Interoperable solutions for implementing holistic **FLEXI**bility services in the distribution **GRID**

FLEXIGRID impact assessment and replication potential

Deliverable 7.1

WP7

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ABBREVIATONS

CA: Consortium Agreement
CC: Communication Committee
DoA: Description of Action
EC: European Commission
DMP: Data Management Plan
GA: General Assembly
H2020: Horizon 2020
IPR: Intellectual Property Right
KPI: Key Performance Indicator
M: Month
PC: Project Coordinator
PH: Project Handbook
R&D: Research and Development
SAIDI: System Average Interruption Duration Index
SAIFI: System Average Interruption Frequency Index
SC: Steering Committee
SME: Small and Medium Enterprise
TP: Technical Partner
WP: Work Package

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EXECUTIVE SUMMARY

The deliverable provides an updated analysis of the expected impact and replicability of FLEXIGRID's solutions. First of all, it is important to evaluate the barriers that hinder the replication of solutions across different regions in Europe, including regulatory, market, technical, and other challenges. By identifying and addressing these barriers, the project aims to maximize the impact of its results by ensuring the replicability and scalability of the solutions developed.

The assessment of impacts focuses on the solutions tested in the eight use cases demonstrated in the project. Each use case is thoroughly examined, considering positive aspects, pre-requisites, constraints, variability, and Technology Readiness Level (TRL) advancements. This evaluation provides valuable insights into the potential impact and feasibility analysis of implementing these use cases in different contexts.

To quantify the impacts, five main indicators have been selected. First, the solutions aim to improve stability and flexibility by reducing System Average Interruption Duration Index (SAIDI) and System Average Interruption Frequency Index (SAIFI). Second, how they contribute to curtailing decrease through enhanced observability and control over the grid. Third, how the solutions help to reduce the need for interconnection reinforcement and investments to maintain grid quality and stability. Furthermore, how they enhance the capability to manage future energy loads effectively. Lastly, how the project's solutions lead to significant CO2 emissions savings, aligning with sustainability objectives.

By considering these indicators, the impact of each solution has been quantified and assessed, comparing the impact expected before the project started and the one obtained after the demonstrations of the use cases. This deliverable serves as a crucial tool for understanding the challenges and opportunities involved in replicating FLEXIGRID's solutions.

Finally, there is an analysis of the replication potential of the project's solutions, developing a Roadmap for replication, considering the different phases. It also evaluates the use of the FUSE platform to guarantee successful replication of the work done in the project's use cases in other countries and/or areas. Moreover, the replication process for FLEXIGRID's solutions is detailed, considering the potential of each of the Use Cases and analysing: technical requirements of the solutions, ideal environment, third-party assistance, resources needed, legal affairs, duration, readiness of the technologies, and warnings.

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1. INTRODUCTION

Throughout the implementation of the FLEXIGRID project, an assessment of the possible impacts of the Use Cases and a comparison of the expected impacts before the beginning of the project will be carried out within the framework of Task 7.1 of Work Package 7 (WP7). The objective is to estimate the potential replication of FLEXIGRID solutions in Europe.

The solutions developed throughout FLEXIGRID project are expected to be tested and demonstrated in four demo-sites located in four different countries to ensure their replicability and scalability. Besides, these demo-sites have been carefully chosen so that each one represents an entirely different scenario. In this sense, FLEXIGRID counts with a micro-grid in a Greek island, a segment of MV/LV distribution grid in the north of Spain, a city district in Zagreb, and a remote valley which can act as isolate mode. Furthermore, during the project ATOS made use of the FUSE platform to facilitate the replicability of services and solutions in different pilots and beyond the boundaries of the project.

This task will analyse the best potential replication cases across Europe for the FLEXIGRID solutions to be implemented in a Short-medium term period.

Deliverable 7.1 FLEXIGRID Impact assessment and replication potential, presents an analysis of the different indicators that are needed to understand the real impact of the work within the use cases and the 4 Demos.

1.1. Scope of the deliverable

Since the replicability and scalability of the solutions is desirable to ensure the maximum impact of the use of the project's results, Deliverable 7.1 aims to update and compare the impact that was expected before the project started to what was expected now, near the end of the project and the demo sites are validated.

It aims to reflect the barriers implicated for replications of solutions through the different regions of Europe, whether they are regulatory, market, technical, etc. It will also serve as a guide to understand the replication process.

1.2. Task relation to the project

Goal #4 of the project is to ensure the interoperability and compatibility of the developed solutions with the different platforms used by the European DSOs guaranteeing a proper and secure data management. **This goal aims to ensure replicability of the solutions to other platforms of the DSOs.** It is expected a development of a common platform including all the necessary protocols and standards to communicate with the different DSOs platforms, regardless of the language and the types of data used.

Goal #5 of the project is to carry out a complete demonstration program up to TRL 8 in four different demo-sites, **obtaining reliable results on its replicability and ensuring its attractiveness for European stakeholders.**

Goal #6 of the project is to identify and analyse the needs and shortfall of the distribution grid as well as the obstacle to innovation under the current local and international context and regulation framework. One of the results that is being seek from this goal is to **evaluate FLEXIGRID's developments not only in the different demo-sites but also in other European countries, ensuring replicability and scalability of the project results.**

2. BACKGROUNDS AND DEFINITIONS

2.1. Replication

Replication refers to reproducing something as similar as possible. However, replication of smart digital solutions for public service or network grid is usually more complex than taking a solution developed to solve a specific challenge in one city or country and copying it to another one the exact same way. With the objective of scaling the solutions and the use cases of the project, a broader definition of replication is more valuable.

The Smart Cities Information System (SCIS) knowledge platform has defined replicability in the following way: "*Replicability refers to the possibility of transporting or 'copying' results from a pilot case to other geographical areas, albeit with potentially different boundary conditions. In other words, if a pilot was proven to work in one community or region, it could be exported to other communities or regions (indigenously or abroad) but taking into account that the boundary conditions could be quite different from those in the piloted community or region. Replication may also encompass the management process that was used in the pilot scheme or the cooperation structure between critical stakeholders*"[1].

With this definition we can understand that replication can mean copying a full solution, however, it is more likely that only parts of a solution can be replicated by taking or adapting components in different scenarios and context.

2.2. Understanding the replication process.

Most of the time, replication of a full solution is not possible, instead the solutions built for one city/country context must be appreciated as smaller components of functionalities (or in some cases actively broken down in components) before being adapted for use in a different context to create a new solution.

