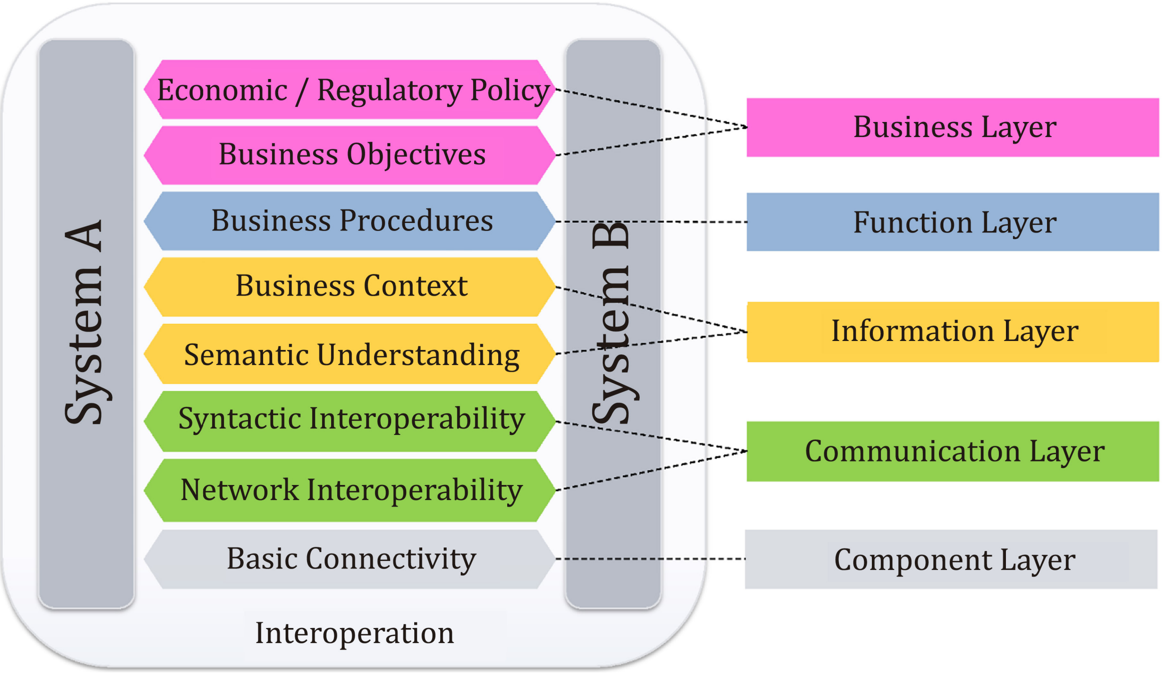

Figure 4 — Interoperability Categories and layers

In succession, the interoperability layers need to be merged with another concept, the smart grid plane, to compose the 3D SGAM framework. In the smart grid plane, an important distinction is made between the electrical processes (domains) and the information management viewpoints (zones) involved in every UC. The five SGAM domains contain the Bulk Generation domain (massive generation of electricity), the Transmission domain (infrastructure and organization for the transportation of energy), the Distribution domain, the Distributed Electrical Resources domain (DER connected to the public distribution grid ranging from 3kW~10.000 kW) and the Customer Premises domain (prosumers of electricity).

Moving on to the six SGAM zones, these are distinguished as follows. The Process zone (refers to the transformation of energy and the equipment involved) is followed by the Field zone (protection, control and monitor equipment) which, in turn, is succeeded by the Station zone (areal aggregation of the previous level). Next comes the Operation zone (control operation systems such as DMS/EMS), followed by the Enterprise zone (commercial aspect/e.g. logistics, staff training, etc.) and finally the Market zone (commercialization of the produced energy).

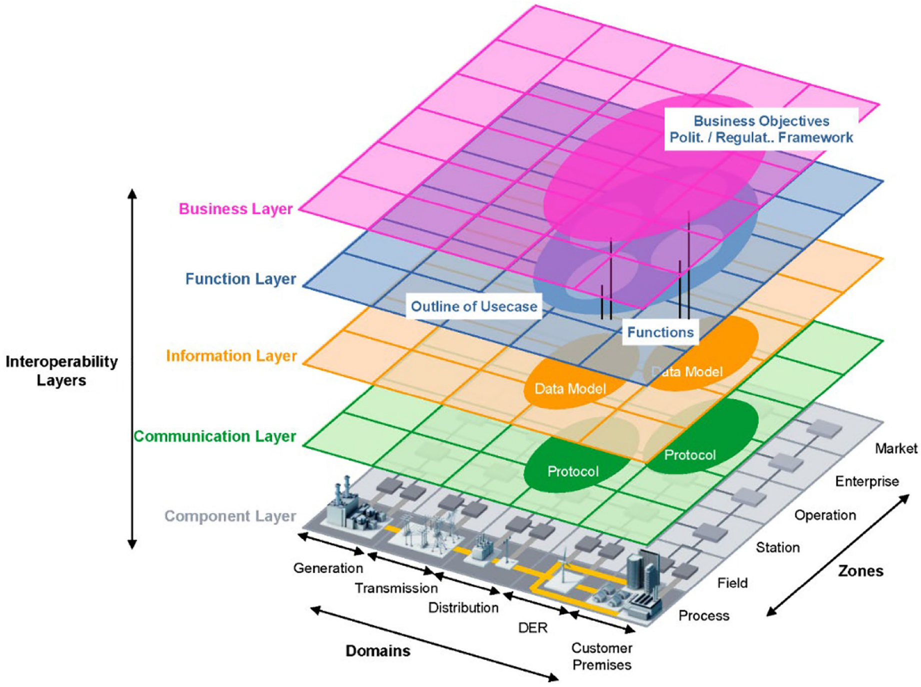

Figure 5 — SGAM framework

The basic principles on which the SGAM modelling framework is based upon are universality, localization, consistency, flexibility, scalability, extensibility and interoperability. So, as far as flexibility is concerned, a UC can be analysed in multiple different ways while many functions or services can be placed in different zones/domains. This feature does not come at the expense of the consistency of the model since all layers, domains and zones must be specified. In the end, the coherency of the final extracted model is guaranteed, since the five SGAM layers are linked and able to interact with each other, as shown in the Figure 5.

Moving on, the mapping process of every UC begins with the analysis phase in which needs to be confirmed that the UC description provides the necessary information (objective, UC diagram, actor name and type, precondition and assumptions, steps, information exchanged and requirements) (Figure 6). Once this phase is completed, each SGAM layer shall be developed.

