Platone

PLATFORM FOR OPERATION OF DISTRIBUTION NETWORKS

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PLATform for Operation of distribution NEtworks

D7.1 v1.0

Definition of data to be collected from the field to perform the analyses

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Abstract

This deliverable aims at identifying the set of data necessary (i) to represent the technical boundary conditions for performing the Scalability and Replicability Analyses (SRA) of the smart grid solutions implemented in the Platone demos as well as for the Multi-criteria Cost Benefit Analysis (MC-CBA) and (ii) to elaborate the representative networks to be used in the respective simulations. Furthermore, a preliminary introduction to the methodologies that will be used in Platone for the SRA is given. Preliminary information on how the general SRA methodologies will be adapted is provided following a per-demo approach. The first version of the methodologies to be followed for the SRA and MC-CBA will be elaborated in the upcoming deliverables D7.2 and D7.3, respectively.

Keyword list

Use cases – KPIs – DSOs – grid observability – Multi Criteria Cost Benefit Analysis – Scalability and Replicability Analysis

Executive Summary

Deliverable D7.1 aims at providing a short description of the types of data that are requested in order to perform cost benefit and scalability and replicability analyses. Moreover, the present deliverable reports some aspects of the methodologies that will be used for the scalability and replicability analysis, to justify the list of data that are requested.

The activities reported in the present deliverable enable the members of Platone project to achieve the following results:

1. To identify, after an overview of the existing methodologies for scalability and replicability analysis developed by past projects, the most important parameters that shall be included in the methodologies for scalability and replicability analysis of the Platone demos that will be described in detail in D 7.2;
2. To identify, for each of the 3 demonstrators included in the Platone project, the use cases that will be investigated in scalability and replicability analysis and to identify, for each use case, the most relevant parameters and data that shall be obtained in order to perform the analysis;
3. To identify the set of relevant data that shall be provided by demo leaders to perform the Scalability and Replicability and the Cost Benefit Analysis;
4. To identify the set of relevant data that shall be exchanged with demo leaders to elaborate a specific set of representative networks.

In particular, regarding the result #1, the Platone project develops a quantitative approach for the scalability and replicability analysis based on simulation models that will estimate how relevant technical, economic and regulatory conditions will impact on the success of the implementation of the solutions tested in the demos. The approach comprises two main stages: (i) technical analysis, and (ii) non-technical analysis to incorporate other boundary conditions: economic considerations, regulatory framework, and stakeholder acceptance. The technical analysis of the Scalability and Replicability Analysis potential is based on the evaluation of Key Performance Indicators (KPI) to measure the impact of the smart grid use cases. In the demonstrators, KPIs are measured under the specific local boundary conditions; in the Scalability and Replicability Analysis, simulation models will be built to assess these KPIs under different boundary conditions. These models will be validated and fine-tuned by comparing the KPIs registered in the demos and those obtained from simulation modelling the conditions of the demo. Then, further simulations will be performed to study the influence of different conditions on the performance of the tested solutions. The scalability analysis is conducted calculating (with simulations), for each demo, the relevant KPIs in a baseline scenario in which the solution was not yet implemented and a scenario that considers the full deployment of the solution. The replicability analysis is performed by calculating KPIs when the solutions are replicated in other representative networks that describe the characteristics of the European distribution systems. The data set that is requested in order to perform the scalability and replicability analysis includes information about the technical characteristics of the networks (e.g.: line length; sizes of transformers and substations; etc.) but also about the characteristic of customers connected to the grid (load, distributed generators, electric vehicle, storage units). The techniques for the Cost Benefit Analysis aim at providing ex-ante evaluation of business models or technical solutions in terms of weighting costs against the corresponding benefits. The Multi-Criteria CBA (MC-CBA) expands on the concept by introducing various non-monetized aspects to the benefits list. In Platone, the MC-CBA approach is followed to align with and expand on well-established approaches such as the EPRI and ISGAN methodologies. In the project, context demo specific and project-wide KPIs will be employed to assist the CBA. The total dataset that is requested by the demo leaders for the purposes of the CBA is built upon these ideas and includes asset costs, benefits under baseline scenarios and benefits under full solution deployment.

Regarding the results #2 and #3, the following achievements were obtained.

The scalability and replicability analysis for the Italian demo is focused on two use cases:

- Congestion management: this use case aims at verifying the contributions that the activation of flexibility sources (provided by loads, DG and EV) could provide to the DSO to solve local congestions that might occur on the grids due to a local emergency or might be caused by a request of ancillary services elaborated by the TSO.

- Voltage control: this use case aims at verifying the contributions that the activation of flexibility sources (provided by loads, DG and EV) could provide to the DSO for the aim to solve local voltage violations that might occur on the grids.

In the two use cases, different rates of actual demand response will be tested to quantify how much volume of flexibility (provided by loads, EV and DG) should be acquired by the DSO to solve congestion or voltage problems. The analysis will assess the variations of KPIs that measure the reduction of congestions and the avoided overvoltages when the solutions are deployed at a larger scale. Other types of networks will be analysed to evaluate the replicability for different types of areas (urban, sub-urban and rural) or feeder lengths. In order to perform these analyses, the data that are needed, the expected scenarios in terms of penetration of DG, EV and flexible loads in the reference network and in the other representative networks, will be defined in the next steps of WP7.

The Scalability and Replicability Analysis for the German demo considers the use case DE-2 (Flexibility provision). A set of baseline scenarios will be defined by taking into account the characteristic profiles of load and generation assets. In the simulations for the baseline scenarios two different constraints will be imposed in the node that connects the distribution grid to the transmission grid ($P'_{breaker}$) i.e. $P'_{breaker}$ equal to 0 (virtual Islanding) and $P'_{breaker}$ equal to an externally defined target value (to simulate a request of export of power produced in the local energy community). For the baseline scenarios, load flow analyses will be run to compute voltage profiles as well as active and reactive power flows. Since there are no voltage/frequency control strategies implemented in the demo and these are out of scope in this context, the computation of voltage profiles will aim purely at assessing potential voltage violations, without evaluating any corrective measure. Moreover, an Optimal Power Flow will be run to verify that the energy dispatching does not cause grid congestions and, in the case of problems, to identify the users' flexibility request. First, the scalability (in size and density) of this UC will be evaluated by considering different degrees of penetration of flexibility solutions that are already present in the demo (e.g.: characteristics and numbers of storage units; amount of controllable loads; different penetrations of DG units). Considering some of these parameters, suitable scenarios will be defined and some selected output variables/KPIs will be computed and the differences with respect to the correspondent values for the baseline scenarios will be evaluated. Then, intra-national replicability of the results will be analyzed considering types of networks which are different from that of the baseline scenario (rural network) but with the same regulatory boundary conditions. Finally, international replicability will also be analyzed to consider different regulatory conditions (e.g.: different voltage limitation allowed by the national regulation) with respect to the ones found in the demo country. The same parameters will be assessed again to perform the previous analyses. In order to perform these analyses, the data that are needed, scenarios about the expected penetration of Distributed Generators (and the different production profiles of the various kinds of distributed generators connected to the grid), EV and flexible loads in the reference network and in the other representative networks, will be defined in the next steps of WP7. The objective of UC-GR-3 is to use network tariffs in order to incentivise a more efficient operation of the network while respecting operation limits (voltages, lines overload). In the scalability and replicability analysis, load flow analysis will be performed in the network to identify network constraints that will arise from the increased penetration of EV, distributed generations and demand. Consequently, an Optimal Power flow will be performed to identify the needs for flexibility sources to be activated to solve local congestions. These analyses aim at identifying the avoided overload and overvoltages in consequence of the activation of flexibility sources. The scalability analysis in the demo area will assess the impact of an increased penetration of technologies that are already deployed in the demo (in particular PV) and an increased penetration of flexible loads enabled by real time tariffs. The replicability intra national will assess the impact of the penetration of different technological solutions that are not yet present in demo areas like electric vehicles (in the short term) and storage (in the long term). Replicability analysis at international level will affect the impact of the solution when deployed in regions with different regulatory boundary conditions (e.g.: different voltage limitations, different tariff schemes; etc.) or in regions characterized by different types of networks (instead of a semi-rural area, island, urban areas or rural area will be considered).

The Cost Benefit Analysis requires as data input:

- The KPI values in Business as Usual or baseline scenarios that are measured without the deployment of the corresponding asset for which the CBA is performed.
- The corresponding KPI after the deployment of the asset under analysis to evaluate the relative benefit between the two cases.

These two data entries cover the *benefit* part of the Cost-Benefit Analysis. For the *cost* part each asset under evaluation should come with a cost of purchase, or deployment and maintenance or both. Therefore one more data entry required by the demos for the CBA is represented by the cost of purchase, deployment, maintenance or other associated with each individual asset deployed for the Platone demonstrations and evaluated by the CBA of the project.

Regarding the results #4 WP7 has started to set up an interactive and iterative process with demo leaders with the aim of collecting the set of needed data so to effectively represent the typical architectures, topologies and characteristics of the actual MV and LV distribution grid. The different representative networks will typically reflect the different types of areas in terms of population density and use of electricity, corresponding to rural/urban/industrial/residential areas and will be used to compute the reference values of the Key Performance Indicators that will be evaluated in the Scalability and Replicability Analysis. The template that was circulated to demo leaders for collecting this information is reported in Annex A.

As a conclusion from this exercise, it can be noticed that the main challenges in the process of identification of data relevant for the analyses are represented by: the level of confidentiality associated to specific set of data (e.g.: network characteristics; customers profiles, etc.) and the procedures for accessing and exchanging data among partners. In order to cope with these constraints, in the future deliverables of WP7 the data that would be collected in this process will be described in only aggregated manner.

The next steps of WP7 will encompass:

- An iterative process between WP7 and the Platone demo leaders to perform the collection of the data required for the SRA and MC-CBA and to identifying the services that can be requested by the DSO to the active customers thanks to the deployment of the Platone platform.
- The elaboration of a first integrated version of the methodologies to be followed for the SRA which will be the scope of the deliverables D7.2 expected at M24 of the project.

It is noteworthy that these main steps are expected to benefit from the further and more detailed level of information that will come from the Platone demos (and the described in deliverables 5.3 and 3.1 that are expected at month 18 and 24 respectively), taking into account the most recent progress of each demo.

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1 Introduction

The project "PLATform for Operation of distribution Networks – Platone - aims to develop an architecture for testing and implementing a data acquisitions system based on a two-layer approach (an access layer for customers and distribution system operator (DSO) observability layer) that will allow greater stakeholder involvement and will enable an efficient and smart network management. The tools used for this purpose will be based on platforms able to receive data from different sources, such as weather forecasting systems or distributed smart devices spread all over the urban area. These platforms, by talking to each other and exchanging data, will allow collecting and elaborating information useful for DSOs, transmission system operators (TSOs), customers and aggregators. In particular, the DSO will invest in a standard, open, non-discriminating, economic dispute settlement blockchain-based infrastructure, to give to both the customers and to the aggregator the possibility to more easily become flexibility market players. This solution will see the DSO evolve into a new form: a market enabler for end users and a smarter observer of the distribution network. By defining this innovative two-layer architecture, Platone removes technical barriers to the achievement of a carbon-free society by 2050 [1], creating the ecosystem for new market mechanisms for a rapid roll out among DSOs and for a large involvement of customers in the active management of grids and in the flexibility markets. The Platone platform will be tested in three European trials (Greek, Germany and Italy) and within the Distributed Energy Management Initiative (DEMI) in Canada. The Platone consortium aims to go for a commercial exploitation of the results after the project is finished. Within the H2020 programme "A single, smart European electricity grid" Platone addresses the topic "Flexibility and retail market options for the distribution grid".

To pave the way for the successful rollout of the innovative solutions tested in the demos, Platone projects addresses also the topics of scalability and replicability analysis (SRA) and cost benefit analysis (CBA), to identify the possible technical, economic and regulatory barriers that might limit the large-scale deployment of innovative solutions.

1.1 Objectives of the Work Reported in this Deliverable

Deliverable D7.1 aims at describing the data that will be needed to perform the scalability and replicability analysis and cost benefit analysis. In order to motivate and contextualize the identification of the preliminary list of data to be collected in the present report, D7.1 anticipates also some elements that describe the methodologies that will be used to perform the Scalability and Replicability Analysis. The methodologies for Scalability and Replicability and Cost Benefit Analysis will be described in the upcoming deliverables of WP7 (D7.2 and D7.3). Moreover, D7.1 provides a description of the data that will be used for defining the representative networks

1.2 Outline of the Deliverable

Chapter 2 provides an overview of the existing methodologies for scalability and replicability analysis and cost benefit analysis that have been developed by past European and national projects and describes the contributions that Platone will provide for the improvement of these methodologies, Chapter 4 provides an overview of the demo use cases that will be addressed by the SRA and describes the methodologies that will for SRA be used in the next steps. Chapter 5 describes the data that will be requested for performing CBA and SRA, Chapter 6 presents the preliminary data collection process for the definition of the representative networks to be used in the SRA activities and describes a potential link with a recent work in the field of the representative networks performed by the Joint Research Centre. Finally, Chapter 7 describes the next steps that will be reported in the future deliverables of WP7. Annex A reports a template for data collection of the information that will be used for defining the representative networks.

1.3 How to Read this Document

D7.1 represents the first steps of the WP7 activities and aims at providing input for the definitions of future deliverables of WP7 (in particular the analysis of Scalability and Replicability and Cost Benefit Analysis that will be performed in D7.4. The input that has been used in this report comes from D1.1 [2], (in particular the list of Use Cases), D4.1 [3] and D5.2 [4].