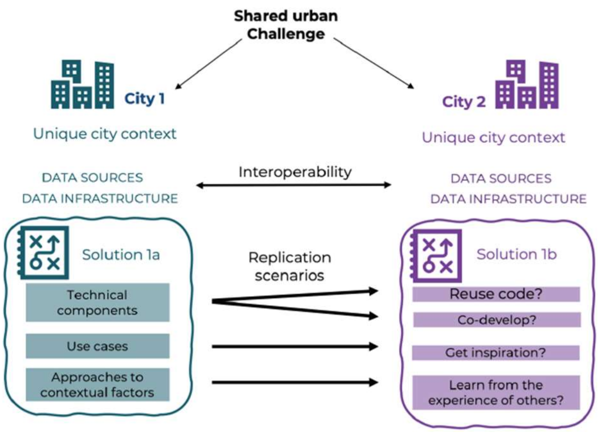


Figure 1. Overview of replication flow[2]

[1]https://smartcities-infosystem.eu/sites/www.smartcities-infosystem.eu/files/document/the_making_of_a_smart_city__replication_and_scale_up_of_innovation_across_europe.pdf

[2] Kouraki , E., Sandberg, C., & van Herk, S. (s.f.). *Replication Guidelines Open source solutions for Public Service Delivery.* European Union.

The figure above aims to show different scenarios of replication from one city to another (it could also be between different policy areas of the same city). The challenges that cities face are in many cases similar between different cities. These 'shared urban challenges' are then experienced locally and embedded in the unique context in each city.

To develop, test and implement a solution in a city, much work is needed in terms of engaging stakeholders, finding financing models or assuring that all aspects of a solution are working within the legal framework.

It is unlikely to find cases where a solution can be replicated as an exact copy to a different context. So instead of looking at replication of a full solution, it is recommended to appreciate the solution as different components (or actively break it down into different components) and then see how some of these components can be used for different use cases contributing to a new solution to the challenges.

2.3. Barriers for replication

In the context of European public projects, there are some common barriers that may arise for the replication of the results. The obstacles mentioned below are often identified in the context of projects like FLEXIGRID.

Technical barriers	Barriers that could arise due to the technological complexity of the project. There may be difficulties in technology transfer or in accurately reproducing results obtained in different conditions.
Financial barriers	Lack of financial resources can be a significant replication barrier. Limited funding may make it difficult to purchase the necessary equipment, hire qualified personnel, or perform additional validations to test the results.
Legal and regulatory barriers	In some cases, there may be legal and regulatory barriers that make it difficult to replicate the results of a project in different countries or regions. This may be due to differences in rules and regulations regarding intellectual property, data protection, ethics, etc.
Knowledge barriers	The lack of detailed information or unclear documentation, procedures and protocols used in the project can make it difficult to replicate the results. Lack of access to specialized knowledge or lack of knowledge transfer between consortium members could also be relevant barriers.
Barriers to collaboration	Replication of results may require collaboration and coordination between different project partners. Barriers to communication, collaboration, and data sharing among consortium members can prevent successful replication.

Cultural and language barriers	European projects often involve teams from different countries with different cultures and languages. Cultural and linguistic differences can hinder understanding, knowledge transfer, and effective collaboration, which could affect replication of results.

3. IMPACT ASSESMENT

3.1. DEMO 1: SPAIN

The Spanish Demo Site focused on two important aspects related to the architecture of the smart grids of the future: the smartening of the grid and the development of new protections for scenarios with a large share of renewable energy sources.

The use cases analysed in this demo were:

- Use case 1: Secondary Substation upgrading for higher grid automation and control.

This new SS will be able to take advantage of the available information and the communications channels used by meters, RTUs and other devices in an optimized way. The innovations proposed will be suitable for both the development of brand-new SSs and the retrofitting of existing ones thanks to the use of the integration of the Energy Box. This Secondary Substation will be complemented by the implementation of operation algorithms and efforts will be made towards the development of a new generation of smart meters with improved Feeder Mapping features.

- Use case 2: Protection functions operating with large RES share penetration in the distribution grid.

Improvement of the protections of primary (HV) and secondary (MV) distribution networks and the algorithms for their operation, in grids with high penetration of RES, is the primary goal of this use case. As it has been showed in previous BRIDGE projects such as MIGRATE (focused on the transmission network), current protection systems have problems for the correct fault detection in cases where there is a high contribution of RES connected to the grid through power electronics. The typical protection functions of distribution grid currently have a higher level of dependency of fault current magnitudes than those of transmission network, therefore are more vulnerable to changes in fault currents behaviour, as expected in scenarios intensive in renewable energies, with a consequent risk to the security of the grid.

More information on the sites is included in Deliverable D2.1 (Demo-sites description and boundary conditions report).

For the evaluation of the Use Cases, a form was shared with the partners who participated in each Use Case so that they could respond about the impact. The form can be found in ANNEX 1.

3.1.1. USE CASE 1: Secondary Substation upgrading for higher grid automation and control

The development of the "Secondary Substation (SS)" as a vehicle that includes operation and control algorithms and functionalities is proposed. These new SS will be able to take advantage of the available information and the communications channels used by meters, RTUs and other devices in an optimized way. The innovations proposed are suitable for both the development of brand-new SSs and the retrofitting of existing ones thanks to the use of the integration of the

Energy Box. This Secondary substation was complemented with the implementation of operation algorithms and efforts were made towards the development of a new generation of smart meters with improved Feeder Mapping features.

Positives Aspects

The Secondary Substation of Villabermudo is in a Low Voltage grid with a 46% of renewable generation (Photovoltaic generation). This is one of the reasons why this area could be greatly benefited from the UC1 developments.

A Smart Transformer can help control the very variable voltage in the LV grid by the means of continuous self-adjustments. As a note, an average of 11 daily changes have occurred for the 6 months that the transformer has been operating.

The development of grid operation technologies for the management of the grid can also be of great importance due to the variability and the intermittence of the solar generation which, as it has been mentioned before, rises up to the 46% of the Secondary Substation capacity.

Pre-Requisites

The identification of the prerequisites for each potential (to-be-installed) use case is a vital step towards its applicability to other countries. Physical, technical, or other factors might act as prerequisites for the installation of each use. Each partner, from each point of view, provided a list of the prerequisites for each UC, a short justification, and any quantifications related (if related). Prerequisites might be related to a specific installation area or might be referring to the country in general.

Number	**1**
Title	**Reliable network communications**
Description	Smart equipment for remote control and supervision requires reliable and secure network connection.
Quantification	• Reliable 3G speed or higher • VPN recommended for security
Number	**2**
Title	**Voltage variations**
Description	Smart transformers are most interesting in locations where the variations in the grid make it recommendable (or necessary) to make continuous changes in the position of the transformer
Quantification	• Voltage variation > 5% at LV side
Number	**3**
Title	**Equipment with implemented communications**
Description	The Energy box is designed to act as a hub for different equipment. However, this equipment needs to include some kind of communications so that the Energy box can read the output or, in some cases, issue commands.
Quantification	• N/A

Constraints

Each use case application might be subject to limitations and constraints in potential demo-site or country. The reasons for these constraints might be legal, environmental or of any other domain. As laws are different in each country, generic references based on experience and/or European Legislation are enough for the purposes of this document.

Number	**1**
Title	**Photovoltaic roof installation**
Description	Photovoltaics cannot be installed in areas that were not legally authorized for that purpose.
Quantification	Can be installed in distances >1km.

Variability

Each UC was composed by several components that are entitled to perform a specific task and to deliver a certain result. Within the variability template, the possibility of using different components is examined that can deliver the same result. The usage of different components might be better instead of the original component in terms of efficiency or just the original component might not be able to be replicated in other areas.