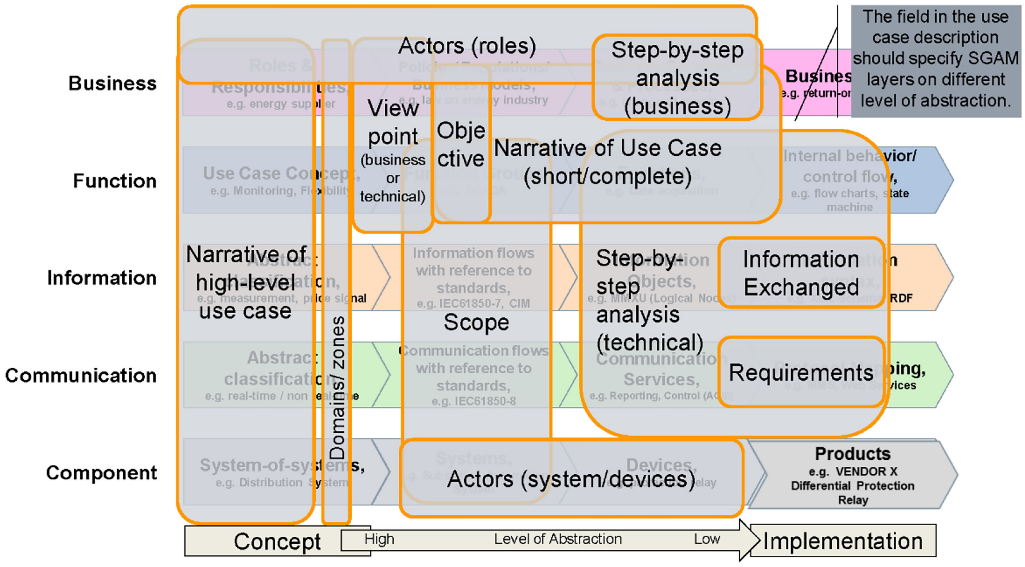

Figure 6 — Mapping of fields in the use case templates to SGAM analysis pattern

7 Key performance indicators

7.1 General

In order to evaluate the results of the solutions proposed and implemented within the DMS development process, it is necessary to quantify the fulfilment of the expected main requirements.

It is recommended to focus on tangible and measurable impacts which contribute to specific EU policy goals. To this end, the methodology proposed by GRID+ [1] for defining the Key Performance Indicators (KPIs) is followed. KPIs aim to highlight the added value of the solutions proposed and their alignment with EU ambitions and targets for future power grids. KPIs' role is to be used from active policy actors and energy market players to contribute for future decisions concerning network planning and operation.

Other impacts can be more relevant in other developments, but it is crucial to quantify measurable factors through indicators to know the degree of accomplishment of the implemented solution to the needs for which it was designed and developed.

7.2 KPI design

The purpose of defining KPIs is to support the developers of the DMS to measure the accomplishment of the expected functionalities.

The design of KPIs in any development process is in line with GRID+ guidelines, according to which a KPI should be:

— *meaningful*: it should relate with one or several expected innovation impacts, and therefore makes sense since contributing to reach the program goals;

— *understandable*: the KPI definition relates clearly with the expected impacts;

— *quantifiable*: experimental values coming from field testing at an appropriate scale are used to develop ad hoc simulation tools able to estimate the expected innovation impacts.

KPI are classified in two categories: "*Implementation Effectiveness KPI*", used as a metric for the completion of research and innovation (R&I) objectives of the European Electricity Grid Initiative (EEGI) roadmap, expressed as a percentage of the status of the activities (*not yet started, under proposal, ongoing* and *completed*). The second category "*Expected Impact KPIs"* measure the benefits achieved by European R&I projects and are split into the following three levels:

A) Overarching KPIs:

— A.1 Increased network capacity at affordable cost: Network capacity increase aims to ensure load demand coverage and can be achieved by adding new RES, network reinforcements, etc. Operating expenses (OPEX) and capital expenditure (CAPEX) should be considered when increasing network capacity.

— A.2 Increased system flexibility at affordable cost: System flexibility refers to the amount of electric power needed to be available to ensure the secure and robust operation of the network. Hence, flexibility requires the commitment of redundant units by implementing cost minimization planning.

B) Specific KPIs:

— B.1 Increased RES and DER hosting capacity: Increase of RES/DER penetration in distribution systems characterizes active distribution networks. RES/DER connection requires their optimal integration, without endangering system's stability.

— B.2 Reduced energy curtailment of RES and DER: Energy curtailment is often proposed as a solution to operation problems raised by the connection of new RES/DER units. However, operation and control tools providing alternatives reducing the amount of green energy curtailed should be developed.

— B.3 Power quality and quality supply: High penetration of RES and DERs very often leads to stability problems and reliability issues, thus requiring the implementation of preventive actions to maintain a high quality of power supply.

— B.4 Extended asset lifetime: The optimal usage and the maintenance of the equipment should be considered in operational planning to extend the lifetime of assets.

— B.5 Increased flexibility from energy players: New energy control schemes, such as DR services, are exploited to provide further flexibility in network operation.

— B.6 Improved competitiveness of the electricity market: Energy and ancillary services for the management and control of active distribution networks calls for multiple energy players, thus improving the competitiveness of the electricity energy market.

— B.7 Increased hosting capacity for EVs and other new loads: The presence of new technologies, such as electric vehicles makes necessary the existence of infrastructure, ensuring their increased hosting capacity in the distribution system.

C) Project KPIs, based on specific functionalities.

The relation between the first two KPI categories (*Overarching KPIs* and *Specific KPIs)* and EU energy policy goals can be depicted in Table 1.

Table 1 — Overarching and Specific KPIs compliance with EU energy policy goals

KPIs	Compliance with EU energy policy goals		
	Sustainability	Market competitiveness	Security of supply
A.1 Increased network capacity at affordable cost	✓	✓	✓
A.2 Increased system flexibility at affordable cost	✓	✓	✓
B.1 Increased RES and DER hosting capacity	✓	✓	✓
B.2 Reduced energy curtailment of RES and DER	✓	✓	✓
B.3 Power quality and quality supply	✓	✓	✓
B.4 Extended asset life time			✓
B.5 Increased flexibility from energy players		✓	✓
B.6 Improved competitiveness of the electricity market		✓	
B.7 Increased hosting capacity for EVs and other new loads	✓	✓	✓

As mentioned above, KPIs aim to present the added value of innovative solutions compared to the existing practices. The expected benefits (technical and/or economical) that could be provided by innovation versus the benefits already achieved by traditional solutions are quantified through KPIs, as depicted in the following figure.

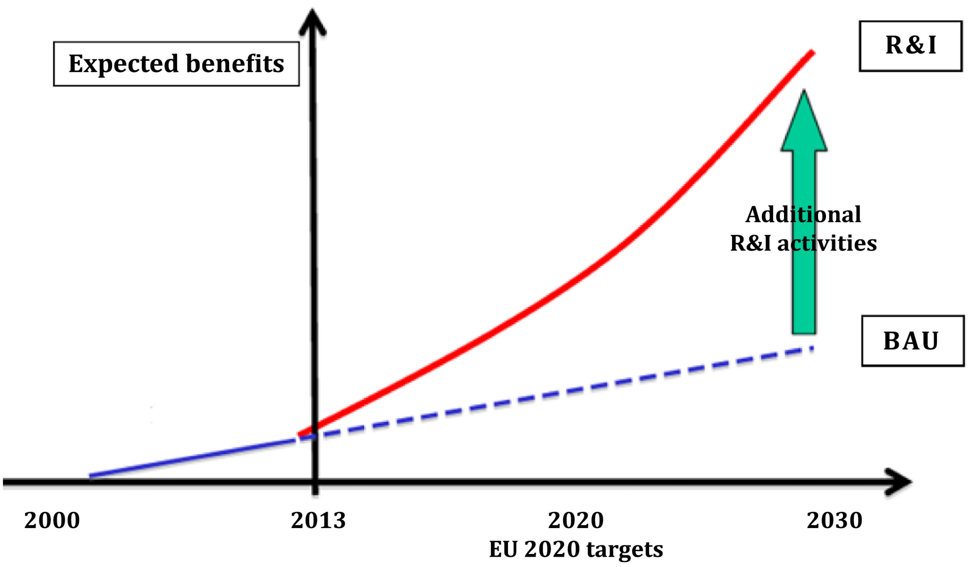

Figure 7 — Comparison of the expected benefits between R&I and BaU scenarios

The two following cases are compared, and the corresponding values of the selected variables are used, to calculate the KPIs.