2 Why SRA and MCBA are needed

The modernization of the European electricity grids is a key priority of the European energy policy that must be achieved in order to safely integrate renewable and decentralized generation, improve energy efficiency, and integrate the active consumers in the energy system. Several European and National research programs are investigating new technologies and solutions aimed at addressing these challenges. These challenges are affecting the way in which energy producers, operators, regulators, and consumers interact in an increasingly complex market. A significant transformation of the existing European electricity grids is required to mitigate these challenges while preserving an adequate level of quality of service. Such a change will not happen in the medium to long term without further development and rollout of innovative solutions that enable the deployment of technological innovations, innovative business models and schemes that guarantee a fair reward for the services. The European Commission, acknowledged the risks and the threats that an inadequate integration of energy market might pose to end users in terms of inadequate market development, ageing of existing infrastructure, lack of adequate interconnections, insufficient level of security of supply, increase of energy prices, lack of competitiveness of European industries and research and innovation centres and proposed, with the adoption of the Energy Union Package, a framework strategy for a resilient Energy Union with a forward-looking climate change policy. The package aims at achieving in a cost – effective way a fundamental transformation of Europe's energy system. This change will be obtained by moving to smarter, more flexible, more decentralized, more integrated, more sustainable, secure and competitive ways of delivering energy to consumers that can be obtained only if innovative technologies and regulatory and market solutions will be developed and integrated in the existing European electricity networks. In order to speed up the shift from the stage of industrial research to the market uptake of the most innovative solutions, the specifications of the theme recommend developing methodologies to ensure that the solutions demonstrated can be scaled up and replicated and to address the non-technical issues such as public acceptance of grid infrastructures and the acceptance of new market designs and products by all stakeholders and to harmonise regulation and legal framework. In fact, as stated in several papers [5] and reports [6], [7], a lack of adequate assessment of the impacts of the large scale deployment of innovative solutions tested in the demos on the existing network will result in a commercial failure thus originating the concept of the "Valley of Death": a point where a business, (often a technology based business), has a working prototype for a product or service that has not yet been sufficiently developed to earn money through commercial sales. The transition from the research to the deployment phase is a crucial and risky step in the process.

The so called the 'Valley of Death' occurs when there is a lack of communication and expertise between the companies or institutions that deal with research of innovation business and those on the commercialization side. In these situations, the economic profitability of a given solution and/or the technical, economic aspects related to the integration in the existing market of a given prototype were not adequately addressed and the barriers related to market and stakeholder's acceptance haven't been investigated [6]. In order to limit the risk that the solutions tested in Platone might fall into the so called "valley of Death", it is important to develop methodologies and tools to ensure that the solutions demonstrated can be scaled up and replicated taking into account the actual regulatory and markets frameworks and stakeholder acceptance potentials. These methods need to address not only technical aspects, but also the non-technical issues such as public acceptance of grid infrastructures or new market designs and products by all stakeholders and to harmonize regulation and legal framework. Moreover, the Multi Criteria Cost Benefit Analysis (CBA) shall be also taken into account in order to evaluate which parameters can influence the economic profitability of a given solution. The combination of the traditional methodologies for CBA with elements of the methodologies for the multi-criteria analysis can help the decision makers to appreciate the benefits enabled by the Platone solutions with respect to other alternative of investments. In fact, these analyses are fundamental in order to support the large scale deployment of the solutions and to avoid that the solutions tested in the demos might not be deployed at a larger scale because of technical, economic, regulatory or societal barriers that might emerge when the project is deployed in a larger area and/or under different boundary conditions. The Platone project comprises three demonstrators that will test different Smart Grids solutions on real distribution networks at different locations. The results obtained will provide useful information on the impact of the implemented Smart Grids solutions, based on the evaluation of the Key Performance Indicators (KPIs) for different real-life conditions. However, these demonstrators will be conditioned by the technical, regulatory, environmental and social context of each location. Therefore, the impacts of the different tested smart solutions observed in the demonstrators are usually not directly applicable for different contexts and implementations. Therefore, a thorough analysis must be performed to understand the effects of implementing similar solutions at a larger scale or under different contexts that may be found across Europe. This is the so-called scalability and replicability analysis or SRA.

3 Overview of existing approaches

3.1 Definition

Different approaches have been developed by important EU projects such as GRID+ [8], GRID4EU [9], and IGREENGRID [10], to investigate the scalability and replicability potential of the solutions tested in smart grids pilot projects. The methodology that will be followed to carry out the SRA will be described in D 7.2. Nonetheless, it is firstly needed to clarify and describe the major concepts related to scalability and replicability for a correct design and understanding of the methodology. Thus, the concepts of scalability and replicability may be defined as follows:

- Scalability: the ability of a system, network or process to increase its size/scope/range in order to adequately meet a growth in the demand of a given product or service [11];
- Replicability: the ability of a system, network or process to be duplicated in another location or time [11].

The definitions of scalability and replicability could be applied both to simple and complex systems. In case of simple systems, scaling laws describes the relationship between the variation of the dimensions of physical systems and the change of a measurement of output. These scaling laws are practical for deterministic and simple systems that can be described using physics-based equations. However, due to the complexity and the emergent behaviours that characterize engineering systems, these scaling laws are not necessarily applicable to describe complex systems and more articulated models are required to describe the behaviour of industrial systems better. Concerning complex systems, different industrial sectors have systematically analysed the topics of scalability and the replicability analysis of systems, prototypes, and components. For example, several studies (see [12] [11] [13]) have addressed the scalability and replicability potential of sectors like embedded sensor systems, distributed systems, embedding smart relays, substation automation, nuclear power generation air transportation systems, renewables inverters. However, no scaling laws as in the case of simple systems exist [8]. In general, system engineering, in order to shift from the prototyping stage towards the commercial deployment, should provide a systematic engineering methodology to deliver scalable systems and should incorporate the necessary means to guarantee scalability in the design principles.

The analysis of these studies resulted in the identification of a list of common drivers for scalability and replicability. The primary drivers for scalability are:

- Technology evolution: this driver consists of developing a technology that could improve its performances when deployed at large scale (learning curves).
- Design of appropriate interfaces: this driver enables a smart interaction with users and simplify the process of adding new components. For example, the use of distributed control system could simplify the process of connecting new users to the system because the costs associated with this process are lower than the expenses related to a central control system. This choice could, therefore, ease the process of scalability of the proposed solution.
- Modularity: this driver has been identified in the sectors of sensors networks and substation automation. The use of modular components allows the addition of new system utility functions.

Drivers for replicability include then:

- Technological standardization: the establishment of internationally licensed products improve their replication potential as in the case of Westinghouse's PWR nuclear power plants which have been deployed all around the world.
- Interoperability: open and universal standards allow deploying a solution elsewhere with elements applying the same standards.
- Regulatory conditions: the analysis of the regulatory context can identify possible barriers that might limit the deployment of smart grid technologies.
- Plug & play characteristics: reuse of already adopted and proved engineering and maintenance tools that could be directly connected to the existing grids.

3.1.1 Scalability and Replicability Analysis

Several European and national pilot projects have tackled this issue and developed original methodologies to address the challenges and carried out simulations and analyses that have been used to elaborate scalability and replicability (SRA) rules [11]. The aim of this section is to describe the methodologies developed by the most important European projects (GRID+; GRID4EU; IGREENGRID) that have addressed the topic. This challenge represents an innovative research topic, that was not yet adequately addressed by the scientific literature, as stated by [12]; therefore all the projects adopted a learning by doing approach, based on knowledge of the experts involved in the research programs and interview with relevant stakeholders.

The three approaches adopted by GRID+; GRID4EU and IGREENGRID while being significantly different, can be broadly categorized into "qualitative approaches" (GRID+ methodology) or "quantitative approaches" (proposed by GRID4EU and IGREENGRID).

Qualitative approaches, like the one developed by GRID+, aim at assessing ex ante the scalability and replicability potential of the smart grid projects. These approaches identify a set of technical, economic and regulatory parameters that shall be are used to develop a check list that shall be used by developers of smart grids projects in order to evaluate if the demo address the minimum requirements to be successfully replicated or scaled up in real life. Examples of these parameters and checklist are reported in Figure 1, Figure 2, and Figure 3.

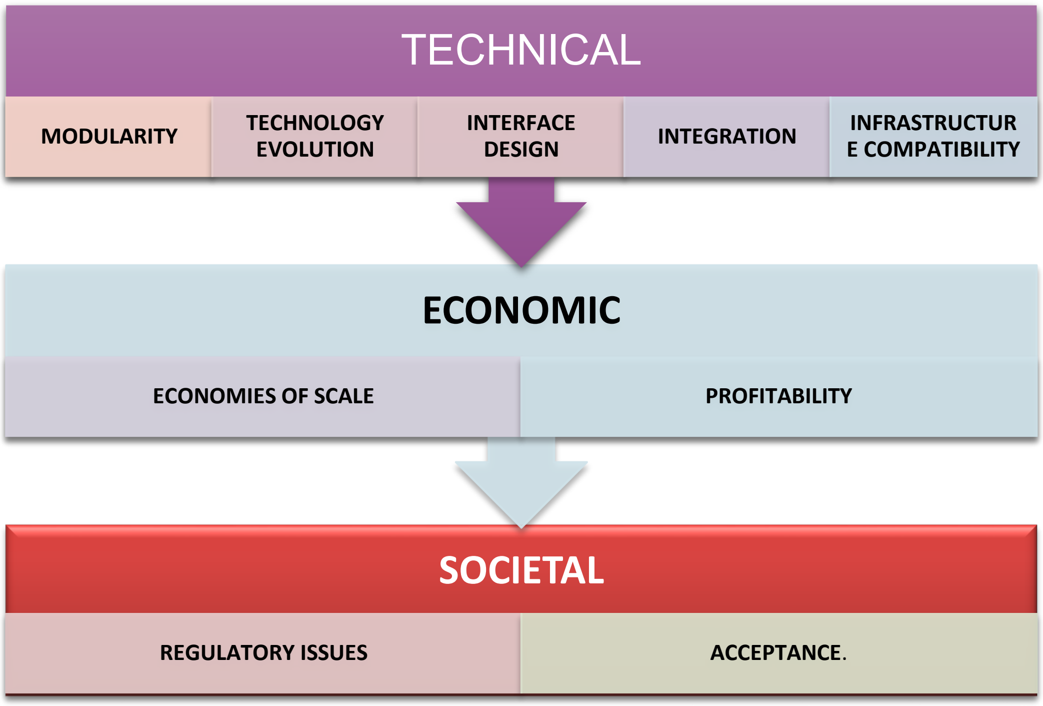

Figure 1: Example of a qualitative parameters for Scalability analysis (developed by GRID+) (source: [8])

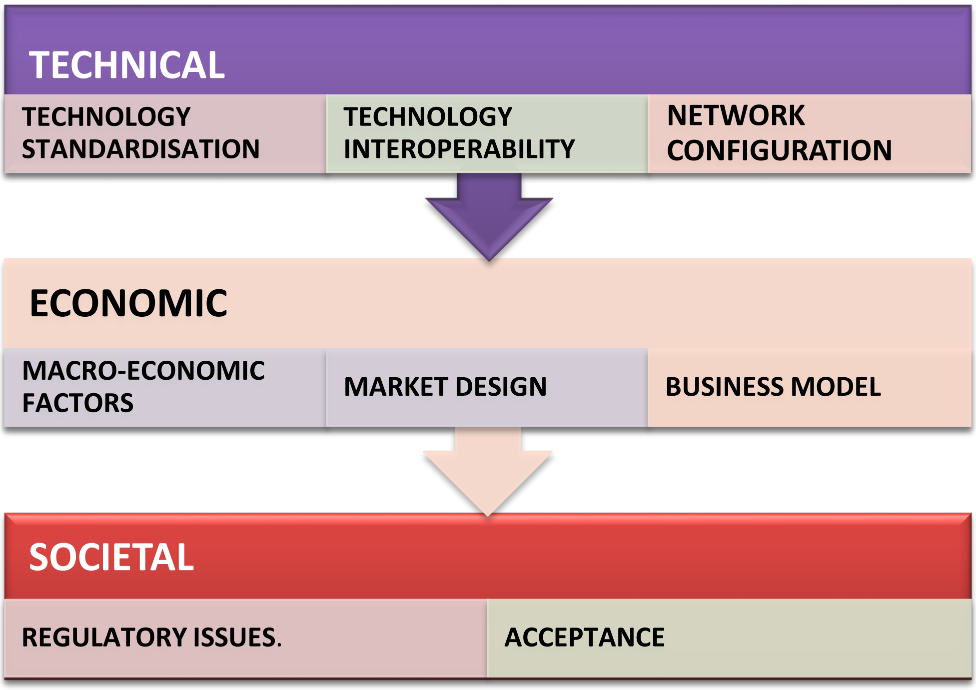

Figure 2: Example of a qualitative parameters for Replicability analysis (developed by GRID+) (source: [8])

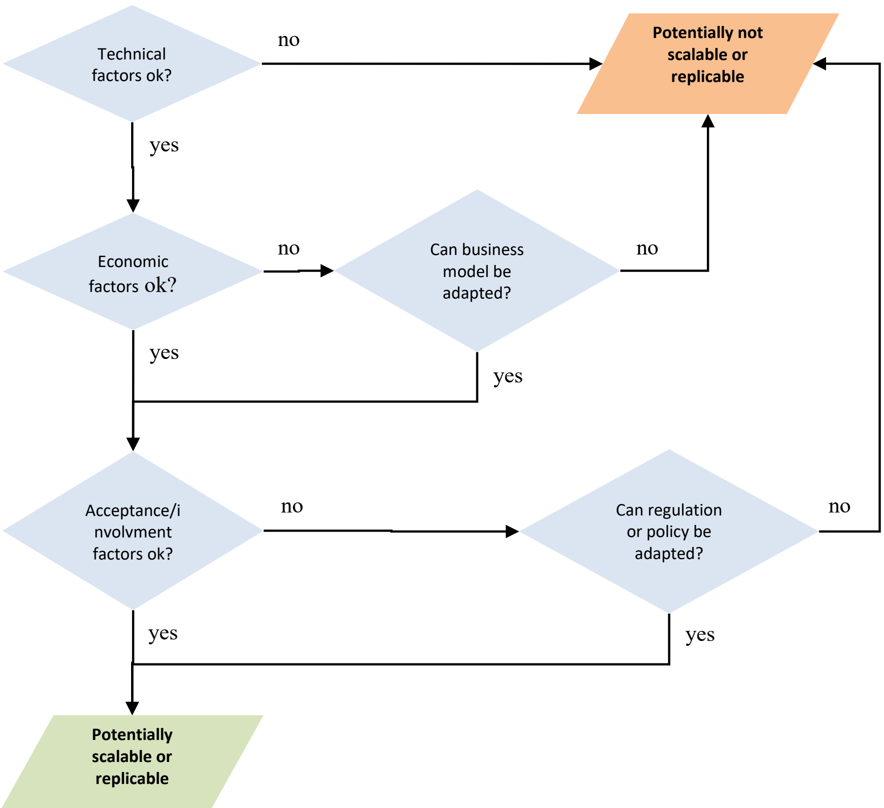

Figure 3: Example of a qualitative methodology for Scalability and Replicability Analysis (developed by GRID+) (source: [8])

The qualitative approaches aim at identifying the aspects that haven't been address adequately in the demo stage and shall be further integrated in ex post analysis in order to ensure a smooth deployment of the analysed solutions.

Quantitative approaches complement the analysis of qualitative parameters with calculations and simulations (e.g. load flows, optimal power flows, etc.) that aim at quantifying the variations of project KPIs when the boundary conditions in which the demos are deployed vary or when the solutions tested in the demos are deployed at a larger scale.