Number	**1**
Original Component	**New smart secondary substation.**
Alternative Components	Upgraded secondary substation.
Description	Secondary substation with only some of the new developed technologies
Justification	Sometimes a full change to a smart secondary substation is worthwhile, but in some cases, it is not due to the costs. Upgraded secondary substations can have some of the components instead of all of them. The main example is the smart transformer. A change in the transformer might not be necessary but remote supervision of the Secondary Substation is still available without that change.

TRL Advances

Solution	Initial TRL	Target TRL	Final TRL	Comments
ER1 - Secondary Substation of the future	5	8	8	The main electrical components (automated switchgear, monitored low voltage board and OLTC based transformer) of the Secondary Substation were successfully installed. Since then, the installation has been remotely operated and data gathered.

ER2 - New generation of smart meters	6	8	8	The new modular meter has been validated and is currently ready for controlled rollouts. The feeder mapping algorithm has been validated in the last reporting period in the Spanish demo with data from the meters installed in one of the selected centres. The results obtained during the test have been good and promising.
ER4 - Energy Box	6	8	8	The device has been successfully installed in two demos, Greece and Spain, where its integration with the demos' assets and the fuse platform is being verified. The telemetry and operating parameter setting was completed, performing some remote tests and algorithm executions in several trials.
ER5 - Software module for fault location and self-healing	5	8	6	The self-healing module has been tested in the Spanish demo (MV distribution grid). With data from that grid, the performance locating different faults has been compared with the actual manual system, using self-healing with the actual Faul Pass Indicators, and adding TDR.
ER6 - Software module for forecasting and grid operation	6	8	7	The module has been developed during the first reporting period. During the second reporting period the module has been tested in an operational environment during the first phase of the demonstration campaigns in the Greek demo site and the results of the validation have been reported in deliverable D6.7. The module has been deployed in operative conditions during the rest of the demonstration campaigns in Greece.
ER9 – FUSE Platform	5	8	8	During the RP3 the FUSE platform development has been adapted taking in account the adjustments required for the different pilots. In the same way, the visualization dashboards have been configured according to the pilots requirements. Being linked with WP6 activities, the interfaces between FUSE and the demos have been supported to guarantee the correct pilot development and obtaining the KPIs to be reflected in WP6 deliverables.

3.1.2. USE CASE 2: Protections functions with large RES share penetration in the distribution grid

Improvement of the protections of primary (HV) and secondary (MV) distribution networks and the algorithms for their operation, in grids with high penetration of RES. As it has been showed in previous BRIDGE projects such as MIGRATE[3] (focused on the transmission network), current protection systems have problems for the correct fault detection in cases where there is a high contribution of RES connected to the grid through power electronics. The typical protection functions of distribution grid currently have a higher level of dependency of fault current magnitudes than those of transmission network, therefore are more vulnerable to changes in fault currents behaviour, as expected in scenarios intensive in renewable energies, with a consequent risk to the security of the grid.

Positives Aspects

This Use Case not only had a very positive impact in the area where it is going to be implemented but also the Demo Site had a very positive impact in the development of the technology.

Some of the fault location equipment is going to be tested in two demo sites, one for training and another for verifying. The verifying area needs of very precise fault location and self-healing due to recurrent ghost faults that disappear by themselves making it very difficult to find the cause. But the important thing about this Demo is that the training Site was a real grid where a real fault was generated at a known spot. This makes it unique and perfect for the adjustment of the fault location equipment.

Pre-Requisites

Number	**1**
Title	**High renewable energies share**
Description	Though some of these solutions are oriented to high-RES share, fault location and fault passage devices are important and useful everywhere.
Quantification	• RES share > 40%

Constraints

Number	**1**
Title	**Distance to fault**
Description	TDR fault location equipment is expected to work properly at relatively short distances from the fault. These distances have to be verified on the field
Quantification	• TDR distance to the fault < 10 to 12 km.
Number	**2**
Title	**Number of devices**

[3] https://cordis.europa.eu/project/id/691800

Description	TDR location requires more than one device in range to the fault. The device output is distance, but several point of the grid may be at the same distance from the device.
Quantification	Bare minimum of 2 devices in range of every point of the grid in the best case. At least 3 devices in most cases.

Variability

In this case, variability analysis does not apply since these are complex hardware devices designed to improve what already exists. There is no variability in the components of the solutions, there could be variability in the manufacturer. Furthermore, there are also components that were developed by CIRCE specifically for FLEXIGRID.

TRL Advances

Solution	Initial TRL	Target TRL	Final TRL	Comments
ER3 - MV protections hardware	5	8	8	The new protection algorithms have been implemented in ZIV MV protection relays. They were tested in RTDS lab and then installed in the field. The records obtained have shown a much better reliability than conventional algorithms. The improved protection units have tripped during fault not tripped by the conventional units.
ER5 - Software module for fault location and self-healing	5	8	6	The self-healing module has been tested in the Spanish demo (MV distribution grid). With data from that grid, the performance locating different faults has been compared with the actual manual system, using self-healing with the actual Faul Pass Indicators, and adding TDR.
ER9 – FUSE Platform	5	8	8	During the RP3 the FUSE platform development has been adapted taking in account the adjustments required for the different pilots. In the same way, the visualization dashboards have been configured according to pilots' requirements. Being linked with WP6 activities, the interfaces between FUSE and the demos have been supported to guarantee the correct pilot development and obtaining the KPIs to be reflected in WP6 deliverables.

3.2. DEMO 2: GREECE

The Greek Demo Site, located at a hotel resort in Thasos, showcases a modern approach to energy management through a 400kVA substation integrated within the resort. This setup includes several bungalows, three of which are furnished with Photovoltaic (PV) production installations alongside battery storage systems. The substation, a contemporary medium voltage asset, is meticulously monitored using an Energy Analyser, with additional monitoring equipment dedicated to data acquisition for a circuit supplying a double Electric Vehicle (EV) charging point on-site.

Within the demo, the total PV generation stands at 50kWp, and energy storage is facilitated through three Lithium-ion batteries boasting a collective peak capacity of 24.9 kWh at a 95% depth of discharge. The Schneider PM2200 energy analysers, connected at the substation, keep tabs on the overall load and the EV charging point, providing insights into 4-quadrant energy, power quality, demand, and true Root Mean Square (RMS). The bungalows' inverters are linked to individual smart meters, measuring local load parameters, PV production, and battery states. This robust setup is fortified with a secured local network, utilizing encryption and an optical fibber network extending to each bungalow, ensuring a seamless connection among monitored and controllable devices like inverters, energy analysers, energy meters, and the control relay for the EV charging point.

For the evaluation of the Use Cases, a form was shared with the partners who participated in each Use Case so that they could respond about the impact. The form can be found in ANNEX 1.

3.2.1. USE CASE 3: Holistic energy system optimization & emulation for commercial and residential customers

Positives Aspects

The deployed FLEXIGRID solutions in the Greek demo site (namely the load and PV forecasting algorithms and the grid congestion management algorithm) were expected to enhance the accuracy of demand and generation forecasting, hence improving the visibility over the local grid and enabling the accurate definition of flexibility requirements in the mid and short term. This will subsequently allow for the better maintenance of the quality of supply while optimising energy flows towards improving network utilisation.