— Business-As-Usual (BAU) scenario: values of the variables calculated by using traditional technologies.

— R&I case: values of the variables calculated by using the innovative solutions.

It should be mentioned that to can be able to perform the match, a BAU solution should exist. The "*four step approach*" to value KPIs is as follows:

— Step 1: Identification of the problems needed to be solved or the situation that needs to be improved.

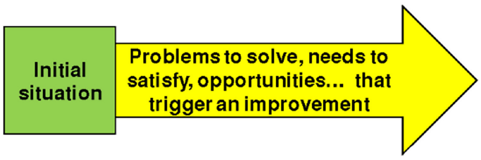

Figure 8 — Step 1 of the process for calculating the KPIs

— Step 2: Selection of the already available tools to be used in the above described situation and other scenario cases of this in BaU and estimate the results and the progress made after applying this approach.

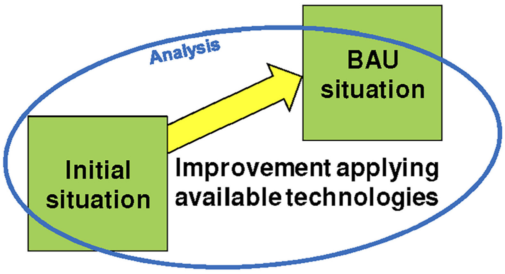

Figure 9 — Step 2 of the process for calculating the KPIs

— Step 3: Implementation of the R&I developed solutions in order to deal with possible future situations and analysis of the estimated results.

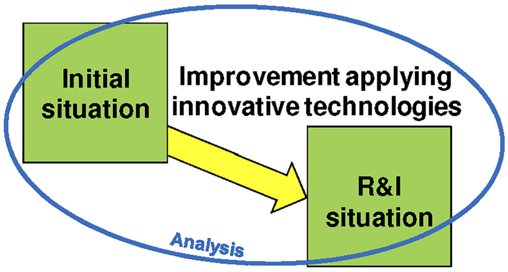

Figure 10 — Step 3 of the process for calculating the KPIs

— Step 4: Calculation of KPIs in order to compare the R&I with the BaU approach, by applying the proposed formula for each KPI.

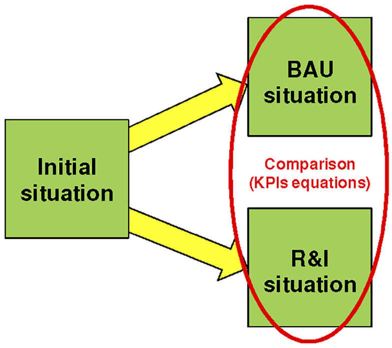

Figure 11 — Step 4 of the process for calculating the KPIs

7.3 KPI definition

The first step towards the KPI definition is to clarify their applications. Hence, it should be determined what KPIs are impacted by the expected or achieved innovative results. Therefore, a short analysis of how the innovative results contribute to each KPI and an estimation of the values of each affected KPI should be provided.

Both *Specific KPIs* and *Project KPIs* should be defined and selected in a way to measure the impact and evaluate the results of PUCs. Therefore, KPIs are associated at first level with PUCs and through them with HLUCs and SUCs. It should be mentioned that one KPI can be related to one or more PUCs and vice versa. To facilitate this process, the information needed for the optimal definition of KPIs is categorized and presented as follows:

— KPI ID;

— Strategic Objective(s): the specific European energy policy goals (*Sustainability*, *Market competitiveness* and/or *Security of supply*) to the attainment of which the Project contributes; the success in attaining one or more of these goals can be measured through each KPI;

— Project Objective(s): the project objectives to which the KPI is related;

— Description: gives the purpose and the use of the KPI;

— Formula: the analytical formula for the calculation of the KPI;

— Unit of measurement;

— Related PUC(s): the PUCs that could use the specific KPI;

— Project relevance: the relevance of each KPI in quantifying the innovation impacts is identified either as direct or as indirect (i.e. the improvement observed in a KPI with direct relevance can be attributed directly to the solutions proposed);

— General comments: any peculiarities in the calculation method, or specific details for facilitating and ensuring the correct usage of the KPI, such as risk factors for the quality of the data used as input for the KPI calculation, time delays, etc. are also included.

Annex A
(informative)

Example of use: The WiseGRID case

A.1 General

The application of the methodology explained in the previous clause provided the following reference model tool characteristics.

A.2 Requirements

A.2.1 General

WiseGRID used ETRA's Volere-based web tool to define the requirements. The Volere tool is not new to some of the project partners. It was first used by a number of the project partners in the NOBEL [2] and NOBELGRID [3] projects where it was used mainly because of its simplicity. It helped project partners to describe, formalize and track the project requirements in an explicit and unambiguous manner. Besides being a success in the above-mentioned previous projects, the Volere tool was selected for the following three reasons:

1. It requires simple steps to identify and formalize the requirements in an unambiguous manner.

2. It provides an easy process to track and evaluate the progress of the project.

3. A number of the project partners have already experience with the Volere tool. Hence, they did not need an extra learning effort.

The consequent application of the Volere tool is not only useful in the initial phases of the project for specifying requirements but it is also helpful in specifying a reference point for the later stages. During the use case analysis, for example, it can be used to ensure that different use cases cover different aspects of the requirements and that all important requirements are covered by them. Besides being efficient and easy to use, the Volere tool allows all partners to specify the requirements in a common format.