An example of quantitative methodology (developed by the IGREENGRID project) is illustrated in Figure 4. This quantitative assessment aims at evaluating the variation of a project KPI HC (hosting capacity) when the solution tested in the project is deployed at larger area.

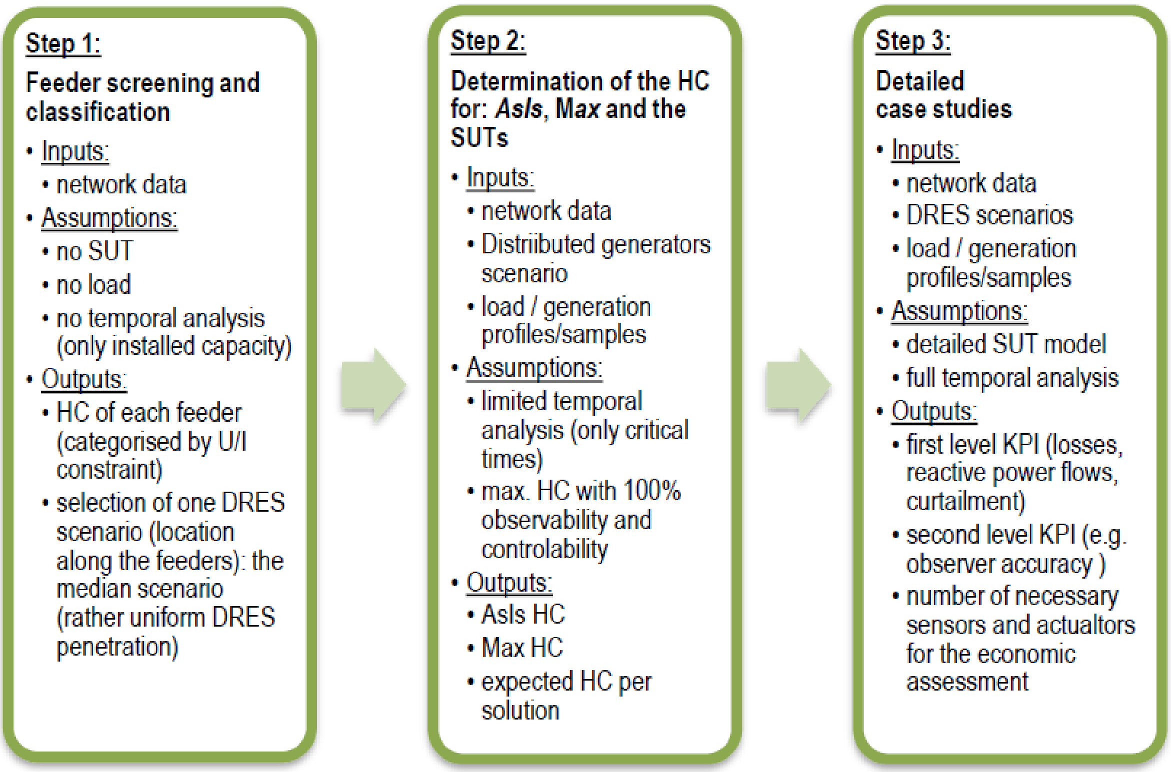

Figure 4: Example of a quantitative methodology for Scalability and Replicability Analysis (developed by the IGREENGRID project: source: [11])

The IGREENGRID methodology for SRA can be mainly divided into three main steps as illustrated in Figure 4. More in details, they can be described as follows:

- The first step consists of an initial analysis of the characteristics of the grid in a baseline scenario without the Solution Under Test (SUT). Investigation identifies the current constraints and potential bottlenecks of the networks before the implementation of the SUT. For each single distribution of generation, the hosting capacity is evaluated by scaling up the power of each generator according to the distribution along the feeder until one of the constraints (voltage/current) is reached
- The second step aims at determining a more realistic hosting capacity value for the following cases:
    - without any modification: “AsIs” hosting capacity (network as it is, without reinforcement and without smart grids solutions).
    - with a perfect control assuming 100 % observability and 100 % controllability:
- In the third step, for the detailed case-studies, more accurate models of the solutions under tests are used and the full temporal analysis (i.e. using load and generation samples generated from time series) is done to be able to evaluate integral values (e.g. annual network losses or curtailment). By using a detailed model of the solutions, their actual performance (e.g. accuracy) can be assessed. First, the solutions are implemented and simulated for the full set of samples

collected from field measurements. Finally, the simulation results are analysed and then processed to extract performance indicators (e.g. hosting capacity increase, losses, curtailment, observer accuracy, etc.).

Another example of quantitative methodology for Scalability and Replicability analysis is provided by the GRID4EU project and illustrated in Figure 5.

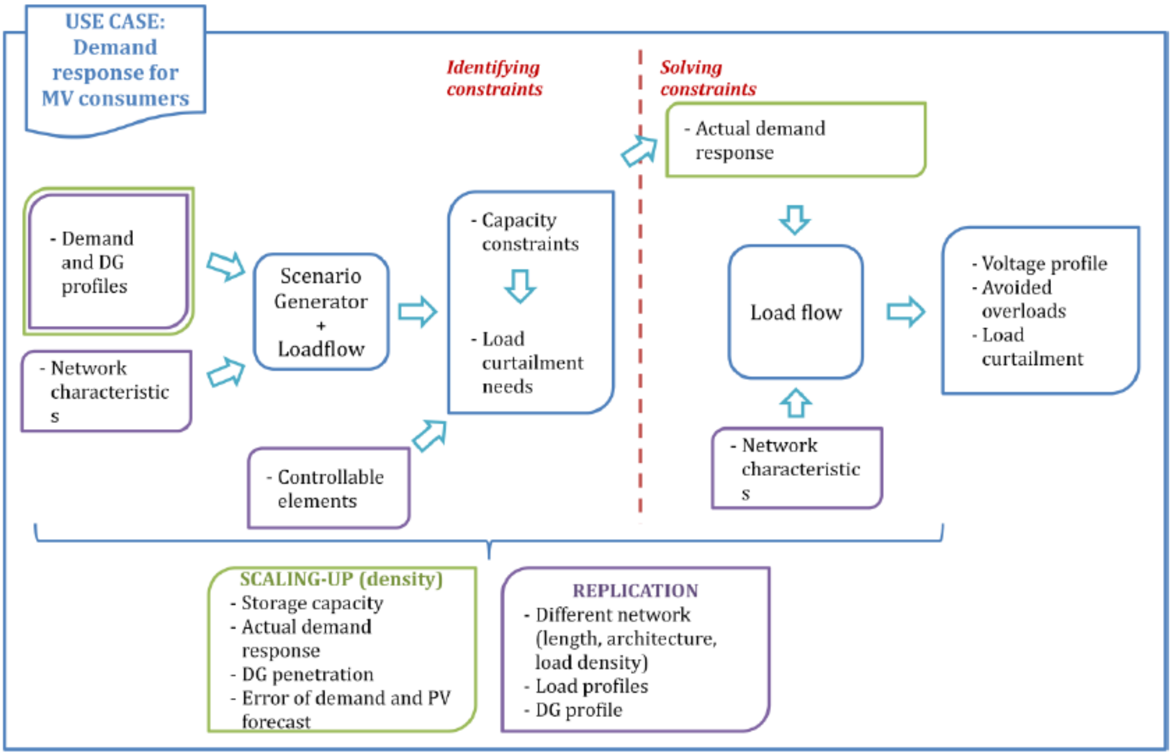

Figure 5: Methodology for Scalability and Replicability Analysis developed by GRID4EU for the analysis of the use case use case of reduction of power demand. (Source: [9])

This use case consists in the curtailment of MV controllable loads under situations where some network constraint, i.e. voltage limits in MV and thermal capacity in MV or HV, is violated. The request for demand reduction can be performed by the DSO and performed by means of automatic load shedding according to the contractual agreement with consumers. The SRA aims at evaluating how the project KPIs (voltage profile, network hosting capacity, active and reactive power flows, avoided congestions or overloads) considering load and generation scenarios with different demand response rates, avoided overloads and avoided excessive voltage drops may be estimated. Different scenarios of generation and demand as well as batteries' State of Charges (SoC) will be analysed. Thus, the impact of different generation and demand profiles to be simulated in the load flow analysis. Additionally, this model will provide the value of load that is necessary to curtail under different network situations, which can be a useful indicator of the effect of the use case. Qualitative methods are based on the analysis of the physical architecture of the systems and of the specific characteristics of the different components of the demos, i.e. they can be characterized as being technology-oriented. They can be applied to a broad range of smart grid solutions, as they are not closely related to the functions implemented by the demonstrator analysed. These methodologies do not require the development of simulation models, and the results consist in the identification of the potential technical, economic and regulatory barriers that might limit the large-scale deployment of the most promising solutions. Therefore, they can be used by the project proposers at the design phase as a tool that verifies that the demonstrator includes the minimum requirements that enable to scale and replicate the results easily and to prepare a successful roll-up of the most promising solutions. Quantitative methodologies are functionality-oriented, i.e. they do not focus on the specific components and devices of the solutions demonstrated but on the scalability and replicability potential of the concepts and solutions implemented. For instance, the case of network automation, they would not evaluate the modularity or standardization of communications and control technologies, but on what effect such smart grid functionality would have on different types of distribution grids or at different penetration levels. The expected impact is quantified through the corresponding KPIs, e.g. hosting capacity for DG, energy losses, reliability indices, etc. The aim of Platone project is to develop quantitative approaches for the Scalability and replicability Analysis that follows the steps identified in Figure 4 and Figure 5 and to complement these analysis with the inclusions of the parameters identified in the most outstanding qualitative approach (see Figure 2)

Scalability

The analysis of scalability aims at answering the question “what to expect if the use case were to be implemented at a larger scale under the same boundary conditions?” The implementation of a use case at a larger scale could mean the implementation of a higher degree of smartness, a larger area of action, the engagement of a larger number of consumers, the penetration of higher volumes of distributed resources, etc. In this regard, scaling-up may be classified according to the two main dimensions

- Scalability in **density**: This analysis includes the evaluation of the effects of the increased penetration of a given solution within the same area that hosts the demo: e.g.: higher penetration degree of distributed generation in the network, higher degree of flexibility of consumers, higher degree of network automation, etc.
- Scalability in **size**: This analysis includes the evaluation of the effects of the deployment of a given solution at a larger scale involving different types of areas within a region or country.

In order to analyse scalability, sensitivity to all aspects (technical, economic, regulatory and stakeholder related) involved in a larger-scale implementation must be studied.

- Technical aspects would include technical parameters such as: size of the network, number and size of consumers, peak demand, number size and location of distributed resources, etc. Additional technical aspects to take into account could include saturation effects for network hosting capacity, overloading of lines and transformers, simultaneity factors, saturation of the potential for load shifting, etc.
- Economic aspects to analyse would mainly comprise the economic signals received by different agents.
- Stakeholder acceptance aspects address the potential of acceptance of the solution by key stakeholders in another context.

Replicability

The analysis of replicability aims at answering the question “what to expect if the use case were to be implemented at a different location, where different boundary conditions can be found?” In order to analyse replicability, different scenarios must be considered and sensitivity to the main parameters that constitute the boundary conditions of the demonstrator. The dimensions of a replication analysis are:

- Intranational replication: it addresses the analysis of the replication of the same solution in the same country that hosts the demo but in situations in which technical boundary conditions may differ, but the same economic and regulatory boundary conditions prevail and the different stakeholders have similar points of view. Variations in the penetration degree of distributed resources, degree of automation in the network, impact of demand side management, etc. will be also studied, to account for the effect of changes in the regulatory and stakeholder related boundary conditions
- International replication: it addresses the analysis of the replication of the same solution when all types of boundary conditions may differ from those in the demo site due to different regulation schemes and incentives, different economic situations, different strategies from policy makers and distribution companies, different types of networks, different social concerns, etc.

The impact of different boundary conditions will also be assessed, thus identifying identification of best-practices or more-friendly boundary conditions. Figure 6 summarizes the methodology proposed by the Platone approach for the analysis of the scalability and replicability analysis of the relevant use cases identified in the 3 pilots included in the project.

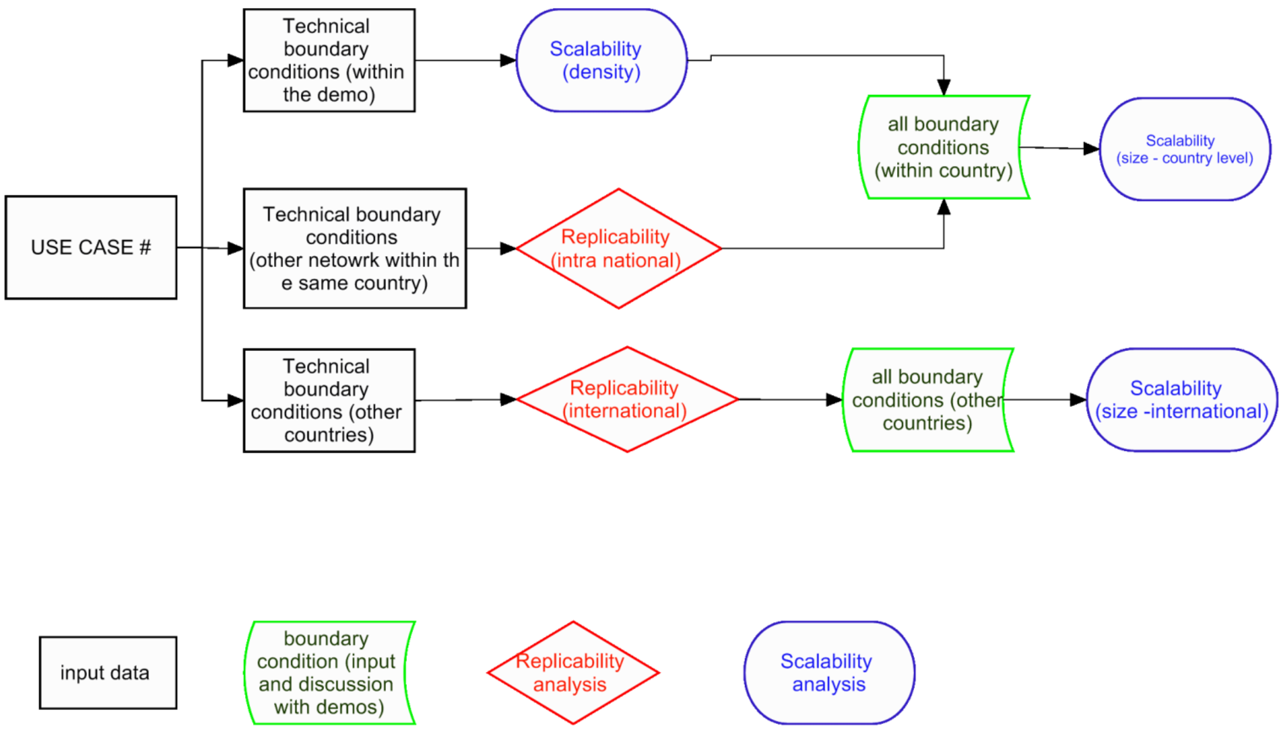

Figure 6 – Step by step application of the SRA methodology for the analysis of the relevant use cases