The key positive impacts were assessed via dedicated KPIs in the Greek demo and fall into the categories of energy cost reduction (for both cost of energy and network charges) as well as grid congestion management, peak shaving and demand response.

Pre-Requisites

Number	**1**
Title	**Photovoltaic roof installation**
Description	The existence of locally installed PV systems is essential for the implementation of UC3.
Quantification	• Appropriate regulatory framework • Annual PV potential >1000kWh/kW • Annual PV yield >1000kWh/sqm (A general rule of thumb is that a PV array should produce at least 1,000 kilowatt-hours (kWh) per year per square meter (sqm) of solar panel. However, this figure can vary depending on the specific circumstance).

	• Available capacity in the local substation > • Financing capability
Number	**2**
Title	**Battery**
Description	The existence of locally installed storage systems is essential for the implementation of UC4.
Quantification	• Physical space • Electrical space • Appropriate regulatory framework
Number	**3**
Title	**Communications infrastructure**
Description	The devices are connected to the communication gateway through a Modbus TCP network. The gateway gathers the information of the rest of the system and send it to the central platform.

Quantification	• Bandwidth > 1Mbps
	• Existence of communication gateway (e.g. Energy Box) with:
	  ○ processing power Cortex-A53 64-bit Soc @ 1.2GHz
	  ○ memory 1 GB RAM
	  ○ Ethernet and serial interfaces, also WiFi

Number	**4**
Title	**Defined tariff regime**
Description	The energy pricing comprises a number of charges applicable to commercial customers in Greece. These include energy prices for different periods, distribution and transmission charges for different periods, other fees and taxes, etc. UC3 can be replicated if a clear charging regime is defined, and the scheduling algorithm (ER7) is re-programmed to take it into account.
Quantification	N/A.

Constraints

Number	**1**
Title	**Photovoltaic roof installation**
Description	Photovoltaics cannot be installed in areas where the upstream network is congested
Quantification	• Available capacity > installed capacity of PV

Variability

Number	**1**
Original Component	**Photovoltaics**
Alternative Components	Wind turbine
Description	Renewable energy production unit
Justification	Wind turbines can be used when the solar potential is not adequate and in large-scale replications but there are several environmental

	constraints as well as higher cost for their implementation compared to the PVs
Number	**2**
Original Component	**Electrical battery Li-ion**
Alternative Components	Electrical battery Lead Acid Small Hydro storage Redux flow battery
Description	Energy Storage Unit
Justification	In general, the choice of battery technology depends on the specific requirements of the application. Lead-acid batteries are typically less expensive than lithium-ion batteries and have a longer history of use, which means that they are widely available and well-understood. They are also reliable and have a high tolerance for overcharging, making them suitable for applications such as backup power systems, golf carts, and boats. However, lead-acid batteries have a lower energy density than lithium-ion batteries, which means that they are bulkier and heavier for a given energy capacity. They also have a shorter cycle life and a slower charging time than lithium-ion batteries. Redox flow batteries on the other hand store energy in two tanks of liquid electrolyte, which are pumped through a cell stack where the energy is converted into electricity. The energy density of a redox flow battery is typically lower than that of a lithium-ion battery, but they can offer longer cycle life, higher safety, and better scalability. Redox flow batteries are particularly suitable for applications that require long-duration energy storage, such as grid-scale energy storage and renewable energy integration. They can also be useful in applications that require high safety, such as backup power systems and remote power systems. However, redox flow batteries also have a lower energy density than lithium-ion batteries, which means that they require more space for the same energy capacity. They can also be more complex and expensive to install and maintain. Lastly, small hydro storage systems use a small-scale hydroelectric generator to convert the potential energy of water into electricity, which is then stored in a battery or used to power devices directly. These systems can be particularly useful in areas with a reliable water source and a significant elevation change. Compared to lithium-ion batteries, small hydro storage systems have several advantages. They have a longer lifespan and can last up to 50 years or more, while lithium-ion batteries typically have a lifespan of 10-15 years. Small hydro storage systems also have a high energy density, which means that they can store a large amount of energy in a small space. However, small hydro storage systems require a constant supply of water and a significant elevation change, which may not be available in all locations. They can also be expensive to install and maintain, and they require a significant amount of infrastructure to operate.

TRL Advances

Solution	Initial TRL	Target TRL	Final TRL	Comments
ER4 - Energy Box	6	8	8	The device has been successfully installed in two demos, Greece and Spain, where its integration with the demos' assets and the fuse platform is being verified. The telemetry and operating parameter setting was completed, performing some remote tests and algorithm executions in several trials.
ER6 - Software module for forecasting and grid operation	6	8	7	The module has been developed during the first reporting period. During the second reporting period the module has been tested in an operational environment during the first phase of the demonstration campaigns in the Greek demo site and the results of the validation have been reported in deliverable D6.7. The module has been deployed in operative conditions during the rest of the demonstration campaigns in Greece.
ER7 – Software module for congestion management	5	8	7	The module has been developed during the first reporting period. During the second reporting period the module has been integrated with FUSE platform and testing has started in an operational environment during the first phase of the demonstration campaigns in the Greek demo site. The testing has been completed during the 3rd reporting period and final results have been reported in D6.11.
ER9 – FUSE Platform	5	8	8	During the RP3 the FUSE platform development has been adapted taking in account the adjustments required for the different pilots. In the same way, the visualization dashboards have been configured according to the pilots requirements. Being linked with WP6 activities, the interfaces between FUSE and the demos have been supported to guarantee the correct pilot development and obtaining the KPIs to be reflected in WP6 deliverables.

3.2.2. USE CASE 4: Microgrid congestion management and peak shaving. Impact Assessment

Use cases 3 and 4 in the context of the Greek demo work interdependently since the two solutions deployed in the Greek demo (PV and load forecasting module (S6) and congestion management module (S7)) are tested in both Use Cases, as also described in D4.2, D4.4 and the deliverables of T6.3.

Hence, the impact assessment of Use Case 3 applied as well to Use Case 4.

3.3. DEMO 3: CROATIA

The Croatian demo site encompasses two distinctive locations: a Medium Voltage (MV) distribution network designed with a meshed network potential, and two residential apartments fortified with smart metering infrastructure at Demo Site 4 (UC6). The MV network houses various switching devices and relays that facilitate both network reconfiguration, for instance, altering network topology due to heightened network losses or voltage limitation violations, and adaptive protection within urban networks.

The first residential apartment is equipped with smart metering and advanced communication infrastructure, alongside controllable flexible devices like electrified heating and HVAC systems. The second apartment boasts an advanced communication infrastructure that enables bidirectional signalling for flexibility activation concerning controllable loads. HYPERTECH significantly contributed to the design of the communication module used in UC6 activities, primarily aimed at activating flexibility services provided by end-users. This architecture, along with the communication establishment, has been meticulously documented in deliverable D6.12.