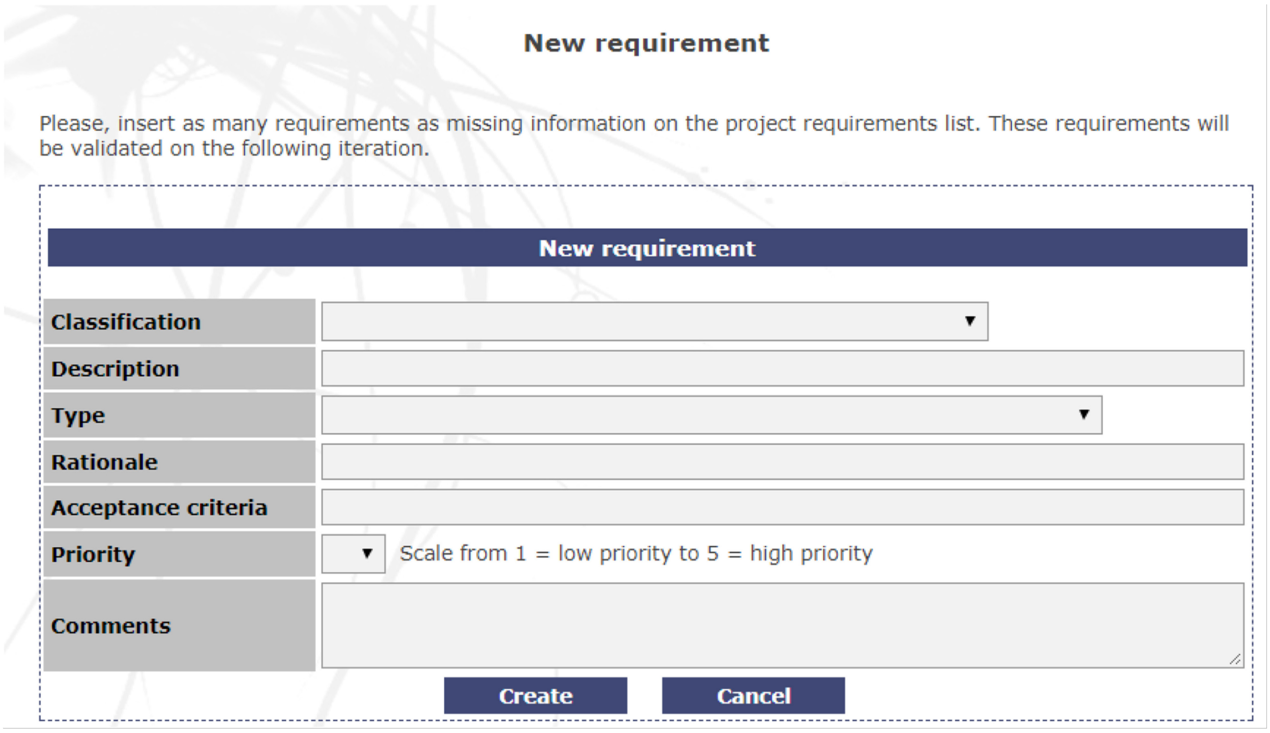

Figure A.1 — Example of standardized format for the definition of new requirements

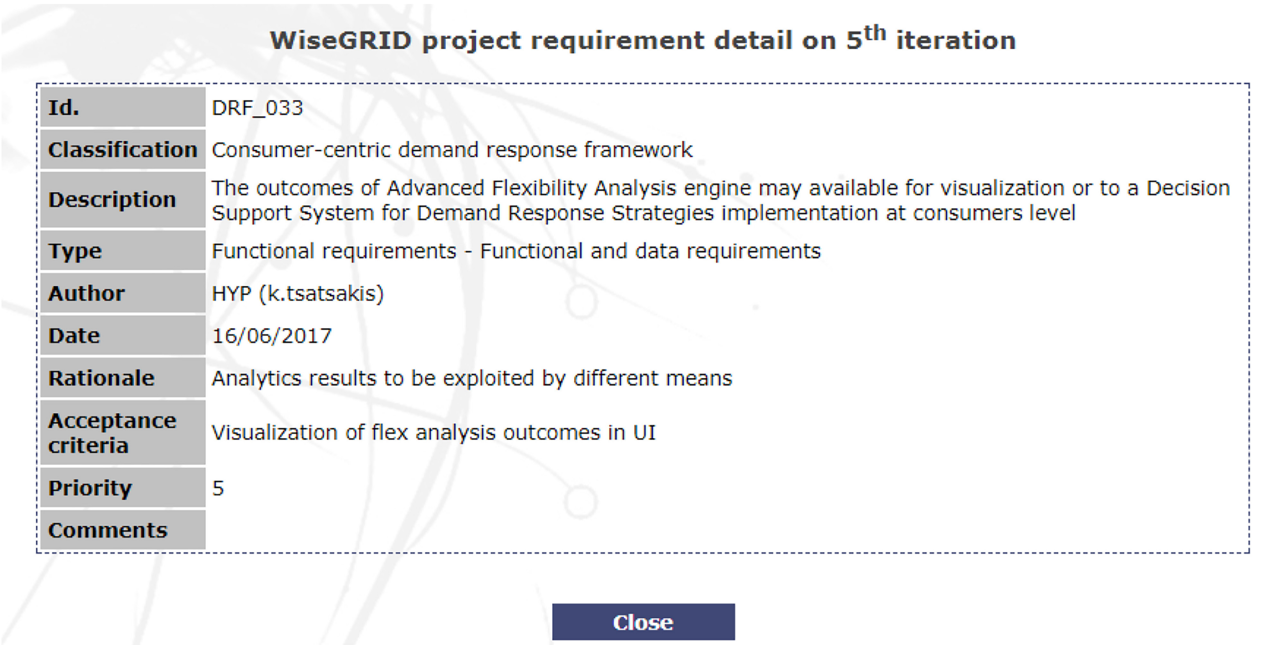

Figure A.2 — Example of requirement details

Following the prescribed methodology, the requirements per WiseGRID product as well as the general requirements have been identified summing up to a total of 391 requirements that deal with various aspects of the project and its tools.

a) General requirements

The list of general requirements helps settling the high level objectives of the project, thus helping to spread a common understanding of the work to be developed. Several different perspectives of the energy field have been taken into account – cultural, legal, regulatory and technical. This list contains the requirements (57 in total) that will guide the first steps of the project, namely:

— Objectives of the project that need to be taken into account at the design of the technological solutions.

— Implications of the interoperability among the different technological solutions to be developed.

— Horizontal technical requirements affecting all the 9 interoperable WiseGRID products.

b) Particular requirements

The 58 requirements identified cover different aspects of the development and deployment of the WiseGRID reference model tool:

— Prerequisites: Communication channels and standard protocols available for interacting with field devices and existing systems (including Geographical Information System, Supervisory Control And Data Acquisition system, Enterprise Resource Planning system, etc.); availability of assets to demonstrate the expected features (Renewable Energy Sources, smart meters, etc.); availability of data to demonstrate the expected features (measurements, topology, etc.).

— Legal requirements (contractual agreements needed among different actors for the system to operate).

— Expected features: monitoring; increased observability; information to be displayed to the operator; enhanced maintenance, fault-detection and recovery of problems in the grid; enhanced operation of the grid by interoperating with services offered by other WiseGRID technological solutions.

A.2.2 Requirements

A.2.2.1 General requirements

A.2.2.1.1 Overview

WiseGRID project aims at increasing the smartness, stability and security of an open, consumer-centric European energy grid, by helping all actors involved – DSOs, aggregators, retailers, prosumers, consumers, ESCOs, EV fleet operators, etc. to become more active and empowered players. Towards this objective, the project will develop a set of technological solutions packaged within 9 different interoperable products, each of them targeting a specific set of end-users.

The list of general requirements helps settling the high level objectives of the project, thus helping to spread a common understanding of the work to be developed. Several different perspectives of the energy field have been taken into account – cultural, legal, regulatory and technical. This list contains the requirements that will guide the first steps of the project, namely:

— Objectives of the project that need to be taken into account at the design of the technological solutions.

— Implications of the interoperability among the different technological solutions to be developed.

— Horizontal technical requirements affecting all the 9 interoperable WiseGRID products.

A.2.2.1.2 Detailed requirements

All partners of the WiseGRID project have participated – in parallel to the use cases definition – in the definition of the project general requirements list.

The list of requirements covers different aspects about the objectives of the project. A short summary of those includes:

- General requirements.
  - Project objectives.
  - Technological solutions horizontal requirements.
- Architectural requirements, focusing on the interoperability of the different solutions.
- Specific big data-related requirements, which is a horizontal aspect to all the solutions to be developed within the project.

An overview of all general requirements provided by the consortium can be found in Table A.1.