As already explained, the objective of scaling-up and replication analysis is to assess the expected outcome of implementing the use cases tested in the demonstrators under different conditions. For this purpose, sensitivity of the expected values of the KPIs and other relevant indicators to different parameters will be analysed. Thus, the SRA can be summarized in the following steps:

1) **Scaling-up in density** will be analysed to determine the effect that would be obtained if the use case were implemented in the same network, but at a larger scale regarding density aspects such as: larger penetration of DG in the network, higher demand in terms of contracted power or new consumers, higher degree of demand response in terms of number of engaged consumers or higher shares of “shiftable” or “sheddable” load and higher amounts of storage connected to the network. Different values will be given to the technical input parameters related to these aspects and the new values of relevant indicators will be recalculated with the simulation tools.
2) **Replicability within the country.** Different networks are studied, computing KPIs for different types of representative networks (urban / sub-urban /rural /industrial). The technical parameters that will have to be re-adjusted need to include network configuration (architecture, length of feeders, typical values of cables and lines parameters such as resistance, reactance and thermal limits), reliability levels (protection schemes, typical values of reliability indices) and density of demand (number of consumers per feeder length, amount of power contracted, number of substations per km2, installed capacity of MV/LV transformer substations), typical consumption profiles and characterisation of DG connected in the network (technologies, size, penetration degree). This analysis is focused on, thus assuming the same boundary conditions of the demo regarding regulatory aspects and stakeholder acceptance.
3) **Scaling-up in size**. Scalability of the use case will be analysed, considering the implementation at a larger scale throughout the country to establish guidelines regarding its feasibility and advisability.
4) **Replicability international**. Replicability will be analysed to consider different boundary conditions to assess the potential effect of the use cases in other countries.

3.1.2 Cost Benefit Analysis

The application of Multi-Criteria Analysis (MCA) and Cost-Benefit Analysis (CBA) is part of the Task 7.3 of the Platone project, along with the Scalability and Replicability Analysis which collectively form Work Package 7.

The Multi-Criteria Analysis and Cost-Benefit Analysis are innovative business models which can provide an ex-ante evaluation of design and development options for large projects to the investors and governments. The main purpose of those analyses is to evaluate and identify the benefits and the beneficiaries of the project from an economic, social and environmental aspect and assess the economic viability and sustainability of a project by comparing the costs and the expected benefits within a certain time frame, which is typically the expected life cycle of the project. CBA is an important decision support tool which evaluates the worthiness of innovative Smart Grids solutions in view of an extended roll-out. As CBAs for development projects are usually largely based on estimated values of expected benefits and costs, the outcomes of Platone demonstration projects can contribute to improve this benefits evaluation giving to the estimation a solid foundation, based on measured impacts. In addition, the realization of demonstration projects gives practical indications about all the cost items that have to be taken into account in the CBA. Expected benefits from Smart Grids projects typically affect a wide range of stakeholders (e.g.: producers, consumers, distributors, aggregators, market players, etc.) as well as higher level and more general interests (e.g. environment, society, etc.). Therefore, CBA applied to this class of projects requires taking into account different points of view in order to evaluate global benefits and understand cost and benefits allocation among stakeholders. Moreover, the attribution of economic value to technical improvement and innovations often depends on regulatory and other boundary conditions in each country and there is interest to possibly evaluate also non-monetary benefits through a qualitative impact analysis. CBA could be done with several scopes, i.e. either at demo level considering current costs and the measured benefits only, or at a larger scale by scaling up the expected outcomes and evaluating the changing of costs due to time and scaling up. The main interest certainly concerns CBA outcome considering wide scale deployments, but the up-scaled values of costs and benefits may be affected by higher estimation uncertainties.

In this task, a hybrid MC-CBA will be carried out based on the method proposed in 2012 by the JRC [14] (Joint Research Institute) for Europe and the MC-CBA toolkit developed by ISGAN [15] (International Smart Grid Action Network), combining the advantages of the two families of techniques, while also utilising the experience gathered in other relevant European projects such as GRID4EU [13]

The JRC methodology builds upon the EPRI methodology [16] which was developed in the USA, providing modifications and additions in order to take into account both technological and regulatory differences present in Europe. The main idea behind the JRC methodology for CBA is that assets provide a set of functions that can in turn enable Smart Grid benefits which can be quantified and eventually monetised.

The Figure 7 portrays the seven steps that eventually lead to the comparison of costs and benefits:

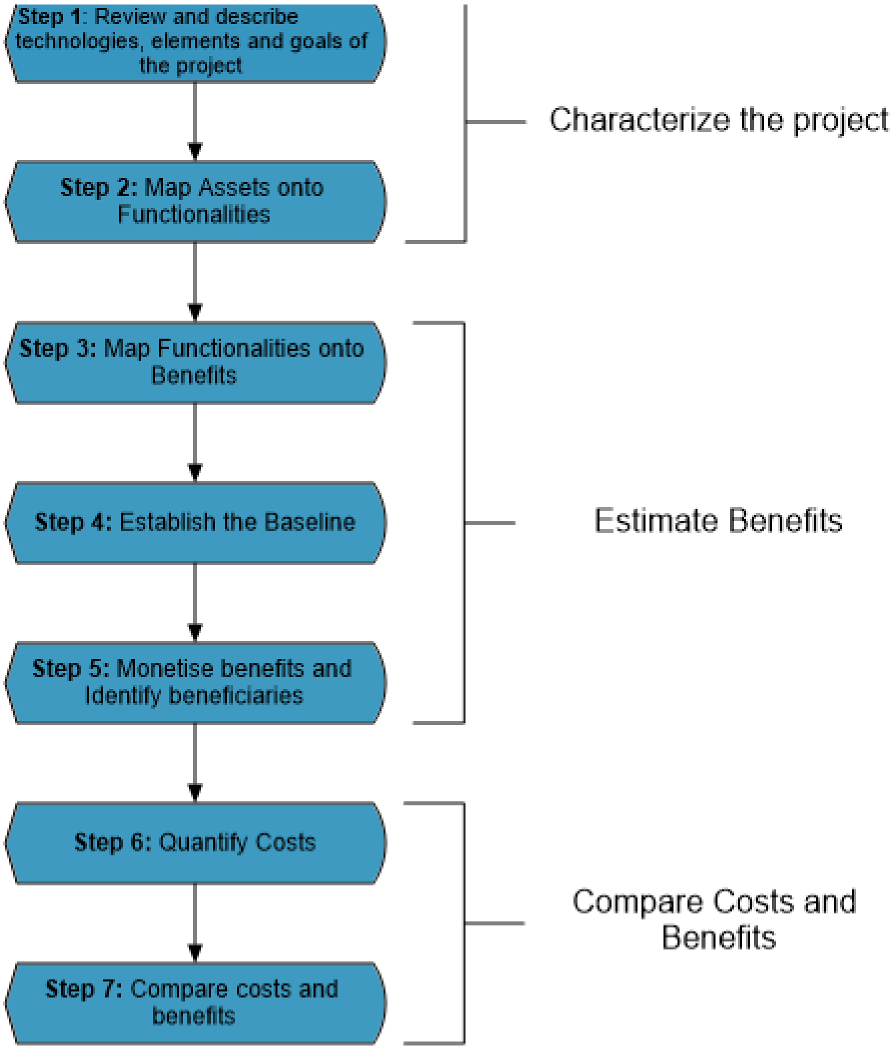

Figure 7: Cost-Benefit Analysis Framework (source: [14])

- **Step 1:** Provision of a main summary and a description of the elements and the goals of the project.
- **Step 2:** Determination of which Smart Grid functionalities are activated by the assets proposed by the project.
- **Step 3:** Linking of the Smart Grid functionalities identified in Step 2 with their potential benefits.
- **Step 4:** Establishment of a baseline which describes and compares the Baseline Condition (Business as Usual) with the Estimated/ Realized Condition.
- **Step 5:** Identification, Collection and Report of the data required for quantification and monetization of the benefits described in Step 3.
- **Step 6:** Identification and quantification of the costs incurred in implementing the project, relative to the baseline described in Step 4.
- **Step 7:** Comparison of the costs and benefits in order to evaluate the cost-effectiveness of the project. The cost-effectiveness can be determined by annual comparison, cumulative comparison or with the Net Present Value.

The MC-CBA toolkit developed by ISGAN aims to complement the aforementioned CBA by adding the multi-criteria factor. Typically, smart grid projects are responsible for a wide range of impacts which span from the electrical power system to the entire society. Often, these impacts are not easily quantifiable thus an assessment based on their monetary value is not attainable. In this context, traditional approaches as the cost-benefit analysis (CBA) become unfit. The reliable assessment of several planning options can be obtained by using hybrid approaches which combine monetary appraisal tools within a generalized framework based on multi-criteria analysis (MCA). A combined MC-CBA approach preserves the advantages of each methodology while overcoming the respective weaknesses. This methodology aims at supporting the decision makers by providing an assessment framework which rejects any personal bias by preserving the stakeholders' interests and allows for an output-based assessment of the smart grid alternatives based on an automated comparison procedure.

The MC-CBA toolkit decomposes the decision-making problem by dividing the impacts in three main areas:

- Economic Impacts (Net Present Value, Internal Rate of Return and Cost-Benefit Ratio);
- Contribution towards the smart grid realisation (Role of the smart grid project in government policies);
- Externality impacts (e.g. social impact, consumer satisfaction etc.).

Since the systematic assessment considers simultaneous effects, which belong to the different areas, companies are able to verify the performance achieved by the different options, while government bodies can consider both monetary and non-monetary impacts according to different views. Since the combined approach does not require to monetise all impacts, it is suitable for taking into account the effects of power system planning on society and environment.

3.1.3 Interaction and complementarities of SRA and CBA

The previous sections have shown that SRA and CBA pursue different objectives. The major result of a CBA would consist in a final figure determining the economic viability/profitability of a specific Smart Grid solution backed by quantitative studies on the associated costs and benefits. An evaluation of additional potential qualitative benefits is performed too. On the other hand, the main goal of scalability and replicability analyses is to determine as precisely as possible what is to be expected when that functionality is implemented at a larger scale or in a different context or location. Thus, the outcomes would consist in the identification and characterization of the key parameters and conditions that would determine the success of replicating or scaling-up the functionalities demonstrated. Hereinafter, these would be referred to as scaling-up and replication rules. Both analyses intend to provide general conclusions that can be valuable beyond the scope of the demonstrations themselves. This is done by addressing both relevant and complementary questions. However, CBA and SRA should not necessarily be carried out fully independently. Some interactions between both approaches can be exploited. In this regard, it is possible that some of the results of the SRA will be used as an input to the CBA. More specifically, SRA results could contribute to the quantification of certain benefits as well as the sharing of costs and benefits among the stakeholders affected. Note that implementation costs and their potential evolution will not be addressed within the SRA but within CBA. SRA incorporates technical, economic and regulatory issues. Some of the indicators, often needed to quantify and monetize the benefits for the CBA, particularly those related to the impact on the distribution grids, can be quantified by the technical analysis. In fact, the economical SRA may even provide support and useful results regarding benefit monetization.

3.2 Contributions provided by Platone

With respect to the methodologies illustrated in paragraphs 2, Platone proposes these innovative aspects of the methodologies:

Regarding SRA, Platone develops a quantitative approach based on simulation models that will estimate how relevant technical, economic and regulatory conditions will impact on the success of the implementation of this solution. The approach comprises two main stages: (i) technical analysis, and (ii) non-technical analysis to incorporate other boundary conditions: economic considerations, regulatory framework, and stakeholder acceptance. The technical analysis of the SRA potential is based on the evaluation of Key Performance Indicators (KPI) to measure the impact of the smart grid use cases. In the demonstrators, KPIs are measured under the specific local boundary conditions. Simulation models are built for assessing these KPIs under different boundary conditions. These models are validated and fine-tuned by comparing the KPIs registered in the demos and those obtained from simulation modelling the conditions of the demo. Then, further simulations are carried out to study the influence of different conditions on the performance of the tested. The technical and economic analysis of the use cases is performed by calculating the relevant project KPIs and by assessing (with the support of simulation models) the variations of these indices when the local conditions that characterize the project demos changes. Common simulations models and common sensitivity analyses will be used to cross compare of the results under different boundary conditions. The scalability analysis is conducted calculating (with simulations), for each demo, the relevant KPIs in a baseline scenario in which the solution was not yet implemented and a scenario that considers the full deployment of the solution. The replicability analysis is performed by calculating KPIs when the solutions are replicated in other representative networks that describe the characteristics of the European distribution systems. These replication models are built taking into account the network models developed by the JRC repository of representative networks.

Regarding CBA, Platone aims at combining the existing approach of CBA proposed by JRC [14] with the multi-criteria CBA methodology proposed in the ISGAN paper [17]. This will enable us to evaluate project alternatives on the basis of the monetary and non-monetary criteria as described above. The hybrid MC-CBA approach will combine the economic analysis with a quantitative and qualitative impact analysis, which includes the costs and benefits of wider social impacts, such as security of energy supply, consumer participation and improving market operation. Finally, the CBA will be carried out by associating the KPIs provided by each demo to specific benefits. This is the approach that we proposed and agreed upon and it is slightly different than the JRC approach where the assets are associated to functionalities and the functionalities into benefits. This particular approach will contribute to a better understanding of the Estimated Condition and a more accurate quantification and monetization of the benefits after the full deployment of the Smart Grid Assets. Finally, the aforementioned data will be used to compare the costs and the benefits and eventually evaluate the cost-effectiveness of the project.

Further details about these methodologies will be reported in deliverable D7.2.