For the evaluation of the Use Cases, a form was shared with the partners who participated in each Use Case so that they could respond about the impact. The form can be found in ANNEX 1.

3.3.1. USE CASE 5: Coordinating distribution network flexibility assets & protections schemes in urban districts. Impact Assessment

Positives Aspects

Besides the customer's participation in the project, other solutions oriented to the increase of a network's flexibility will be achieved by using DSO's assets and physical devices. The solutions include: i) the capability to change the medium voltage distribution network topology with the goal of preventing the unwanted events and increasing the network's reliability; ii) mapping of the DSO side flexibility towards the transmission system in so called capability charts. The value of this model is multiple, from assisting in TSO-DSO coordination when utilizing flexibility on the distribution side to new options and services such as voltage-led demand response which will ensure the improvement of network conditions provided by DSO's assets that are able to change their operating schedule and provide UQ regulation.

The obvious benefit is the installation of new devices and communication equipment in a distribution network that will enable the mitigation of unwanted events without additional costs caused by the network reinforcement.

The extra, and not so obvious benefits, are the following:

- Scenarios of self-consumption and energy efficiency will be demonstrated in the project, both leading to a reduction in the overall energy consumed from the electricity network, and therefore to lower electricity bills.
- Community-level consumption optimization scenarios will be also demonstrated. Useful learning on additional revenues streams for energy communities and their members will be created. New business models will be proven, possibly leading to revenue stacking strategies for energy communities.
- Higher energy awareness, more active participation of customers in the energy sector
- Increase of the network's observability and the capability of the network to operate in a less conservative way.

Mapping of the DSO operational limits in the context of both operational capacity but also future hosting capacity.

Pre-Requisites

Number	**1**
Title	**Switching equipment / Relays**
Description	Before the installation of relays used for the network reconfiguration on the pilot site, several analyses need to be conducted: a) establish a capability of the network to switch its topology (meshed structure), b) perform initial analyses of load flows, short circuits, c) define the switching locations and redo the above analyses, d) test the equipment in the laboratory environment
Quantification	Life expectancy of the relays (expected number of trippings) Number of false (unnecessary) trippings
Number	**2**
Title	**Access to static/historic data**
Description	The static and historic data is needed for adequate modelling, testing and analysis of the potential solution. In addition, historical data for a period of a minimum of 2 years needs to be available for off-line verification of the modelling results.
Quantification	Number of times that data could not be accessed
Number	**3**
Title	**Access to dynamic data**
Description	In order to access the data necessary for the successful operation of devices installed on the pilot site, data exchange between different parties is required. Additional equipment is installed and tested so that the successful communication is established and verified. Successful communication will ensure activating the devices only in the extreme events (e.g., avoiding of unnecessary relays tripping).
Quantification	Number of times that data could not be accessed

Constraints

Number	**1**

Title	**Authorized personnel**
Description	Certified electricians to install hardwire IoT devices, training personnel to conduct the commissioning of the IoT devices
Quantification	N/A
Number	**2**
Title	**Skilled/educated personnel**
Description	Advanced operation of the distribution networks also requires additional education and training for the DSO's personnel, from field engineers to dispatchers
Quantification	N/A
Number	**3**
Title	**"Sensitive" consumers**
Description	Very often meshed networks, or N-1 connected networks are designed close to sensitive or large consumers. Testing innovative solutions in areas of the networks with such consumers might be difficult due to interruptions of supply
Quantification	Number of consumers that are identified as a target group for the trial.

Variability

Number	**1**
Original Component	**Relay installed in an MV network**
Alternative Components	Other manufacturer/vendor switching equipment / relays
Description	Relays installed in the demo site defined in UC5 are of a certain type manufactured by a certain producer. The goal of the relays is to enable the change of the topology based on the set goal, e.g., a decrease in network losses. Alternatively, some other switching devices with the similar characteristics can be used if a defined goal can be achieved by using those devices.
Justification	If the alternative device is cheaper, has a better control or has some additional advantages compared to the used one, it can be installed as long as it provides the wanted functionalities.

TRL Advances

Solution	Initial TRL	Target TRL	Final TRL	Comments
ER3 - MV protections hardware	5	8	8	The new protection algorithms have been implemented in ZIV MV protection relays. They were tested in RTDS lab and then installed in the field. The records obtained have shown a much better reliability than conventional algorithms. The improved protection units have tripped during fault not tripped by the conventional units.

ER5 - Software module for fault location and self-healing	5	8	6	The self-healing module has been tested in the Spanish demo (MV distribution grid). With data from that grid, the performance locating different faults has been compared with the actual manual system, using self-healing with the actual Faul Pass Indicators, and adding TDR.
ER7 – Software module for congestion management	5	8	7	The module has been developed during the first reporting period. During the second reporting period the module has been integrated with FUSE platform and testing has started in an operational environment during the first phase of the demonstration campaigns in the Greek demo site. The testing has been completed during the 3rd reporting period and final results have been reported in D6.11.
ER9 – FUSE Platform	5	8	8	During the RP3 the FUSE platform development has been adapted taking in account the adjustments required for the different pilots. In the same way, the visualization dashboards have been configured according to the pilots requirements. Being linked with WP6 activities, the interfaces between FUSE and the demos have been supported to guarantee the correct pilot development and obtaining the KPIs to be reflected in WP6 deliverables.

3.3.2. USE CASE 6: Virtual Energy Storage for urban building. Impact Assessment

Positives Aspects

The FLEXIGRID’s context-aware, human-centric virtual thermal energy storage system was trialed at customer premises. It is a system that automatically adjusts the energy consumed by some household devices (either shifts their operation at different times or consumes less energy) without compromising the comfort of the occupant(s) at the household.

The obvious benefit for the customer participating in the FLEXIGRID project is the installation of smart, off-the-shelf devices (using project funds) which will allow the customer to i) monitor the indoor conditions at the premises, ii) monitor the consumption of certain devices at their premises, iii) control remotely certain devices at their premises (turn on/off their electric water boiler for example, or pre-heat their house by turning on their heating), and iv) monitor their overall household consumption (particularly insightful for those that currently do not have a smart meter installed).