Table A.1 — WiseGRID general requirements

Requirement ID	Description	Type
ARC_001	The systems designed within WiseGRID must be based on open standards (as much as possible).	The scope of the product
ARC_002	Systems shall have appropriate interfaces for working with WiseGRID and securely exchange data with operational facilities.	The purpose of the product
ARC_003	End Users should be grouped by consumption profiles and invited to interact in favour of more energy efficiency.	Usability and humanity requirements
ARC_004	WiseGRID System should be designed according principles of modularity, scalability and interoperability.	Operational requirements
ARC_005	Strong WiseEVP and WG FastV2G coordination due to the fact that they are using so much common data.	The scope of the work
ARC_006	WiseEVP has an EVSE management module and an EV fleet management module.	The scope of the product
BDP_001	The platform shall be able to work with several types of data.	Functional and data requirements
BDP_002	The platform shall be able to apply different algorithms on the data.	Functional and data requirements
BDP_003	The platform should provide enough storage capacity to deal with the storage of data managed within the project.	Operational requirements
BDP_004	Data quality assessment and substitution	Functional and data requirements
BDP_005	Temporal and spatial integration	Functional and data requirements
BDP_006	Clustering	Functional and data requirements
BDP_007	Periodic data analysis is supported.	Functional and data requirements

Requirement ID	Description	Type
BDP_008	Data reduction	Functional and data requirements
BDP_009	The platform shall be able to apply privacy policies on different segments of data.	Functional and data requirements
BDP_010	The platform shall be able to communicate with a defined number of protocols.	Functional and data requirements
BDP_011	The platform will be able to work as a distributed system.	Functional and data requirements
BDP_012	The database(s) will store data based on CIM data model (extensions may be needed from standardized CIM).	Functional and data requirements
BDP_013	Where CIM is difficult to apply and data models have complex and hybrid structure, database(s) shall be able to store and retrieve JSON structures.	Functional and data requirements
BDP_014	The platform will be able to make data carving.	Functional and data requirements
BDP_015	The platform will have a real-time data section which will allow much higher number of transactions than on persistent database section.	Functional and data requirements
BDP_016	Access to different database information will be based on Role-Based Access Control (RBAC).	Functional and data requirements
BDP_017	The platform will support powerful scripts which will support data protection schemes according to GPDR requirements.	Functional and data requirements
BDP_018	The platform will support powerful data security features.	Functional and data requirements
BDP_019	The platform will need a concept if key management for the data security features.	Functional and data requirements
BDP_020	The platform will allow micro transactions for different segmented markets. Blockchain solution will be considered.	Functional and data requirements
BDP_021	The platform will allow data anonymization by using anonymous labels in some databases and personal reference in other databases.	Functional and data requirements
BDP_022	The platform will allow data anonymization by using aggregation of personal data, where the applications allow and gives meaning for the aggregated data (e.g. aggregated active powers of a cluster of end-users).	Functional and data requirements
BDP_023	Triggered data analysis is supported.	Functional and data requirements
GEN_001	WiseGRID must advance the UN sustainable development goals (e.g. low carbon energy security, energy efficiency over consumption).	Cultural and political requirements
GEN_002	WiseGRID must advance a low carbon based circular economy (cradle to grave production and waste management; renewables penetration).	Cultural and political requirements
GEN_003	WiseGRID must foster citizens' empowerment and decentralization of the energy system (e.g. prosumers' markets, micro-generation, community energy).	Cultural and political requirements

Requirement ID	Description	Type
GEN_004	WiseGRID must promote consumer-centric smart grid related data management systems.	Security requirements
GEN_005	WiseGRID must promote a 'level playing field' which does not discriminate between competitors (e.g. suppliers, aggregators) as well as flexibility solutions (e.g. storage, DR, EVs).	Operational requirements
GEN_006	WiseGRID must make use of existing standards or standards under development to provide easier access to the market and the dissemination of the resulting solutions worldwide.	Legal requirements
GEN_007	WiseGRID can promote new standards using the results of the project looking for higher market penetration.	Legal requirements
GEN_008	The apps developed should be aligned and easily adaptable to the regulatory framework.	Legal requirements
GEN_009	Quality of historical data from pilot sites must be ensured.	Operational requirements
GEN_010	All product GUIs should be designed utilizing user (stakeholder) feedback at the design phase.	Look and feel requirements
GEN_011	The apps developed within WiseGRID should be compatible with different operating systems (Windows, Android, Linux, MacOS, iOS, etc.).	Functional and data requirements
GEN_012	A support system to the users should be created for the support of the tools deployment in the pilot sites.	Users of the product
GEN_013	Maximize the implementation of local renewable production.	The scope of the work
GEN_014	The governance of the system needs to be collegial and include the end-users.	Usability and humanity requirements
GEN_015	Standard Communication Protocols need to be used.	Naming conventions and definitions
GEN_017	WiseGRID must prioritize self-generation.	Cultural and political requirements
GEN_018	Feedback option of every WiseGRID final product.	Usability and humanity requirements
GEN_019	Advertising to encourage users to use WiseGRID products.	Cultural and political requirements
GEN_020	Implementation of algorithms that calculate the forecast of renewable production according to meteorological data (solar irradiation, wind).	Functional and data requirements
GEN_021	WiseGRID products translation to different languages.	Usability and humanity requirements
GEN_022	Granularity at the device level to identify and to isolate anomalous devices.	Operational requirements
GEN_023	Phasor Measurement Units (PMUs) in strategical places to monitor the quality of the grid.	Operational requirements
GEN_024	Smart meters infrastructure should be deployed and integrated into the grid.	Functional and data requirements
GEN_025	Smart meter must have a network connection.	Functional and data requirements

Requirement ID	Description	Type
GEN_026	Real data in real-time from smart meters, sensors, metering, etc. must be available.	Functional and data requirements
GEN_027	The WiseGRID app ecosystem should support coherent user management between apps.	Mandated constraints
GEN_028	Date time data will always be processed in UTC.	Mandated constraints
GEN_029	Data owners will decide on which purposes their data can be used.	Legal requirements

The complete set of requirements and their priority will be refined in next stages of the project, with inputs from demonstrators and from the development of the applications, thus some requirements will be enhanced, discarded or adapted.

In order to be sure that the features and characteristics of the technological solution meet the expected performance, the following requirements for the tool were identified.

A.2.2.1.3 Detailed requirements

All partners of WiseGRID project have participated – in parallel to the use cases definition – in the elaboration of the requirements list for the WiseGRID Cockpit solution. The list considers, therefore, several different perspectives of the product, from whose DSO operation - and aspects that can be improved -, ICT requirements and pilot site expectations may be highlighted.

The list of requirements covers different aspects about the development and deployment of the tool. A short summary of those includes:

- Prerequisites
  - Communication channels and standard protocols available for interacting with field devices and existing systems (including GIS, SCADA, ERP, etc.)
  - Availability of assets to demonstrate the expected features (RES, smart meters, etc.)
  - Availability of data to demonstrate the expected features (measurements, topology, etc.)
- Legal requirements (contractual agreements needed among different actors for the system to operate)
- Expected features
  - Monitoring
  - Increased observability
  - Information to be displayed to the operator
  - Enhanced maintenance, fault-detection and recovery of problems in the grid
  - Enhanced operation of the grid by interoperating with services offered by other WiseGRID technological solutions

An overview of all requirements for the WiseGRID cockpit requirements provided by the consortium can be found in Table A.2.