4 Overview of Use Cases implemented in the demos and impact on the Scalability and Replicability Analysis

The present Chapter describes which UCs will be considered in the SRA and the approaches that will be used to simulate them

4.1 Focus on the Italian demo

The Italian demo comprises 3 separated areas:

- Tor di Valle
- Centocelle
- Acea headquarters

4.1.1 Structure of the Italian demo

Tor di Valle is a residential district located in the south-western area of Roma hosting both important industrial sites and different residential buildings. This area hosts also the waste-water treatment plant “ATO 2 Roma Sud” (one of the largest plant in Europe); among the residential buildings several condos are included but also small villas equipped small scale with PV plants (see: Figure 8)

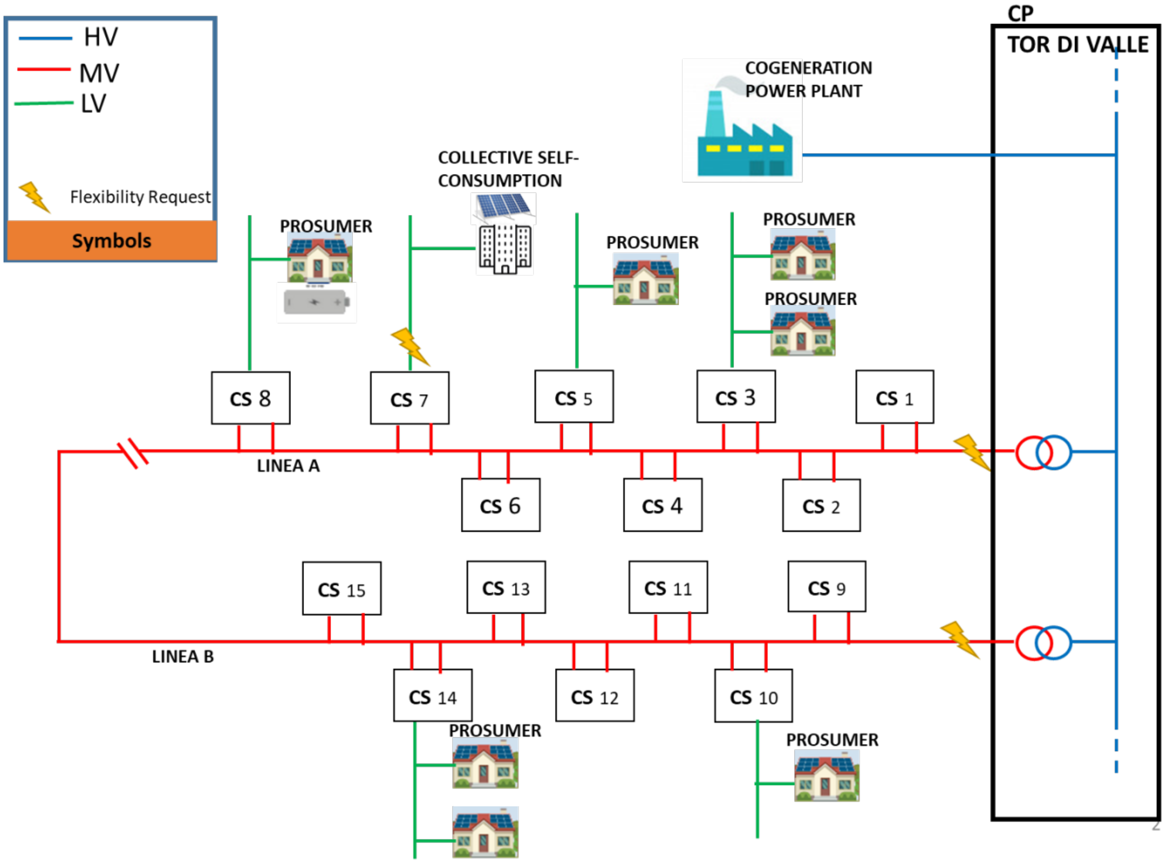

Figure 8: Electricity network serving the Tor di Valle area

The controllable elements that will be used in the Tor di Valle area to provide flexibility are described in Table 1**.**

Table 1: Flexibility elements in Tor di Valle area

Flexibility sources	
Tor Di Valle waste-water treatment plant	*This plant, following a request elaborated by the aggregator, (based on DSO request) can limit the request of power withdrawal from the main grid and can supply the internal demand by leveraging on self-production. In the demo, the following use cases can be included: congestion management and voltage control enabled by load flexibility.*
Condos	*Some condos located in that area will participate to the demo leveraging on the flexibility of the aggregated demand of the residential customers that live in these buildings. The users will be equipped with small-scale storage devices (2 kWh.) that could store or release power following the aggregator request. In the demo, the following use cases can be included: congestion management and voltage control enabled by load flexibility.*
Prosumer	*Customers already equipped with PV plants in residential units will also be equipped with small-scale storage devices (2 kWh.) that could store or release power following the aggregator request. In the demo, the following use cases can be included: congestion management and voltage control enabled by load flexibility.*
Passive users	*These users will be equipped with controllers and other devices that can adjust the load curve to meet the flexibility request elaborated by the DSO. The amount of demand that could be modulated in each load will be around 100 W,* mainly depending on the manual activation of the end-user*. In the demo, the following use cases can be included: congestion management and voltage control enabled by load flexibility.*

Centocelle

This is a large and popular neighbourhood located in the southeast of Rome. Here, the residential buildings usually host ten apartments each and shops located on the ground floor. Customers involved in the Italian demo belong to an already existing Citizen Energy Community (CEC) managed by ENEA. The CEC is composed of 10 apartments each one equipped with EMS. In some apartments are also installed storage (~2kWh) and/or small-scale PV units. The users of the virtual community are distributed over a broad territory, and it is therefore very important to implement a coordination activity, thanks to the role of the aggregator. The Italian demo aims at testing the demand response of the CEC to respond to the local flexibility requests, in order to solve the congestion and the voltage issues. The characteristics of the Centocelle demo area are illustrated in Figure 9.

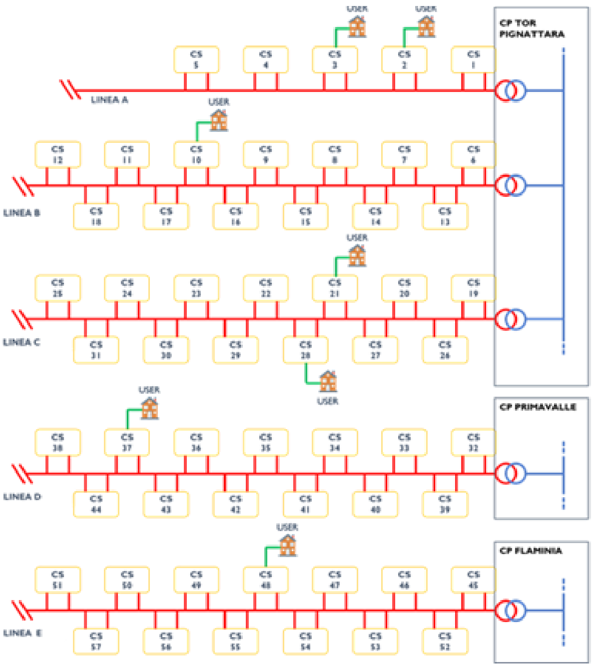

Figure 9: MV/LV network of the Centocelle demo area

The controllable elements that will be used in the Centocelle area to provide flexibility are described in Table 2.

Table 2: Flexibility elements in Centocelle area

Flexibility sources	
Prosumer	*Some of the PV users will be equipped with PV plants and storage units (about 2kWh) to test the possibility to provide flexibility services (Upward / downward reserve) upon DSOs requests.*
Passive users	*These users will be equipped with controllers and devices that will be able to modulate the load curve (Demand Response). Modulating power depends on the characteristics of each user but it will be about equal to 100 W/user. In this demo, Acea aims at experimenting congestion management*

ACEA headquarters "Piazzale Ostiense"

This is a central and historical neighbourhood of Rome, but it is also an important railway junction attended every day by thousands of people. The zone includes the Aventino Hill; and the following infrastructures for industrial and social activities: Acea's headquarters, several service companies, a bus station and a railway station; and residential zones. For the last two years, Areti has been updating the grid of this area, installing secondary substations and technologies to increase the observability. In this area, the Italian demo aims to improve the simulation tool and test the flexibility provided by smart EV parking located in the district to solve local congestion that occur during Summer when the electrical demand for cooling services reaches its yearly peak

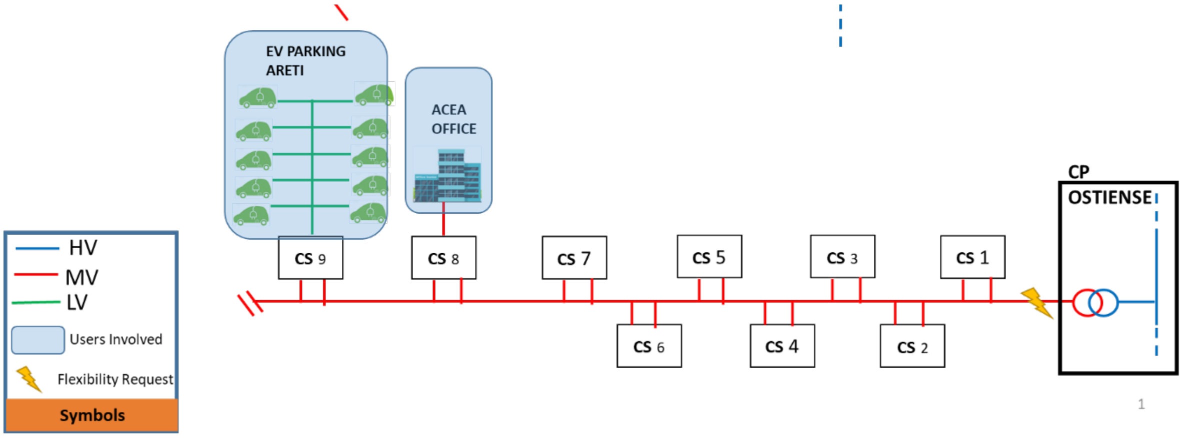

Figure 10: Flexibility sources included in the Acea headquarter

The controllable elements that will be used in the Acea headquarter area to provide flexibility are described in Table 3:

Table 3: Flexibility elements in Acea headquarter area

Flexibility sources	
Areti Smart Parking (Electric Vehicle)	*The Areti Smart Parking is equipped with V1G charging stations, therefore they can module the energy withdrawn from the network, and therefore it can provide ancillary services like upward / downward reserve/regulation. For this reason, this area can be used to test the congestion management UC.*

4.1.2 Description of the Italian Use cases

Table 4 illustrates the objectives that will be included in the three areas of the Italian demo that will be analysed in the scalability and replicability analysis. Further details about these use cases will be reported in deliverable 3.3.

Table 4: Use cases included in the Italian demo

ID	Use case objectives	Expected benefits
IT-1	Congestion management: This use cases aims at verifying the contributions that the activation of flexibility sources (provided by loads, DG and EV) could provide to the DSO for the aim to solve local congestions that might occur on the grids due to a local emergency or might be caused by a request of ancillary services elaborated by the TSO	• Deferred / avoided distribution grids investments • Reduction of momentary outages
IT-2	Voltage control**:** This use cases aims at verifying the contributions that the activation of flexibility sources (provided by loads, DG and EV) could provide to the DSO for the aim to solve local voltage violations that might occur on the grids	• Deferred/avoided distribution grids investments; • Reduction of momentary outages

4.1.3 Methodologies for Use Cases analysis

Congestion management in MV/LV grids

The scalability of congestion management enabled by demand response and production management will be assessed considering different amounts of flexible resources requested by the DSO. Additionally, different rates of actual demand response will be tested to quantify how much volume of load should be acquired by the DSO and evaluate how to divide the network in different relevant areas. Then, similarly to the previous use cases, other types of networks will be analysed, to evaluate the replicability for different types of areas (urban, sub-urban and rural) or feeder lengths. The analysis will focus on what results are to be expected for the KPIs that will be considered in the SRA (specific KPIs can be defined in WP7 with the support of WP3 to perform the SRA). The results obtained in the previous steps will be scaled-up to determine the potential of the implementation of this use case to a broader area. Then, scaling-up will be considered at a larger scale to assess the effects that could be expected for an implementation across the country, where the same boundary conditions prevail. Finally, replicability will be analysed to consider the different boundary conditions that could be found in different countries. In this regard, regulatory arrangements concerning the possible agreements between the stakeholders, and set point received by consumers can be particularly relevant. The diagram in Figure 11 summarizes the process of the technical analysis to be performed to evaluate the scaling-up and replication of the use case of congestion management enabled by demand response. The diagram shows the required inputs and tools for the analysis and the main outcomes at each step of the process. First, a scenario-based analysis will be performed in order to identify network constraints and determine demand reduction plans. Then, the analysis must be performed using data representing the actual behaviour of consumers, i.e. affected by actual response rates. Scaling-up and replication analyses will involve sensitivity analysis for the parameters listed in the green and purple boxes, respectively.