Pre-Requisites

Number	**1**
Title	**Controllable Electric Appliances**
Description	The pilot sites must include controllable electric appliances, like electric heating/ cooling systems and electric water heaters
Quantification	Energy (power) that can be activated for the flexibility provision
Number	**2**
Title	**Controllability by the occupants**
Description	The pilot sites must provide direct controllability of these loads by the occupants according to their preferences
Quantification	Temperature range that defines the occupants' comfort zone
Number	**3**
Title	**Installation of IoT equipment**
Description	Occupants must consent to the installation of specific sensing, actuating and metering equipment (consisting of the FLEXIGRID gateway & commercial sensing/actuating and metering equipment) to allow the tools developed within the project to learn user preferences and act on their behalf in other to conserve energy or create demand flexibility.
Quantification	N/A
Number	**4**
Title	**Residential end users**
Description	Residential electricity consumers with an active (in force) supply contract with permanent residence in a dwelling
Quantification	Occupants shall ideally remain at the participating properties for at least three (3) years from the start of the participant recruitment (most preferably they should be owners of the property) and they should also be willing to participate in the project activities for three (3) years (this is an estimated period that will be adjusted/reduced depending on the time of formal engagement to the project demonstration activities).
Number	**5**
Title	**Access to end user premises**
Description	Residential users willing to give access to qualified personnel for the installation of necessary monitoring and control equipment for the relevant controllable devices (i.e., electric heating/cooling systems and electric water heaters).
Quantification	N/A
Number	**6**
Title	**End user participation to project activities - consent**
Description	Residential users willing to sign a consent form to allow the collection and processing of necessary (and only those) data, as well as give feedback about their user experience.
Quantification	N/A
Number	**7**
Title	**Solution user acceptance**

Description	Residential users that are willing to test a semi-automated control system at their premises. The possibility of user bypass will remain available so that the user can "correct" system actions.
Quantification	Number of users that are willing to participate in similar projects
Number	**8**
Title	**Wi-Fi availability and access**
Description	Residential users with an active, constantly-enabled wi-fi internet connection (required for local connection of monitoring and control devices – minimum bandwidth requirements) who can and will allow other devices to be connected to it (e.g. can provide the connection credentials).
Quantification	Wi-Fi speed
Number	**9**
Title	**Access to static/historic data**
Description	The static and historic data is needed for adequate modelling, testing and analysis of the potential solution. In addition, historical data for a period of a minimum of 2 years needs to be available for off-ine verification of the modelling results.
Quantification	Number of times that data could not be accessed
Number	**10**
Title	**Access to dynamic data**
Description	In order to access the data necessary for the successful operation of devices installed on the pilot site, data exchange between different parties is required. Additional equipment is installed and tested so that the successful communication is established and verified. Successful communication will ensure activating the devices only in the extreme events (e.g., avoiding of unnecessary relays tripping).
Quantification	Number of times that data could not be accessed

Constraints

Number	**1**
Title	**GDPR compliance**
Description	Ensure that all data collected and processed from customers participating in the demonstrations (in Croatia) of FLEXIGRID are treated according to the relevant legislation of each country and of the EU and safeguarded throughout and after the end of the project.
Quantification	N/A
Number	2
Title	**Installation of IoT devices**
Description	Procurement, installation and commissioning of the appropriate IoT devices.
Quantification	Number of installed IoT devices.
Number	3
Title	**Consumer's digital skills**
Description	Customers should be technology literate
Quantification	N/A
Number	**4**

Title	**Regulation Barriers**
Description	Many MSs have not yet defined the regulatory framework for the operation of storage systems and the services they can offer, the rules for connecting to the network etc.
Quantification	N/A
Number	**5**
Title	**Capital Costs**
Description	Energy poverty - exclusion of most vulnerable customers from participation in DR markets due to capex requirements
Quantification	Amount in euros that is needed for the investment
Number	**6**
Title	**Lack of incentives (e.g., energy tariffs, DR compensation etc.)**
Description	Missing whole-system benefits in electricity market design: value of DR services in the energy market is not yet fully recognized
Quantification	Amount in euros that is missing in order to fully exploit the potential of services

Variability

Number	**1**
Original Component	**IoT equipment and sensors**
Alternative Components	Other manufacturer
Description	If some other manufacturers can ensure real-time measuring and storing of measurements in the database, they can alternatively be installed.
Justification	If the alternative device is cheaper, has a better control or has some additional advantages compared to the used one, it can be installed as long as it provides the wanted functionalities.

TRL Advances

Solution	Initial TRL	Target TRL	Final TRL	Comments
ER6 - Software module for forecasting and grid operation	6	8	7	The module has been developed during the first reporting period. During the second reporting period the module has been tested in an operational environment during the first phase of the demonstration campaigns in the Greek demo site and the results of the validation have been reported in deliverable D6.7. The module has been deployed in operative conditions during the rest of the demonstration campaigns in Greece.
ER8 - Virtual thermal energy storage model	6	8	7	The VTES components and their integration in a single module was performed during the previous reporting periods. The remaining deployment issues were resolved in the 3rd reporting period.

				Following this, the VTES model was demonstrated in operational environment. Unforeseen issues prevented the conduction of trials for a longer period.
ER9 – FUSE Platform	5	8	8	During the RP3 the FUSE platform development has been adapted taking in account the adjustments required for the different pilots. In the same way, the visualization dashboards have been configured according to pilots' requirements. Being linked with WP6 activities, the interfaces between FUSE and the demos have been supported to guarantee the correct pilot development and obtaining the KPIs to be reflected in WP6 deliverables.

3.4. DEMO 4: ITALY

The Italian Demo Site showcases a Medium Voltage (MV) grid connected to the Sarentino primary substation in South-Tyrol, characterized by its high penetration of dispersed generation, predominantly from hydroelectric plants, and limited connectivity with the broader grid via one High Voltage (HV) and one MV line. The grid's design presents challenges, especially during certain grid events where both lines could be out of service, jeopardizing the power supply to customers. Similar issues arise at the ends of the MV lines, where alternative feeders for emergency supplies are absent. Moreover, the extensive distributed generation units along the lengthy MV lines pose difficulties in load-flows and voltage regulation.

The pilot project aims to establish a dispatching platform to manage segments of this grid in an islanded mode during emergencies, utilizing existing MV hydroelectric plants. In normal conditions, the pilot also seeks to regulate the reactive power of these plants to control the voltage in the MV grid and manage reactive power exchanges with the HV grid. To ensure a substantial volume of grid measurements, a smart RTU (STCE-SG) provided by SELTA has been installed in 19 MV secondary substations, encompassing both transformation MV/LV and MV customer substations. Within the hydroelectric plants participating in the pilot, the STCE-SG interfaces with plant controllers to regulate the generator. The dispatching platform's entire process is overseen by the Smart Grid Controller, situated at the system control room in ALPERIA.

For the evaluation of the Use Cases, a form was shared with the partners who participated in each Use Case so that they could respond about the impact. The form can be found in ANNEX 1.

3.4.1. USE CASE 7: Dispatching platform for MV generation. Impact Assessment

Positives Aspects

During the development of use case 7, the implementation of real-time data exchange with Medium Voltage (MV) users emerged as a notable milestone, enhancing dynamic interaction between the grid and its users. Coupled with precise control of MV producers, this initiative facilitates active and reactive power modulation. The adjustment of reactive power further accentuates these benefits, leading to a host of advantages that significantly contribute to the overall efficacy of the power system.

Moreover, the demonstration has showcased meticulous control of the voltage profile along the lines, reducing limit violations and ensuring a more stable grid operation. The reduction in peak current is crucial for effective congestion control, mitigating potential grid overloads during high demand periods. This, along with marked reductions in grid losses, not only conserves energy but also lowers operational costs.

A promising outcome is the increase in Hosting Capacity, allowing a higher number of producers to connect to the grid.

Pre-Requisites

Number	**1**
Title	**Hydroelectric MV producers**
Description	It`s easier to regulate the active/reactive power, frequency.
Quantification	Depends on the goal and the usable grid.