Table A.2 —WiseGRID Cockpit requirements

Requirement ID	Description	Type
AMG_001	Bidirectional communication between DSO and involved energy stakeholders is established.	Functional and data requirements
AMG_002	Contractual agreements between the DSO and the rest of the actors are in place.	Legal requirements
AMG_003	The proprietor of the unit (if different from the DSO) has signed a contract with the DSO that describes the conditions that apply regarding the load control actions.	Legal requirements
AMG_004	Reliable calculation of customer response to control signals.	Functional and data requirements
AMG_005	Characteristics of load control actions (timeframe, triggering events) should be well-established.	Legal requirements
AMG_006	The resource operator has signed a contract with the DSO that describes the conditions that apply regarding the load control actions.	Legal requirements
AMG_007	The Prosumers, EVs and other local energy resources have signed a contract with the resource operator for load control actions.	Legal requirements
AMG_008	Actor's portfolio (characteristics) is known.	Functional and data requirements
AMG_009	The optimization algorithm is robust.	Functional and data requirements
AMG_010	The optimization algorithm produces reliable results.	Functional and data requirements
AMG_011	Adequate amount of pieces of equipment for monitoring the distribution network is installed.	Functional and data requirements
AMG_012	Regulation allows islanded operation of part of the distribution network.	Legal requirements
WCP_001	Smart meters shall be installed in enough ratio to allow proper measurements of the grid buses.	Operational requirements
WCP_002	Smart meters shall be installed in participant prosumers to allow proper consumption/production/power quality measurements.	Operational requirements
WCP_003	WiseGRID Cockpit must visualize all collected measurements of the grid.	Functional and data requirements
WCP_004	WiseGRID Cockpit must visualize KPIs of Power Quality-related metrics.	Functional and data requirements
WCP_005	DER attached to the grid must include control interfaces.	Operational requirements
WCP_006	Ancillary services market must offer an open interface to post requests.	Operational requirements
WCP_007	VPPs and Storage as a Service (including DR, RES, EVs and batteries) must offer an open interface to post requests.	Operational requirements
WCP_008	The tool must provide an interface to inform fault detections to operators.	Functional and data requirements
WCP_009	The tool must provide operators with grid reconfiguration proposals in the event of (expected) faults.	Functional and data requirements

Requirement ID	Description	Type
WCP_010	The tool must be able to automatically apply optimized grid reconfiguration.	Functional and data requirements
WCP_011	Switches available in the feeders must be controllable.	Operational requirements
WCP_012	The platform will be able to manage grid imbalance.	Functional and data requirements
WCP_013	The tool must perform grid state estimation.	Functional and data requirements
WCP_014	The tool will monitor the distribution network.	The scope of the product
WCP_015	The tool will improve the flexibility of the distribution network.	The scope of the product
WCP_016	The tool will enhance RES integration in the distribution network.	The scope of the product
WCP_017	The tool will detect faults in the distribution network.	The scope of the product
WCP_018	The tool will self-configure the distribution network.	The scope of the product
WCP_019	The tool will manage remotely the switching elements in the distribution network.	The scope of the product
WCP_020	WiseGRID should use open standards, if possible and define interfaces for all interconnected systems under WiseGRID Cockpit app.	The scope of the product
WCP_021	The tool will enable a connection bus between different various operational facilities and applications of the DSOs.	The scope of the product
WCP_022	The tool should be able to provide suggested solutions as best practises to faults in case of repetition, or in cases of grid reconfiguration.	Functional and data requirements
WCP_023	The topology of the grid at pilot sites must be known in advance.	Operational requirements
WCP_024	The developed fault location algorithms should work effectively on both underground and overhead networks.	Functional and data requirements
WCP_025	Real-Time or near Real-Time update of asset database/GIS.	Functional and data requirements
WCP_026	Bidirectional communication between installed devices and central control unit.	Functional and data requirements
WCP_027	Data transfer between different applications based on a common data model.	The scope of the product
WCP_028	It should perform/provide the results of load flow analysis.	Operational requirements
WCP_029	It should provide information on the status of the asset and their maintenance to the DSO.	Functional and data requirements
WCP_030	The tool shall provide a clear and effective visualization of the topology, so that the DSO can easily spot the whole affected area in case a fault happens at the grid.	Functional and data requirements

Requirement ID	Description	Type
WCP_031	The tool must have an open interface with GIS (through IOP).	Functional and data requirements
WCP_032	The tool must support communication with DMS, through IOP.	Functional and data requirements
WCP_033	The tool should allow DSOs to generate curtailment warnings.	Functional and data requirements
WCP_034	The tool allows the active voltage control and the management of switching components in the network.	The scope of the product
WCP_035	The tool provides support for grid automation based on Unbundled Smart Meters measurements.	The scope of the product
WCP_036	The tool has to support grid operators to better manage and control the energy network.	The scope of the product
WCP_037	The tool provides SCADA support and DER dispatch services, for Smart Grid using real-time data (at the consumer level) and direct control of DERs.	The scope of the product
WCP_038	The tool provides energy quality monitoring service (e.g. voltage levels and voltage asymmetries, current asymmetries in low voltage, time of voltage, and failures at customer levels).	The scope of the product
WCP_039	The tool shows energy grid load, RES forecast, state estimation and load flow.	Functional and data requirements
WCP_040	The tool will support grid energy storage system (g-ESS) optimization for grid capacity management. In this context, g-ESS will be DSO asset and shall be combined with SaaS (Storage as a Service) offered by market aggregators.	Functional and data requirements
WCP_041	The tool will support grid survey and will highlight critical nodes in terms of voltage and critical sections in terms of power flow.	Functional and data requirements
WCP_042	The tool will have a suitable interface to energy market platform.	Functional and data requirements
WCP_043	The tool will have a suitable interface for balancing market platform.	Functional and data requirements
WCP_044	The tool should perform/provide the results of short circuit calculations.	Functional and data requirements
WCP_045	The tool shall provide zoning of the grid with clear allocation of each RES, storage and/or dispatchable consumer. This would manage also the visualization of the topology, so that the DSO can easily evaluate actors implication within various operating	Functional and data requirements
WCP_046	The tool will have a refreshing period for data update to suit various functions availability.	Functional and data requirements

A.3 Use Cases

A.3.1 General

A first step towards achieving the project objectives is to define several Use Cases each one describing a distinctive operational situation expected to occur within the future distribution grid that is fundamentally different from the status quo due to integration of new types of resources.

Within WP2 of WiseGRID, the process of UC identification and definition has been performed following an analytical approach: starting from the project objectives, seven High-Level Use Cases are defined, each one considering the needs of the end-users and of the energy infrastructure in the presence of high penetration of Renewable Energy Sources (RES), DR programs, energy storage and electric vehicles:

— HL-UC 1 Distributed RES integration in the grid: Large-scale integration of intermittent decentralized RES, providing services to the grid (increased stability and security), while minimizing RES curtailment.

— HL-UC 2 Decentralized grid control automation: Intelligent distributed control facilitating the tasks of the Distribution System Operator (DSO) in ensuring the smooth and uninterrupted operation of the distribution grid (fault detection, self-healing, etc.).

— HL-UC 3 E-mobility integration in the grid with V2G: Integration of e-mobility and electric transport systems into the network with implementation of V2G technology, in order to provide services to the grid.