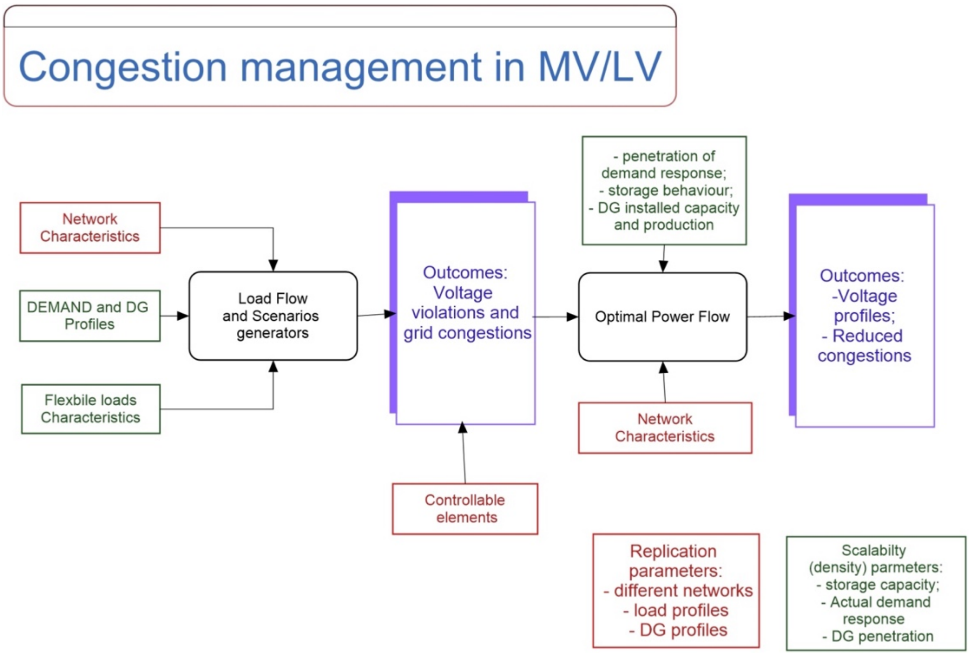

Figure 11: Methodology for SRA of the MV/LV congestion management enabled by congestion management UC

Voltage control in MV/LV grids

In order to evaluate perform the Scalability and Replicability analysis of the demo, an Alternate Current Optimal Power Flow (OPF) that minimizes network energy losses subject to voltage and capacity constraints in the MV grid will be used (these are commercially available software like PSSE and DIG Silent). The control variables are, storage charge/discharge rate (a 2kWh battery), and curtailment of controllable loads and distributed generators. The MV and LV network will be modelled by means of reference or representative networks, using a power flow tool such as PSSE. For a given set of baseline load and generation profiles, voltage profiles, active and reactive power flows will be computed. The next step consists in identifying violations of voltage constraints, which require corrective actions. These corrective actions comprise operating power factors, voltages or power injections are controlled) and storage discharge rate. The outcome of the AC Optimal Power Flow analysis will be simulated through a scenario generator with different control capabilities, e.g. load control only, load control and storage etc.; different amounts of controllable load, etc. Thus, the flexibilities that must be triggered to prevent voltage violations will be obtained. These simulations aim at quantifying the need of flexibility services that shall be provided by users in order to support the DSO in solving the voltage issues. The mechanisms that the DSOs will implement to procure these services (e.g.: market; bilateral contract, etc.) are out of the scope of the present analyses. Comparing the results obtained with different degrees of controllability/flexibilities and response rates of DG and consumers, the KPIs of network hosting capacity, energy losses and voltage line profile will be computed. Moreover, avoided overvoltages and a quantification of the load and DG curtailed may also be obtained, as indicators of the impact of this use case. In the demo, the control variables are, storage charge/discharge rate (a ~2kWh battery), and curtailment of controllable loads and distributed generators. The MV and LV network will be modelled by means of reference or representative networks, using a power flow tool such as PSSE. For a given set of baseline load and generation profiles, voltage profiles, active and reactive power flows will be computed. The next step consists in identifying violations of voltage constraints, which require corrective actions. These corrective actions comprise operating power factors, voltages or power injections are controlled) and storage discharge rate. The outcome of the AC Optimal Power Flow analysis will be simulated through a scenario generator with different control capabilities, e.g. load control only, load control and storage etc.; different amounts of controllable load, etc. Thus, the flexibilities that must be triggered to prevent voltage violations will be obtained. Comparing the results obtained with different degrees of controllability/flexibilities and response rates of DG and consumers, the KPIs related to voltage line profiles will be computed. Moreover, avoided overvoltages and a quantification of the load and DG curtailed may also be obtained, as indicators of the impact of this use case.

Scaling-up and replication

The scalability of this use case will be firstly assessed considering different amounts of available flexibilities from load, DG and storage, different DG penetration degrees, etc. Some of the most relevant parameters are the following:

- Number of batteries (considering new locations)
- Storage capacity of the batteries connected to the MV/LV network
- Amount of controllable loads
- Higher penetration of DG (including other technologies)
- Higher penetration of Electric Vehicle

A sensitivity analyses will be performed on the actual response of controllable devices that are not operated by the DSO

- Different degree of demand response (measured by the recruitment and demand response KPIs)
- Different incentives for DG participation
- Response of storage

Then, replicability will be analysed considering different types of networks and the same boundary conditions. This analysis will focus on the effect of the use case on the KPI of voltage profiles. Scaling-up will be then considered at a larger scale across the country, where the same boundary conditions prevail. In order to do this, the relative importance of each type of representative network selected will be taken into account. Finally, replicability will be analysed to consider the different boundary conditions. The typical values of network, generation and demand parameters will be different for different countries. Replication analyses will deal with these issues performing the previous steps for different urban, sub-urban and rural networks. Additionally, non-technical boundary conditions will be considered, such as regulatory conditions.

Figure 12 summarizes the process of the technical analysis to be performed to evaluate the scaling-up and replication of the use case named voltage control in MV grids. This figure shows the required inputs and tools for the analyses and the main outcomes at each step of the process. First, an analysis based on baseline load and generation profiles is performed in order to identify possible voltage problems and determine the flexibility activation plans. Then, the analysis must be performed using the data of the actual behaviour of loads, generation and storage.

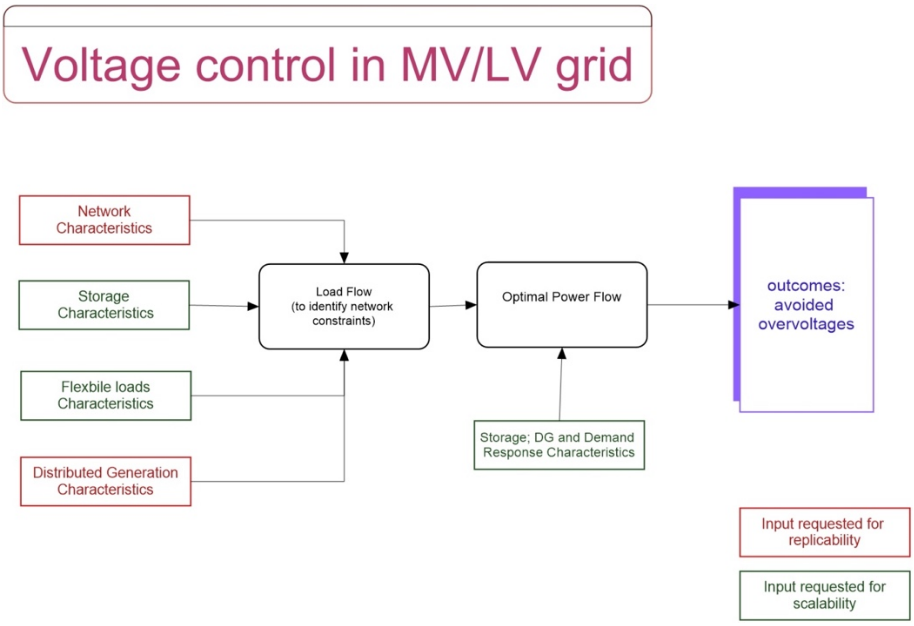

Figure 12: Methodology for SRA of the MV/LV voltage control enabled by demand response UC

4.2 Focus on the German demo

4.2.1 Structure of the German demo

AVACON, the German DSO, leads the German demo, which is located in a rural area characterized by low residential and commercial consumption as well as a high penetration of DER (mainly provided by roof top PV systems).

Briefly, the German demo aims at developing and testing innovative strategies for integrating energy communities (as defined by the European Commission in [18]) into DSO network operation strategies in order to increase distribution grid hosting capacity and its efficiency. In the field test trial, a testing environment is going to be set up so to promote the integration of local customers and RES in a local EMS enabling the energy community to maximize local consumption, to guarantee flexibility provision upon external request and to apply new package-based energy delivery strategies for energy supply.

The field test site consists of the following actors/components:

- A smart distribution station including metering devices, SCADA systems and a control module for local flexibility coordination.
- A BESS for energy storage and the enabling of the UCs.
- Flexible assets installed at the customer premises.
- Customers equipped with smart metering and control devices to leverage flexibility in households.
- A central control engine in the grid control environment for monitoring the network and the flexibility sources and for coordinating between local balancing mechanism and SCADA.

4.2.2 Description of the German Use Cases

Table 5 summarizes the objectives targeted in each of the four German demo UCs:

- DE-1: Islanding;
- DE-2: Flexibility provision;
- DE-3: Bulk Energy Supply;
- DE-4: Bulk Energy Export

DE-1: Islanding: this UC aims at balancing generation and demand of the local energy community via an EMS (ALF-C) so that the load flow across the MV/LV grid connection point ($P'_{breaker}$) is reduced to a minimum. In the demo, the power flow across the LV/MV transformer is monitored by the ALF-C, which controls also a BESS connected directly to the LV-terminal of the substation. Energy surplus generated inside the local energy community will be stored in the BESS and released when situations of generation deficit occur inside the community. Batteries and controllable electric heaters located at the private households can be managed and dispatched to further increase the energy self-sufficiency level.

DE-2: Flexibility provision. This UC targets the objective to demonstrate how future local energy communities can practically maintain a fixed non-zero power exchange with the MV distribution network for a certain defined duration when they are required to provide flexibility to third parties (e.g. because of technical circumstances or according to market incentives).

DE-3: Bulk Energy Supply. When a local energy community runs into energy-deficit situations (potentially occurring in low local generation periods), energy deficits could be compensated by the supplying distribution network. For reducing the stress on the MV network and the overall network costs, energy deficits could be forecasted, and discrete energy packages could be supplied by the MV network ahead of time at fixed time slots and stored in local storages inside the LV network until demand arises.

DE-4: Bulk Energy Export. When a local energy community runs into surplus-energy situations (potentially occurring in low local demand periods), energy surpluses could be exported to the MV distribution network. For reducing the stress on the MV network and the overall network costs, surplus generation could be forecast, temporarily stored in local storages within the local energy community and exported time shifted in discrete packages at fixed time slots out of the LV grid. A brief narrative of each UC is also provided in Table 5. Further details can be found in D5.2 [4] and D 1.1 [2].

Table 5: Narrative and objectives of the four German demo UCs

ID	UC narrative	UC objectives
DE-1	This UC, basis for DE-2 to DE-4, targets the maximization of the energy self-consumption inside the local energy community up to a "virtual" island mode, where the local energy community is temporarily independent from the energy provision by the MV network, A real islanding mode is never reached, being the connection between the LV network and the MV network always maintained	Main scope is the implementation of an EMS, which operates the LV network in virtual island mode (i.e. minimization of the power exchange with the connected medium voltage feeder by utilizing available flexibility, e.g. local energy storage systems and controllable loads). Other objectives of the UC are: • Maximizing consumption of local generation • Minimizing demand satisfied by the public grid • (Virtual) islanding of the local grid by using flexible loads and storages of the local energy community • Maximizing duration of the islanding operation
DE-2	Local energy communities with high RES penetration and installed capacity are likely to produce energy surplus during times of peak generation and low local demand, and vice versa to run into an energy deficit during seasons when the generation is low. Surplus of energy could be stored and shifted to times of low generation so to satisfy temporary local demand, therefore increasing self-sufficiency degree.	Main scope of DE-2 is demonstrating how the flexibility required to enable a local balancing mechanism could temporarily be allocated to other uses, e.g. for flexibility provision to a third party such as the grid operator. DE-2 uses the available flexibility in the local energy community to maintain, for a limited duration, a fixed non-zero setpoint at the LV-MV grid connection point externally defined by the grid operator.
DE-3	Energy communities characterized by a high proportion RES penetration (and therefore self-generation) as well as flexible consumers and storage would be able to maximize self-consumption of the energy generated inside them.	• Demonstrating how energy deficit of will be supplied (time shifted) by the MV grid • Enabling temporary (virtual) islanding even when energy deficits occur the community • Forecasting the residual energy demand and generation of the energy community • Executing a power exchange schedule for the LV/MV grid connection point • Determining a setpoint schedule for individual local assets to meet the setpoint schedule of the energy community. • Executing the defined power exchange program
DE-4	Energy communities characterized by a high proportion of self-generation as well as few flexible consumers could make use of local storages for the maximization of the self-	• Demonstrating how generated energy surplus of a local energy community with a high amount of RES will be exported (time shifted) out of a LV grid into the MV grid • Enabling temporary (virtual) islanding when energy deficits occur in the community • Forecasting the residual energy demand and generation of the energy community

	consumption of locally generated energy.	• Executing a power exchange schedule for the LV/MV grid connection point • Determination of a setpoint schedule for individual local asset to meet energy community setpoint schedule • Executing the defined power exchange program

4.2.3 Approaches for the SRA analysis

Scaling-up and replication

The impact of the first two German UCs (DE-1, DE-2) is going to be assessed using the approach described in the present paragraph and schematically depicted in Figure 13.

For the technical SRA, the rural LV network where the local energy community is located will be modelled by using a representative network (see [18]).

A set of baseline scenarios will be defined by taking into account the characteristic profiles of load and generation assets. For taking into account both DE-1 and DE-2, two different constraints will be imposed for the baseline scenario simulations, i.e. $P'_{breaker}$ equal to 0 and $P'_{breaker}$ equal to an externally defined target value, respectively.

For the baseline scenarios, load flow analyses will be run to compute voltage profiles as well as active and reactive power flows. Since there are no voltage/frequency control strategies implemented in the demo and the interest does not lay on that, the computation of voltage profiles will aim purely at assessing potential voltage violations, without evaluating any corrective measure.

Moreover, an Optimal Power Flow will be run to verify that the energy dispatching does not cause grid congestions and, in the case of problems, to identify the users' flexibility request.

First, the scalability (in size and density) of this UC will be evaluated by considering different amounts of available flexibilities inside the LV grid. The impact of varying some technical parameters will be considered via sensitivity analysis. Some of the most relevant parameters to consider for the scalability might be:

- number of BESS (e.g., more than one BESS connected to the LV grid) and its location (e.g., considering new locations for assessing the effect of different sparsity levels of the storage capacity and/or its closeness to the LV/MV grid connection point)
- storage volume of the BESS connected to the LV grid
- amount and type of controllable loads in the LV grid (e.g., variation in size, number of consumers/supply points, different loads etc.)
- different penetration degrees and location of the DG (mainly PV)

Considering some of these parameters, suitable scenarios will be defined and some selected output variables/KPIs will be computed and the differences with respect to the correspondent values for the baseline scenarios will be evaluated.

Then, intra-national replicability of the results will be analysed considering types of networks which are different from that of the baseline scenario (rural network) but with the same regulatory boundary conditions. The impact of the UC in e.g. semi-urban and urban networks will be evaluated. For this purpose, suitable representative networks will be used. Different types of loads and DG (in terms of e.g. different size, load/generation profiles, location etc.) could be also investigated to take into account the main load and DG characteristics of different areas within the demo country.

Finally, inter-national replicability will also be analysed to consider different boundary conditions with respect to the ones found in the demo country. The same parameters will be assessed again to perform the previous analyses.

The diagram in Figure 13 summarizes the proposed process for the technical SRA for the evaluation of the scaling-up and replication potential of the first two UCs of the German demo. The inputs requested for scalability and replicability analysis are identified in the green and red boxes, respectively.