Constraints

Number	**1**
Title	**Environmental influences**
Description	If the geological area is not suitable, the amount of active power produced hydroelectrically will be minimal.
Quantification	Depends on the grid you want to create.

Variability

Number	**1**
Original Component	**Hydroelectrical plant**
Alternative Components	Biomass Sources; Photovoltaics, Wind power
Description	Renewable energy production unit
Justification	Hydroelectrical turbines are used because of the constant production.

TRL Advances

Solution	Initial TRL	Target TRL	Final TRL	Comments
ER1 - Secondary Substation of the future	5	8	8	The main electrical components (automated switchgear, monitored low voltage board and OLTC based transformer) of the Secondary Substation were successfully installed. Since then, the installation has been remotely operated and data gathered.

ER2 - New generation of smart meters	6	8	8	The new modular meter has been validated and is currently ready for controlled rollouts. The feeder mapping algorithm has been validated in the last reporting period in the Spanish demo with data from the meters installed in one of the selected centres. The results obtained during the test have been good and promising.
ER6 - Software module for forecasting and grid operation	6	8	7	The module has been developed during the first reporting period. During the second reporting period the module has been tested in an operational environment during the first phase of the demonstration campaigns in the Greek demo site and the results of the validation have been reported in deliverable D6.7. The module has been deployed in operative conditions during the rest of the demonstration campaigns in Greece.
ER9 – FUSE Platform	5	8	8	During the RP3 the FUSE platform development has been adapted taking in account the adjustments required for the different pilots. In the same way, the visualization dashboards have been configured according to pilots' requirements. Being linked with WP6 activities, the interfaces between FUSE and the demos have been supported to guarantee the correct pilot development and obtaining the KPIs to be reflected in WP6 deliverables.

3.4.2. USE CASE 8: Mountainous valley grid operating in island mode. Impact Assessment for UC8

Positives Aspects

In use case 8, the focus shifts towards significantly bolstering the security and resilience of the MV/LV grids, especially under adverse weather conditions. The proactive measures adopted have notably amplified the resilience against major weather events, ensuring a robust continuity of supply even under challenging circumstances. A remarkable outcome is the expedited service restoration, eliminating the time traditionally required for emergency generator installation, thereby ensuring a rapid return to operational normalcy post-disruption. This is further accentuated by the elimination of CO_2 emissions associated with the conventional emergency oil generators, marking a stride towards environmentally responsible grid management.

Moreover, the implementation of this use case has led to improve profit for the Distribution System Operators (DSO), who no longer must spend on traditional emergency generators or the oil they need to run. Producers also benefit from this setup as they can keep their operations running even when there's a problem with the grid, by helping out the DSO. This way, both the DSO and producers save money and time, while also making the grid more reliable and friendly to the environment.

Pre-Requisites

Number	**1**
Title	**Hydroelectric MV producers**
Description	It`s easier to regulate the active/reactive power, frequency.
Quantification	Depends on the grid and the size of the island you want create.

Constraints

Number	**1**
Title	**Network structure**
Description	If the distribution network is not suitable, e.g. cable lengths, power loads too high, it will not be possible to create a distribution island.
Quantification	Depends on the grid and the size of the island you want to create.

Variability

Number	**1**
Original Component	**Hydroelectrical plant**
Alternative Components	Biomass Sources
Description	Renewable energy production unit
Justification	Hydroelectrical turbines are used because of the constant production.

TRL Advances

Solution	Initial TRL	Target TRL	Final TRL	Comments
ER5 - Software module for fault location and self-healing	5	8	6	The self-healing module has been tested in the Spanish demo (MV distribution grid). With data from that grid, the performance locating different faults has been compared with the actual manual system, using self-healing with the actual Faul Pass Indicators, and adding TDR.
ER6 - Software module for forecasting and grid operation	6	8	7	The module has been developed during the first reporting period. During the second reporting period the module has been tested in an operational environment during the first phase of the demonstration campaigns in the Greek demo site and the results of the validation have been reported in deliverable D6.7. The module has been deployed in operative conditions during the rest of the demonstration campaigns in Greece.
ER9 – FUSE Platform	5	8	8	During the RP3 the FUSE platform development has been adapted taking in account the adjustments required for the

				different pilots. In the same way, the visualization dashboards have been configured according to pilots' requirements. Being linked with WP6 activities, the interfaces between FUSE and the demos have been supported to guarantee the correct pilot development and obtaining the KPIs to be reflected in WP6 deliverables.

The SGC solution went from a level 6 (project start) to a level 7 (project end).

4. DIRECT IMPACT INDEX FOR USE CASES

The solutions developed within the framework of this project can be associated to the implementation of the 8 use cases demonstrated in the four pilots of the project. To quantify these impacts, five main indicators were selected at proposal stage: 1) Improved stability and flexibility via the reduction of SAIDI and SAIFI; 2) Curtailment decrease thanks to the improvement of the observability and control over the grid; 3) Reduction of the reinforcement of interconnections and investments needed to maintain the quality and stability of the grid; 4) Improve the capability to manage future energy loads; and 5) CO2 emissions savings.

The measurement of the indicators was carried out by the demo partners considering the measurement that was done out before the start of the project.

4.1. Improved stability and flexibility via the reduction of SAIDI and SAIFI.

Combining monitoring and metering with control methods will reorganize the distribution network, which has been traditionally planned and operated as a passive system, thus making it more flexible, manageable and reliable. Several initiatives exist focusing on ICT-based systems to automate grid-scale operations through balancing loads and generation, optimizing asset dispatch and maintaining power quality. However, current systems lack comprehensive data models and suitable, intelligent software to predict energy generation, manage loads and fine tune the energy produced and delivered, and the energy consumed. Additionally, an increase in the intelligence of the grid infrastructure has become evident to make them capable of interoperate with the cyber layer. Building on these needs, FLEXIGRID develops a set of solutions capable of collecting, screening and using all available data in an effective way towards grid optimization, and the implementation of advance protections functions. In relation to stability and security of supply, FLEXIGRID will focus on reducing the impact of system interruptions, as well as its number. The two main indicators regarding grid failures are SAIDI (System Average Interruption Duration Index), which indicates the average interruption time and SAIFI (System Average Interruption Frequency Index), which indicates the average number of interruptions. Most of these reliability problems are related to failures in distribution grids.

4.1.1. Direct impact of use cases on indicator at the beginning of the project:

SAIDI & SAIFI	UC	1	2	3	4	5	6	7	8
	Impact	Medium	Low	High	Medium	High	Medium	High	Low

4.1.2. Direct impact of use cases on indicator at the end of the project:

SAIDI & SAIFI	UC	1	2	3	4	5	6	7	8
	Impact	Medium	Low	High	Medium	Medium	Low	High	Medium

4.2. Curtailment decreases thanks to the improvement of the observability and control over the grid.

Member States are requested by the European Directive 2009/28/EC to minimize the use of curtailment, which results in RES enjoying preferential treatment in the electricity grid.

However, there are times when this is not possible due to security-based limits of the power systems.