— HL-UC 4 Battery storage integration at substation and prosumer level: Integration of storage systems for providing flexibility to the grid and auxiliary power supply.

— HL-UC 5 Cogeneration integration in public buildings/housing: Integration of cogeneration in public buildings or collective housing and provision of services to the grid by exploiting the thermal storage capabilities.

— HL-UC 6 VPP technical and economic feasibility: Technical and economic feasibility of the aggregated management of distributed resources through the Virtual Power Plant (VPP) concept, in order to exploit the flexibility capabilities offered by the VPP.

— HL-UC 7 Citizens empowerment in energy market and reduction of energy poverty: Participation of prosumers in energy management schemes for reducing energy costs and achieving improved market integration.

Figure A.3 presents the mapping of the HL-UCs to the project objectives and the relevant WG tools per HL-UC.

A.3.2 High-level use cases

In order to facilitate the development and the assessment of the designed solutions, the demonstrations will be conducted following 7 High-Level Use Cases. The tool is linked to all these HL-UCs and their descriptions are shown hereafter.

— HL-UC 1: DISTRIBUTED RES INTEGRATION IN THE GRID

To integrate and demonstrate the largest possible share of intermittent decentralized RESs, showing the services that will provide stable and secure grids in these circumstances, including avoiding curtailment.

— HL-UC 2: DECENTRALIZED GRID CONTROL AUTOMATION

To provide an intelligent distributed control for DSO in order to detect faults, self-protect and self-reconfigure the network in a robust way to restore the power system without the intervention of a central intelligence (self-healing).

— HL-UC 3: E-MOBILITY INTEGRATION IN THE GRID WITH V2G

E-mobility and electric transport systems integration into the network with the implementation of the V2G technology, in order to provide services to the grid, such as storage capacity.

— HL-UC-4: BATTERY STORAGE INTEGRATION AT SUBSTATION AND PROSUMER LEVEL

Use of storage systems integrated into the utilities and substations level in order to provide services to the grid, such as storage capacity.

— HL-UC 5: COGENERATION INTEGRATION IN PUBLIC BUILDINGS/HOUSING

Cogeneration integration in a public building or collective housing, using hot water thermal storage units. Heat can be optimized and can also be used power generated to heat.

— HL-UC 6: VPP TECHNICAL AND ECONOMIC FEASIBILITY

Technical and economic feasibility of the VPP concept using aggregated resources to achieving a higher efficiency; i.e. to deliver peak load electricity or load-aware power generation at short notice.

— HL-UC 7: CITIZENS EMPOWERMENT IN ENERGY MARKET AND REDUCTION OF ENERGY POVERTY

This HL-UC aims to bring the energy prosumers – residential and tertiary – closer to the energy markets in order to reduce their energy costs and improve market integration.

A.3.3 Primary use cases

Simultaneously to the requirements' definition, a set of Primary Use Cases were defined in order to envisage which will be the main actions and scenarios to be tested in the project demonstration. The ones in which the WG Cockpit is the main tool are:

— HL-UC 1_PUC_1_Network monitoring

— HL-UC 1_PUC_2_Control strategies for reducing RES curtailment

— HL-UC 1_PUC_3_Voltage support and congestion management

— HL-UC 1_PUC_4_Grid planning analysis

— HL-UC 2_PUC_1_Distribution network real-time monitoring

— HL-UC 2_PUC_2_Real-time distribution system awareness

— HL-UC 2_PUC_3_Grid control

— HL-UC 3_PUC_3_EV charging management

— HL-UC 3_PUC_4_Interaction with the energy infrastructure

In Deliverable 2.1 it is possible to find further information about these Primary Use Cases.

A.4 Scenarios

Based on the UCs, four scenarios are defined, each one contributing to the project objectives as appearing in Figure A.3.

— *Scenario 1: Innovative and advanced demand-response mechanisms*

Relevant High-Level Use Cases to this scenario are HL-UC 6 VPP technical and economic feasibility and HL-UC 7 Citizens empowerment in energy market and reduction of energy poverty. This scenario refers to the DR strategies for addressing all types of Distributed Energy Resources and the implementation of implicit and explicit DR campaigns by Aggregators, Suppliers and VPP Operators to achieve enhanced user acceptance (less/non-intrusive DR, human comfort considerations) and increased model accuracy. At the same time, portfolio optimization and provision of services to the Grid and Market Operators is a key issue addressed within this scenario.

— *Scenario 2: Smartening of the distribution grid*

Relevant High-Level Use Cases to this scenario are HL-UC 1 Distributed RES integration in the grid, HL-UC 2 Decentralized grid control automation and HL-UC 6 VPP technical and economic feasibility. This scenario addresses the seamless and reliable operation of the distribution grid in the presence of DERs, VPPs and increased penetration of RES (RESCO companies). This is achieved using existing (Energy Management Systems and Distribution Management Systems) as well as new tools (intelligent monitoring equipment, new data concentration structures, big data analysis, novel forecasting tools). Additionally, WG RESCO, WG Cockpit and WG STaaS/VPP allow the management of RES, the distribution grid and VPPs.