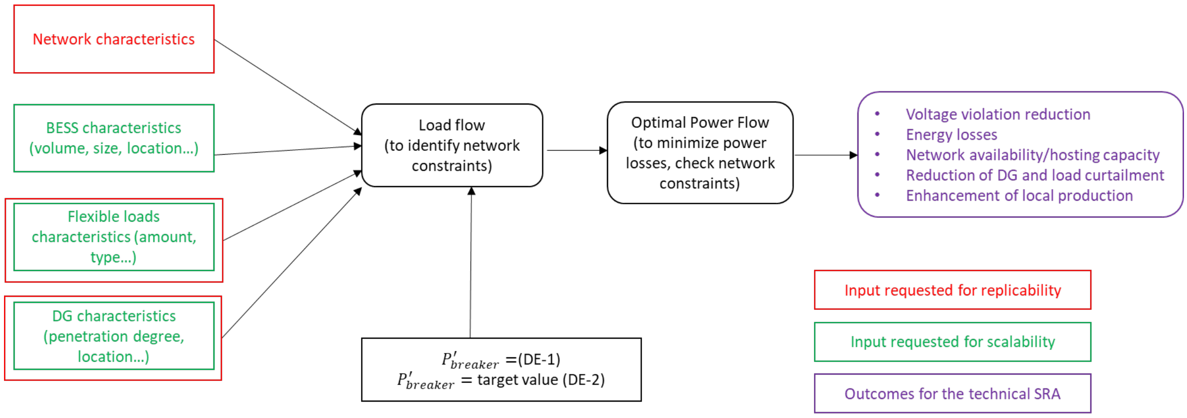

Figure 13 : Application of the technical SRA to the German Use Cases DE-1 and DE-2

In the SRA analysis of DE-3, in order to simulate the scope of bulk energy provision UC, SRA simulations will be run to maximize the production of local DG while keeping $P'_{breaker}$ equal to 0.

In the SRA analysis of DE-4, in order to simulate the scope of bulk energy export UC, SRA simulations will be run to maximize the production of local DG while setting $P'_{breaker}$ equal to an externally defined value.

Further details regarding the definition of the specific SRA methodologies with the inclusion of forecasting considerations will be provided in D7.2, as more specifications regarding the definition of the German UC algorithms will be included in D5.3.

4.3 Focus on the Greek demo

4.3.1 Structure of the Greek demo

The Greek demo is led by the Greek DSO HEDNO and is situated in the Mesogeia area in the Attica region, which encompasses a mix of rural, urban and sub-urban areas servicing Athens as well as the islands Kea, Andros and Tinos. The area supplies approximately 225,000 customers in its LV and MV networks, varied from households to small, medium and large industries. The area benefits from installations of various forms of renewables, windfarms and PV including net metering and rooftop PVs as well.

4.3.2 Demo objectives

The Greek demo objectives are the following as structured by HEDNO:

- To test the Platone architecture and explore its benefits for the Greek DSO (HEDNO).
- To improve grid operation through advanced grid observability.
- To achieve optimal dispatching, addressing local congestion and voltage level issues using novel approaches for flexibility mechanisms at DSO level.
- To investigate potential provision of ancillary services to the TSO by the users of the distribution network.
- To assess the penetration limits of DERs for better control and planning of the distribution network.

4.3.3 Existing Infrastructure

The test-bed for the Greek demo is a real-world distribution network operating in the geographical site of Mesogeia, which is located in the south eastern part of Attica region.

With regard to the existing metering infrastructure, the HV/MV substation of the test site, which is considered the slack bus for power flow purposes, is equipped with a SCADA system that provides voltage and current flow measurements at the top of the distribution feeders. In addition, there are dispersed metering devices throughout the network which support recording, storage and transmission towards HEDNO telemetry centres of measurement data (mainly referring to active/reactive power injection) obtained from all MV customers and selected LV customers. The abovementioned metering equipment serves PVs operating at MV and LV levels, and also includes 200 smart meters installed at LV consumers. The related measurement data have a 15-minute temporal resolution.

The use cases deployed in the Greek demo are described in detail in deliverable D4.1 [3]. Table 6 summarizes the scopes of the use cases.

Table 6: Use cases in Greek demo (source: [3])

Title	Scope
UC-GR-1 - Functions of the State Estimation tool given conventional measurements	The main objective of the Use Case is to improve confidence in actual measurement data obtained throughout the network as well as available load forecasts and to capture the real-time operational network state.
UC-GR-2 - PMU data integration into State Estimation tool	In this Use Case PMU measurements are used in order to reinforce network observability and controllability via improved state estimation performance. Furthermore, it is ensured that synchronised measurement data derived from PMUs are smoothly incorporated into the pre-existing system of conventional measurements.
UC-GR-3 - Distribution Network limit violation mitigation	To use network tariffs in order to incentivise a more efficient operation of the network while respecting operation limits (voltages, lines overload).
UC-GR-4 - Frequency support by the distribution network	To achieve better operating conditions of the distribution network in the case of a frequency restoration reserve activation request by the TSO.
UC-GR-5 - PMU integration and Data Visualisation for Flexibility Services Management	The objectives of UC-GR-5 are to increase network observability and to integrate data coming from different sources in the DSO Technical Platform.

4.3.4 Description of the relevant Greek Use Cases

WP7 focuses on two subjects, SRA and CBA. Of the 5 UCs of the Greek Demo only two are of relevance to the SRA and CBA. UC-GR 1 and 2 test the State Estimation algorithm with and without the introduction of PMUs. UC-GR1 and UC-GR 2 are not suitable for SRA and CBA due to the nature of State Estimation. Therefore, it is not considered in SRA and CBA. Similar arguments apply to UC-GR-5 which is a case that deals with the visualization capabilities offered by the Platone Platform to the Greek demo. Therefore, the SRA and CBA will focus on UC-GR 3 and 4 of the Greek demo. However, given that the follow a similar technical and conceptual narratives only one of the two will be chosen for thorough analyses. All results of the SRA and CBA apply to its sister case, too. To this end, we will perform a more detailed discussion on UC-GR-3 - Distribution Network limit violation mitigation (see [3]). RES systems and customers with flexible loads are connected to the distribution network with the flexible loads considered aggregated for the scope of the UCs regarding their management in the MV level. State of the network is known with a good degree of certainty. The DSO communicates network tariffs in a day-ahead context. These tariffs appropriately reflect the potential of the network exceeding its physical limits resulting in violations and/or curtailment of demand/generation. Compared to the Business-as-Usual scenario of the flat network tariffs, the DSO aims at reducing such negative effects by the use of variable day-ahead network tariffs, which incentivise the appropriate actions of the -assumed as- rational users of the distribution network. Customers' consent required for participation in the flexibility mechanism, so it is assumed that the customers are rational and part of the load is flexible. Moreover, it is assumed that there is a good degree of certainty in the estimation of the network state. For the implementation of the Use Case, the technical conditions that need to be fulfilled are the installation of smart metering, the existence of smart appliances for load shifting and the normal operation of DSO systems (e.g. AMR, GIS, SCADA) during the preparation and demonstration period. Lastly, on the regulatory aspect of this Use Case, it is required that a dynamic network charging scheme is allowed.

4.3.5 Scaling-up and replication

The objective of UC-GR-3 is to use network tariffs in order to incentivise a more efficient operation of the network while respecting operation limits (voltages, lines overload), as illustrated in [19].

As first step, load flow analysis will be performed in the network to identify network constraints that will arise from the increased penetration of EV, distributed generations and demand. Consequently an Optimal Power flow will be performed in order to identify the needs for flexibility sources to be activated in order to solve local congestions.

These analyses aim at identifying the avoided overload and overvoltages enabled by the activation of flexibility sources.

The scalability analysis in the demo area will assess the impact of an increased penetration of technologies that are already deployed in the demo (in particular PV) and an increased penetration of flexible loads enabled by real time tariffs.

The replicability intra national will assess the impact of the penetration of different technological solutions that are not yet present in demo areas like electric vehicles (in the short term) and storage (in the long term). Replicability analysis at international level will affect the impact of the solution when deployed in regions with different regulatory boundary conditions (e.g.: different voltage limitations, different tariff schemes; etc.) or in regions characterized by different types of networks (instead of a semi-rural area, island, urban areas or rural area will be considered)

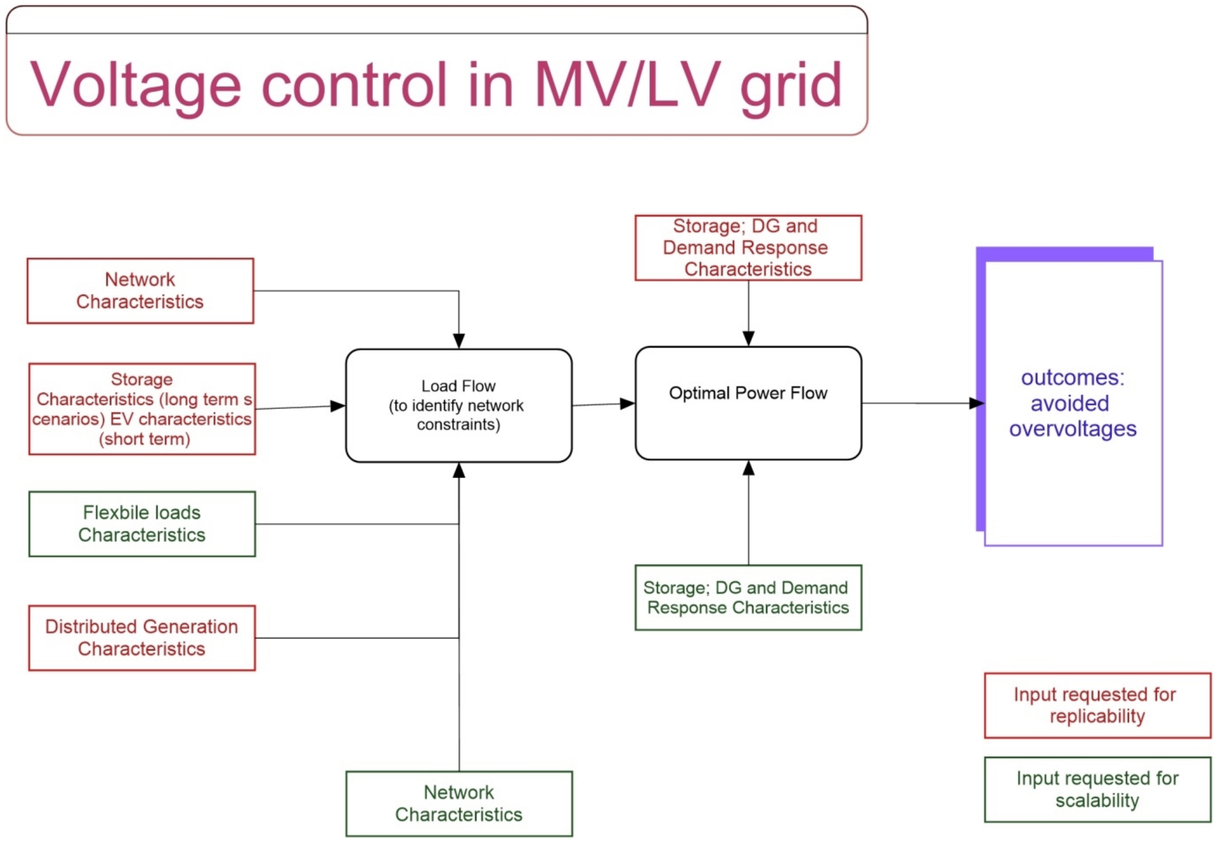

Figure 14 : Distribution Network limit violation mitigation SRA methodology

5 Data Asked for Scalability and Replicability and Cost Benefit Analyses

The scalability and replicability analysis requires a set of common data that shall be provided by demo leaders or shall be retrieved from the analysis of the relevant literature as described in paragraph 4. The list reported in the present deliverable includes a generic set of data that represent grid characteristics that will be described with greater details in the future deliverables of WP7, in which details about the scenarios that will be considered in the cost benefit analysis will be reported and agreed with the 3 Platone demos. In paragraph 5.2, the need of specific data that characterizes each demo are listed.

5.1 General data asked for the 3 demos

A set of representative networks must be defined to represent the area selected for the implementation of the use cases and to perform replicability analysis. Two sets of representative networks are identified: MV networks and LV networks. For each set of networks, we should identify different network types that correspond to urban / sub-urban / rural / industrial / or any other subdivision according to size or dispersion

Information to characterize the distribution grid

This information shall be, broken down per type of network (urban/sub-urban/rural) and voltage level (MV and LV):

- Typical voltage levels
- Size of MV/LV transformers
- Typical network architectures
- Typical length of feeders
- Parameters of conductors (R, X, thermal limits (I or S))
- Reliability indices
- Voltage control strategy (admissible voltage deviations) and elements (tap changers in transformers, capacitors, reactances, etc.)

The list of specific data needed for characterizing the type of network is reported in section D and J of Annex A

Sub-transmission grid

- Interactions between transmission and distribution
- Boundaries between distribution and transmission
- Typical size of substations
- Typical voltage levels for sub-transmission
- Operation of sub-transmission grid

The list of specific data needed for characterizing sub transmission grid is reported in sections E and H of annex A

Network users - load

- Load density: number of consumers and consumption (contracted power or peak demand) per km of line, average size of consumers (contracted power that can flow in the AIM installed in the customers' premises).
- Hourly load profiles for different types of consumers and different voltage levels(residential in urban/sub-urban and rural areas, commercial, industrial)
- Simultaneity factors at different levels (these can be obtained from aggregated load profiles in case the demo leaders hadn't evaluated the simultaneity factor of the region in which they operated)
- Other data that are used to characterized customers connected to the electricity grid as stated in section C of annex A

Network users - generation

- DG: average size of the DG already installed in the area (installed capacity) and technologies per voltage level and type of area
- Hourly Generation profiles per technology
- Characteristics of the battery (size, installed capacity, time of Charge, averages state of charge)
- Efficiency (energy losses in the battery)
- Admissible values of SoC

The list of specific data needed for characterizing network users is reported in sections I of annex A

Platone is already collecting most of this information in the list of data that are requested to build the representative networks and are described in chapter 6 and annex A. However, this list shall be complemented with additional information that aims at describing the evolution of future distribution networks and will be used to define the scenarios for the scalability analysis (at national level) and replicability analysis (international).

5.2 Specific Data asked for the analysis of each demo

The Italian demo aims at assessing the impact of the activation of flexibility sources in the distribution network in an urban area. Therefore, the parameters that will be investigated in details in the SRA include the characteristics of controllable loads and DG units in the network, in particular the forecast for future penetration of EV in the urban areas and the forecast for growth of generation and demand.