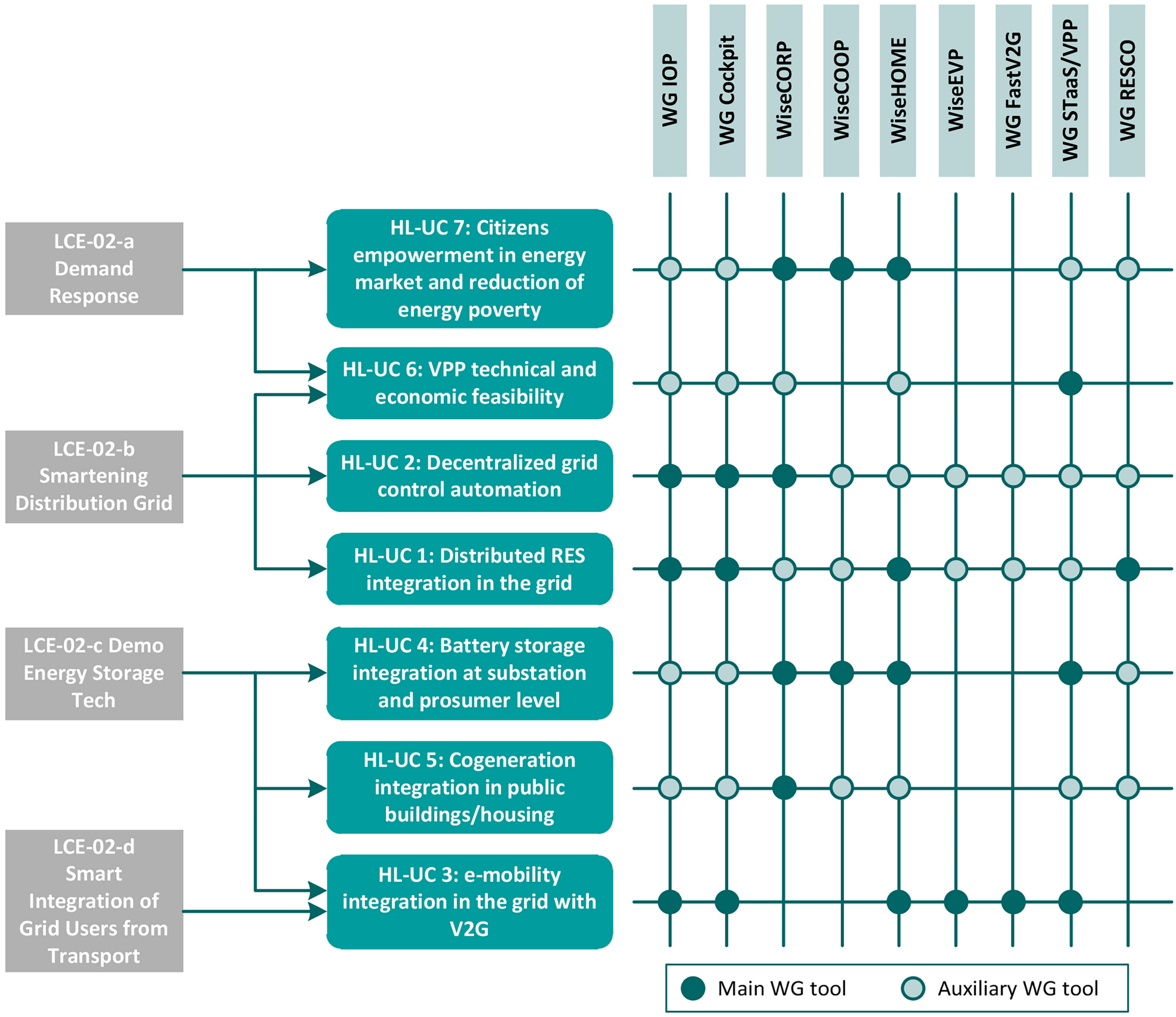

Figure A.3 — HL-UCs mapping to project objectives and WiseGRID tools

— *Scenario 3: Integration of renewable energy storage systems in the network*

Relevant High-Level Use Cases to this scenario are HL-UC 3 e-mobility integration in the grid with V2G, HL-UC 4 Battery storage integration at substation and prosumer level and HL-UC 5 Cogeneration integration in public buildings/housing. This scenario refers to the use of energy storage systems for managing and balancing optimally the network: batteries at substation and prosumer level allow the efficient management for providing services to the grid and for reducing energy cost and environmental impact; HVAC management and comfort-based demand flexibility models allow exploitation of the thermal inertia of the buildings; e-mobility provides flexibility to the grid through application of different charging methods. All these are achieved through the use of WG Fast V2G and WiseEVP for optimizing the activities related to G2V and V2G, WG STaaS/VPP for the management of storage units and WiseCORP for the energy management of buildings.

— *Scenario 4: Smart integration of electric mobility services*

Relevant High-Level Use Cases to this scenario is HL-UC 3 e-mobility integration in the grid with V2G. This scenario addresses the smooth integration of EVs and the charging infrastructure in the network as well as the provision of flexibility while respecting user preferences. To this end, necessary functionalities are identified: user's authentication, EVSE booking and charging session scheduling, as well as the need to offer different types of charging (on user demand, smart, smart with V2G). Relevant WiseGRID tools are: WiseEVP facilitating the EVSE network configuration, EV load forecasting, EV flexibility estimation and reference load profile calculation; WGFastV2G: charging points enabling load shifting and V2G.

A.5 Pilot sites

The five pilot sites in Crevillent (Spain), Flanders (Belgium), Terni (Italy), Mesogia (Greece) and Kythnos (Greece), serve as real test-bed for the solutions developed within WiseGRID. More specifically, the pilot site formal analysis comprises an outline of the current situation in terms of infrastructure as well as services offered to the end-users and applications that facilitate the management of each pilot site. The different needs of the end-users in each pilot renders each one appropriate for testing and demonstrating a variety of UCs as well as for deploying several of the WiseGRID tools, thus ensuring that the proposed solutions and technologies within WiseGRID can be adapted to diverse environments, each one with its own peculiarities and comparative advantages. As the last step of the pilot site formal analysis, a preliminary deployment and demonstration plan is laid out, while potential barriers (regulatory, social, etc.) and the operational constraints due to the prevalent conditions in each pilot site are reported. Having in mind but not limited by the current situation, the potential of each pilot site to implement and test the defined UCs is also identified (Table A.3) and reported in the UCs inventory using a scale 1-5, indicating not only the suitability of each pilot site but also reflecting the vision for the future operation of each pilot site (Annex B, section 13).

Table A.3 — HL-UCs mapping to pilot sites

Pilot site / HL-UC	Crevillent	Flanders	Terni	Mesogia	Kythnos
HL-UC 1	✓	✓	✓	✓	✓
HL-UC 2	✓		✓	✓	✓
HL-UC 3	✓	✓	✓	✓	✓
HL-UC 4	✓	✓	✓	✓	✓
HL-UC 5				✓	
HL-UC 6		✓	✓	✓	✓
HL-UC 7	✓	✓	✓	✓	✓

A.6 KPIs

Following the GRID+ methodology, 52 KPIs are defined. Sixteen of them belong in the “specific” category, while the rest of them are defined according to the WiseGRID project needs and are, therefore, categorized as “project” KPIs. Furthermore, the relevance of each KPI in quantifying the WiseGRID project impacts is identified either as direct or as indirect (i.e. the improvement observed in a KPI with direct relevance can be attributed directly to the solutions proposed within the Project), resulting in 34 KPIs that measure the direct impact of the WiseGRID solutions and 18 KPIs that measure the indirect impact. Last but not least, even though each KPIs is defined only once, there may be identified more than one PUCs to which a KPI is relevant.

The list of identified KPIs is provided below for information:

Increased RES and DER hosting capacity

KPI_1_Increased RES and DER hosting capacity

Reduced energy curtailment of RES and DER

KPI_2_RES curtailment

Power quality and quality of supply

KPI_3_SAIDI

KPI_5_CAIDI

KPI_7_LV faults clearance time index

KPI_8_Voltage variation

KPI_9_Frequency deviation

Increased flexibility from energy players

KPI_12_VPP participation in flexibility requests

KPI_13_Increased EV demand flexibility availability

KPI_14_Increased demand flexibility execution

Improved competitiveness of the electricity market

KPI_16_Improved competitiveness of the electricity market

Project specific KPIs

KPI_17_Ancillary services cost

KPI_18_Load forecasting accuracy

KPI_20_System awareness total time latency

KPI_22_State estimation convergence

KPI_23_Data validation ratio

KPI_24_Assets data collection reliability

KPI_25_Technical losses

KPI_26_Energy generation capability per investment ratio

KPI_27_ Network RES visibility

KPI_28_GHG emissions

KPI_29_Flexibility forecasting accuracy

KPI_31_Supplier portfolio imbalance

KPI_32_EVSE data collection reliability

KPI_33_EVSE availability index

KPI_34_EVSE average communication failure duration

KPI_35_EVSE average communication failure frequency

KPI_36_Success in meeting user charging objectives

KPI_39_Battery balance

KPI_40_Reaction time improvement for providing primary control reserve

KPI_41_Penetration of dynamic energy tariffs

KPI_42_Demand response campaign penetration

KPI_43_Peak load

KPI_44_Peak-to-average ratio

KPI_45_Net metering

KPI_46_Self-consumption ratio

KPI_47_Self-sufficiency

KPI_48_Energy cost

KPI_49_Energy savings

KPI_50_Flexibility on offer

KPI_51_Comfort Level

KPI_52_Optimal use of thermal resources

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