In the framework of the replicability analyses, the impact of the deployment of the solutions in another type of area (e.g.: semi-rural area will be assessed). Therefore, discussion with Areti shall be performed in order to identify the set of representative networks that shall be analysed.

In the German demo the SRA will focus on the impact of deploying flexible solutions in a rural area for experimenting local energy communities. Therefore, the information that will be requested for developing scenarios for SRA include the forecast for the growth of local demand and local energy sources, the forecast for the deployment of EV and storage units in the network, the characteristics of regulatory schemes in Germany related to voltage limitations, network tariffs and the regulatory parameter that will regulate the operation of local energy communities. Finally, the analysis of replicability international will focus on the assessment of the impacts on different types of network (e.g.: urban and rural networks). Therefore, a set of representative networks shall be identified in cooperation with Avacon.

In the Greek demo the SRA will focus on the impact of deploying flexible solutions in a semi urban area. The most important flexibility sources that will be considered in the analysis are represented by the penetration of electric vehicles in the medium-term scenarios (next 10 years) and the penetration of small storage units in the long-term scenarios. The replicability analysis will evaluate the impact of the penetration of the innovations tested in the demos in different networks (e.g. rural networks). Therefore, a set of representative networks shall be identified in cooperation with HEDNO and scenarios that describe the expected penetration of EV and storage units in the Greek distribution networks shall be provided by HEDNO.

5.3 Data asked for CBA

The Cost-Benefit Analysis requires a number of data entries as input. This data primarily is an output of the demo activities. In an effort to align with the priorities and concepts that are defined within the demos, the CBA activity will make use of the benefit definitions provided by the demos, in the form of the KPIs that are planned to be used by the demo leaders. The CBA will extent, interpret and, when necessary, monetize these KPIs accordingly in order to calculate the tangible benefits each asset will provide. However, these benefits are not standalone, but are defined with respect to the status quo, i.e., any Business-as-Usual (BaU) or baseline scenarios. Therefore, the CBA analysis requires as data input:

- The KPI values in BaU or baseline scenarios that are measured without the deployment of the corresponding asset for which the CBA is performed.
- The corresponding KPI after the deployment of the asset under analysis in order to evaluate the relative benefit between the two cases.

These two data entries cover the *benefit* part of the Cost-Benefit Analysis. For the *cost* part each asset under evaluation should come with a cost of purchase, or deployment and maintenance or both. Therefore, one more data-entry required by the demos for the CBA is:

- Cost of purchase, deployment, maintenance or other associated with each individual asset deployed for the Platone demonstrations and evaluated by the CBA of the project.

6 Representative networks

This section briefly introduces the need for employing representative networks and contextualizes their usage within the SRA activities (Chapter 6.1). After, the description of the preliminary DSO data collection process within WP7 is presented (Chapter 6.2).

6.1 Representative networks: definition and context

As mentioned in Chapters 2, 4 and 5, the SRA methodology that will be adopted in WP7 is based on the use of “representative networks” to model the technical boundary conditions of the demo and to compute KPIs and metrics for assessing the impact of the smart grid solutions implemented in the Platone UCs.

A set of representative networks can be defined as a reduced number of model networks or test networks, where each representative network is the best fit to describe the behaviour of a group of real feeders [20] [21].

The concept of “reference” and “representative” networks was proposed as a benchmarking tool for regulation of distribution to set the remuneration for the DSOs [22]. In particular, the aim of representative networks is to reproduce the characteristics of actual networks, while reference networks behave as quasi-optimal networks that could supply actual demand.

In the power system simulation field, representative networks are being widely used as simplified distribution network models to reproduce the behaviour of actual distribution networks. In fact, modelling and analysing each element comprising the distribution system in a region or in a country would not be convenient and prohibitively difficult when it comes to large-scale smart grid analyses. For such a reason, it turns out to be necessary to have a model that can account for the peculiarities of different networks in a condensed manner enabling and facilitating efficient large-scale analyses. Of course, depending on the smart grid functionalities under study, different types of representative networks may be designed, focusing on different aspects and with different levels of detail as also done in past projects and papers [12] [10].

In the perspective of SRA, representative networks are a flexible tool for:

a) Replicability analysis, since having different representative networks enables diverse simulations taking into account different technical boundary conditions;
b) scaling-up analysis (in size and density), since having a comprehensive and meaningful set of representative networks enables “projecting” the simulation results for wider areas (scaling-up in size) and at a larger scale regarding density aspects (scaling-up in density) with respect to the demo area.

Different methods are available in the literature for the elaboration of test feeders and representative networks in the field of smart grid analyses:

- selecting an actual feeder from a real distribution network and anonymizing it to remove sensitive data
- building representative networks by using real networks as the basis utilizing
    - clustering techniques
    - manual design
    - planning tools (e.g., reference network models)
    - a combination of the previous methods

Defining a set of representative networks for a certain region is a very challenging task with non-negligible barriers. One of the main challenges is the availability and accuracy of the data needed for creating the representative network, which affect also the representativeness of the representative network model itself. Some barriers behind the data gathering process are related to:

- the large volume and diversity of infrastructures inside a distribution network;

- the different format of data used by different DSOs;
- the level of accuracy and update of the data inventory (especially for LV levels);
- confidentiality issues which limit the access to the network model details for the non-DSO agents.

Nonetheless, an efficient process of data collection is needed to reach the objective of comprehensively characterize the network of a given area, and then to build/use a set of representative networks which are sufficiently representative of the area under study.

6.2 Preliminary data collection process within WP7

For elaborating a specific set of representative networks, WP7 has started to set up an interactive and iterative process with demo leaders with the aim of collecting the set of needed data so to effectively represent the typical architectures, topologies and characteristics of the actual MV and LV distribution grid. The different representative networks will typically reflect the different types of areas in terms of population density and use of electricity, corresponding to rural/urban/industrial/residential areas.

Within WP7, different strategies as well as methods and research activities for building/deriving representative networks will be investigated. Out of them, focus will be first put on a recent work within the context of representative networks performed within the DSO Observatory project [23] by the Joint Research Centre (JRC) of the European Commission (EU) in 2014. The project launched a survey at EU level directed towards all the European DSOs to collect some basic parameters of the DSOs network designs, network structure, reliability indices and connected DG. One result of this survey participation has been building several network structural indicators, which were used as basis for creating 13 representative networks, 3 large-scale and 10 feeder type networks. These grids are claimed to be representative of European networks, without specifically representing any particular DSO or country. As preliminary characterization of the network models of the Platone demos, WP7 has prepared a questionnaire to be filled out by each demo leader for an initial data collection. This questionnaire is reported in Annex A and it is an adaptation of the original questionnaire created in the context of the DSO Observatory project in the online platform made available for the survey carried out therein. More information regarding the data gathered from this questionnaire will be included in D7.2, of course taking into account the confidentiality level of the DSOs data. Only a high-level description will be therefore provided in D7.2.

The circulated questionnaire is divided in two parts. The first part aims at collecting general information of the DSO company which the demo site belongs to (sections 2B and 2C) and some basic parameters on its network design, like number of customers connected, circuit length and technical data divided per voltage level (sections 2D to 2G). The second part (section 3) aims at providing further information regarding the network structure, network reliability metrics and connected DG. Based on the information collected through this questionnaire, the same set of network indicators produced in the DSO Observatory project (see Table 7) could be computed. By so doing, not only a preliminary and standardized characterization of the demo networks will be available, but also a preliminary evaluation of the similarity level of the JRC representative networks with the specific demo networks will be possible. This way, the applicability/usability for the specific needs of WP7 SRA of (some of) the representative networks produced by the DSO Observatory project will be assessed.

Table 7: Main indicators computed for each Platone demo

ID	Demo main indicators
1	Number of LV consumers per MV consumers
2	LV circuit length per LV consumer
3	LV underground ratio
4	Number of LV consumer per MV/LV substation
5	MV/LV substation capacity per LV consumer
6	MV circuit length per MV supply point
7	MV underground ratio
8	Number of MV supply points per HV/MV substation
9	Typical transformation capacity of MV/LV secondary substations in urban areas
10	Typical transformation capacity of MV/LV secondary substations in rural areas

7 Conclusion and the way forward

This deliverable presented the preliminary set of data necessary for (i) defining the technical boundary conditions in order to perform the Scalability and Replicability Analyses of the Platone demo solutions as well as for the Multi-criteria Cost Benefit Analysis and for (ii) elaborating the representative networks to be used in the SRA simulations that will be run in the next steps of the project.

To motivate and contextualize the identification of the preliminary list of data to be collected in the present report, the approaches that will be used for the SRA have been identified as well as the list of data that are needed for performing these analyses. Moreover, the data required for the CBA have also been described. It is a common theme that in order to quantify most of the benefits coming from the Platone solutions, fully deployed solutions should be compared to Business-as-Usual/baseline scenarios. Furthermore, costs of assets in different time scales should be projected.

As a conclusion of this exercise, it can be noticed that the main challenges in the process of identification of data relevant for the analyses are represented by: the level of confidentiality associated to specific set of data (e.g.: network characteristics; customers profiles, etc.) and the procedures for accessing and exchanging data among partners. In order to cope with these constraints, in the future deliverables of WP7 the data that would be collected in this process will be described in only aggregated manner.

Thanks to the work done in the 18 months the process of defining representative networks for baseline scenarios has started thanks to the data reported in annex A.

The next steps of WP7 will encompass:

- An iterative process between WP7 and the Platone demo leaders for performing the collection of the data required for the SRA and MC-CBA as well as for the elaboration of the needed representative networks.
- The elaboration of a first integrated version of the methodologies to be followed for the SRA, which will be the scope of the deliverable D7.2 that is expected at M24 of the project.

It is noteworthy that these main steps are expected to benefit from the further and more detailed level of information that will come from the Platone demos (and the described in deliverables 5.3 and 3.1 that are expected at month 18 and 24 respectively), taking into account the most recent progress of each demo.

8 List of Tables

9 List of Figures

10 List of References

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11 List of Abbreviations

Abbreviation	Term
DG	Distributed Generation
BaU	Business as Usual
BESS	Battery energy storage systems
CEC	Citizen Energy Community
CBA	Cost Benefit Analysis
DSO	Distributed System Operator
EMS	Energy Management System
HV	High Voltage
ISGAN	International Smart Grids Action Network
LV	Low Voltage
KPI	Key Performance Indicator
MCA	Multi Criteria Analysis
MC-CBA	Multi Criteria Cost Benefit Analysis
MV	Medium Voltage
OPF	Optimal Power Flow
PV	Photovoltaic
SoC	State of Charge
SRA	Scalability and Replicability Analysis
SUT	Solution Under Test
TSO	Transmission System Operator
UC	Use Case

Annex A Questionnaire for data collection

1. Identification

Company/Association	
Country	
Comments	

2. General information (Distribution Business - Basic Figures, Structure & Ownership)

A. **Basic data**

Legal Name of the DSO	
Country	
Regions and/or municipalities covered	
Distributed Annual Energy (on average) (GWh)	
Area of Distribution Activity (approximately) (km^2)	

B. Distribution business

Ownership of the DSO	
A. Private	
B Public state owned	
C Public owned by municipality	
D Other	
Is the DSO part of a bigger group operating in the power industry?	
If yes, type of unbundling with respect to the parent company:	
Business in the power sector the company (or their group) operate besides distribution (e.g. generation, transmission, supply/retail)	

C. Customers

Total Number of Customers connected	
Number of LV (< 1 kV) Customers	
Number of MV (1- 36 kV) Customers	
Number of HV (> 36 kV) Customers	

D. Circuit length per voltage level (km)

Total	
LV (< 1 kV)	
of that Overhead	
of that Underground	
MV (1-36 kV)	
of that Overhead	
of that Underground	
HV (> 36 kV)	
of that Overhead	
of that Underground	

E. Technical data

Number of HV/MV Substations	
Total installed capacity of HV/MV Substations (MVA)	
Number of MV/LV Secondary Substations	
Total installed capacity of MV/LV Secondary Substations (MVA)	
Total installed capacity of generation connected (MW)	
Installed capacity of generation connected to LV networks (MW)	
Number of electric vehicle public charging points	

F. Reliability

Reliability indexes (annual value of each reliability index for long unplanned interruptions)

Reliability index	Value	LV	MV	HV
SAIDI (min./customer)				
SAIFI (int./customer)				

Please fill in the following table in case your reliability indexes are not the proposed ones.

No.	Reliability Index	Unit	Value	LV	MV	HV
1						
2						

3						
4						
5						
…						

G. Comments

Please mention here any comments or suggestions you may have.

3. Additional data

Network structure

H. Network Data:

Typical transformation capacity of HV/MV Substations (MVA)	
Typical transformation capacity of the MV/LV Secondary Substations in urban areas (kVA)	
Typical transformation capacity of the MV/LV Secondary Substations in rural areas (kVA)	
Average number of MV/LV Secondary substations per feeder in urban areas	
Average number of MV/LV Secondary substations per feeder in rural areas	
Average length per MV feeder in urban areas	
Average length per MV feeder in rural areas	
Number of TSO-DSO interconnection points	
Voltage levels of the distribution networks (kV)	
Typical number of voltage levels concatenated in distribution (for example 1 LV level, 1 MV levels and 1 HV level)	
Degree of automation in the MV network [Type of smart grid automation equipment and penetration (e.g. Circuit breaker, Tele-controlled circuit breaker, Switch (on-load), Tele-controlled switch, Fault detector, Directional fault detector, Recloser, …)]	

	Substations equipped with Monitoring/Automation Equipment	Degree of penetration (low/medium/high) °°	Percentage of substations equipped with these equipment (%)
1			
2			
3			
4			
5			
…			

°° Low penetration is 0-5%, medium penetration is 5-20% and high penetration above 20%.

I. Distributed generation

Generation connected to distribution network (ONLY!)

Total Installed Capacity [MW]	Total Gross Electricity Generation [GWh]	Connected to LV (1kV) [%]	Connected to MV (1-36 kV) [%]	Connected to HV (>36kV) [%]
Photovoltaic				
Wind				
Biomass				
Waste				
Hydro				

J. Reliability

Are the reliability indexes measured per type of area?

If yes, in what areas? What are the reliability indexes (annual value of each reliability index per type of area, for long unplanned interruptions)?

	Value
Urban-SAIDI (min./cust.)	
Urban-SAIFI (int./cust.)	

Rural-SAIDI (min./cust.)	
Rural-SAIFI (int./cust.)	

Please fill in the following table in case your reliability indexes or area type are not the proposed ones.

	Area type	Reliability Index	Units	Value
Area 1				
Area 2				
Area 3				
Area 4				