FLEXIGRID smartens the current energy infrastructure with the polyvalent Energy Box and develops efficient operation algorithms for DSOs. These solutions and uses cases range from generation, forecasting and managing loads, to community energy simulation models, all the way to optimizing distribution with third party providers. All of them will be demonstrated within the project, paving the way to the improvement of RES in the grid. FLEXIGRID's software and tools allow to forecast RES generation and optimize the best resources to integrate them in the grid, comparing and optimizing their integration taking into account the foreseen demand.

The amount of data coming from metering and monitoring devices, weather forecast and historical data among other make necessary the use of big data analytics solutions to tackle these predictions. Factoring all these elements in, FLEXIGRID develops new solutions enabling real-time prediction of system inertia and frequency reserves needed, and consequently facilitating the integration of a high share of renewable sources. Thanks to FLEXIGRID and by means of this comprehensive approach that covers all sides, more DER will be integrated at LV and MV grids without compromising the security and stability of the grid and contributing to the security of supply. In this sense, FLEXIGRID will allow DSOs to increase the hosting capacity of DER in their grids to reach the 45% of variable renewables by 2030. Thus, also contributing to the EU power network to integrate large share of renewables exceeding 50% by 2030, in particular variable energy sources, in a stable and secure way.

4.2.1. Direct impact of use cases on indicator at the beginning of the project:

CURTAILMENT	**UC**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
	Impact	Medium	Low	High	High	Low	High	High	Medium

4.2.2. Direct impact of use cases on indicator at the end of the project:

CURTAILMENT	**UC**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
	Impact	Medium	Low	High	High	Medium	High	High	Medium

4.3. Reduction of the reinforcement of interconnections and investments

The power grid infrastructure is very critical and contains a large number of interconnected components: generators, power transformers, and distribution feeders that are geographically spread. Moreover, its increasing complexity, the huge number of geographically spread generators, and the side effects caused by the variable nature and high penetration of RES make it very vulnerable, thus requiring new sophisticated security mechanisms. According to the EU Smart Grid Technology Platform, distribution networks present significant "structural inertia" as they are dominated by passive elements, principally uncontrolled loads. Under such circumstances, the intermittent RES production, as well as the additional EV demand, will require the reinforcement of the existing grid infrastructures according to the foreseeable EV/RES deployment levels, to ensure stable and secure grid operation.

In the short to medium term, FLEXIGRID presents new software solutions that drastically improves the management of loads, reliability of supply and protections, allowing distributors to improve their service with inexpensive investments in their facilities. In the medium to long term, FLEXIGRID reduces the necessity to spend more resources in optimising the service thanks to the development of new smart substations. Once the old infrastructure is updated and these innovative substations are installed, they are already equipped with state-of-the-art software that enable cost-saving, efficient service, which has a direct impact in both the distributors and users. These solutions avoid the future oversizing of the grid infrastructure which is unfeasible for long-term scenarios.

4.3.1. Direct impact of use cases on indicator at the beginning of the project:

REINFORCEMENTS	UC	1	2	3	4	5	6	7	8
	Impact	Low	Low	Low	High	High	High	High	Medium

4.3.2. Direct impact of use cases on indicator at the end of the project:

REINFORCEMENTS	UC	1	2	3	4	5	6	7	8
	Impact	Low	Low	Low	High	High	High	High	Medium

4.4. Capability to manage future energy loads

Similar to the case earlier in “Improve stability and flexibility”, the capacity of managing future energy loads results in a direct impact in the future stability of the grid. Although both impacts are closely related, loads management is directly linked to the control of the assets. To actuate with the different elements of the grid, a close cooperation between the physical and the ICT layer is needed. It has been demonstrated that the large penetration of RES in the distribution grid and the everyday more often role of the electric vehicles in the transport network, will significantly modify the demand profile of power system and will affect the operation and management of the distribution grid. FLEXIGRID addresses these issues by means of introducing both the digitalization of the infrastructure and the ICT software for the management of the distribution grid. FLEXIGRID puts in relevance the role of the consumers in the management of the future grid loads. Smart meters bring the opportunity to reach consumers and suppliers, adapting their consumption throughout the day and providing additional information to grid operators for the accurate management of the grid. FLEXIGRID contributes to replacing at least the 80% of electricity meters by 2020, saving up to €309 per metering point and a 3% of energy.

Furthermore, FLEXIGRID solutions will contribute to reduce consumers demand down to 5%, in other words, the management of domestic loads will allow that more than the 95% of electricity supply comes from domestic power plants, being aligned with the European renewable energy target for 2030.

Finally, FLEXIGRID will demonstrate the management of the grid through the execution of control and operation algorithms in the distribution grid. These algorithms will allow grid operators to remotely operate the grids, managing DER and increasing the observability and controllability over the assets. FLEXIGRID’s software and tools allow to forecast and manage RES generation and domestic assets such as the EV charging stations and optimise the best resources to integrate them in the grid, comparing and optimizing their integration taking into account the foreseen demand. This approach will facilitate the objectives of the EU energy roadmaps, encouraging electricity systems to allow higher RES levels in an economic and safe manner.

4.4.1. Direct impact of use cases on indicator at the beginning of the project:

MANAGE LOADS	UC	1	2	3	4	5	6	7	8
	Impact	Low	High	Low	High	Low	High	Medium	Medium

4.4.2. Direct impact of use cases on indicator at the end of the project:

MANAGE LOADS	UC	1	2	3	4	5	6	7	8
	Impact	Low	High	Medium	High	High	High	Medium	Medium

4.5. CO2 emissions savings

Solutions implemented in FLEXIGRID transform current and future energy grids in more sustainable, since they improve the energy efficiency of operation and allows for better management of the energy sources. GHG emission reduction is achieved, for example, thanks to peak-shaving solutions and RES curtailment. The quantifiable emissions reduction achieved with FLEXIGRID is a true benefit and also serves as motivation for more active engagement in demand-response plans. Considering a policy scenario whereby the major policy barriers for the participation of small-scale demand response in the markets are removed by 2030 and smart meter deployment moves forward as planned, the energy system stands to reduce its CO2 emissions by 12.7 Mton annually. This is due to the non-utilisation of peaking generation plants, typically more polluting plants are the costliest to activate and are last in the merit order. Demand response (peak load reduction effectively) removes the need to activate them. These savings correspond to an aggregated EU level DR potential of 52.5 GW. The remaining emissions reduction by 2030 (ca. 430 Mtons) are achieved thanks to the avoidance of curtailment of 8 TWh of intermittent RES annually, contributing to the 2030 Climate-Energy objectives of 40% GHG reduction with respect to 1990 and at least of 27% share penetration of renewables by 2030, thanks to the transition of the RES penetration from transmission networks to distribution networks. This is an optimistic but very plausible and likely scenario for emissions reduction.

4.5.1. Direct impact of use cases on indicator at the beginning of the project:

CO2 SAVINGS	UC	1	2	3	4	5	6	7	8
	Impact	Medium	Medium	High	High	High	High	High	Medium

4.5.2. Direct impact of use cases on indicator at the end of the project:

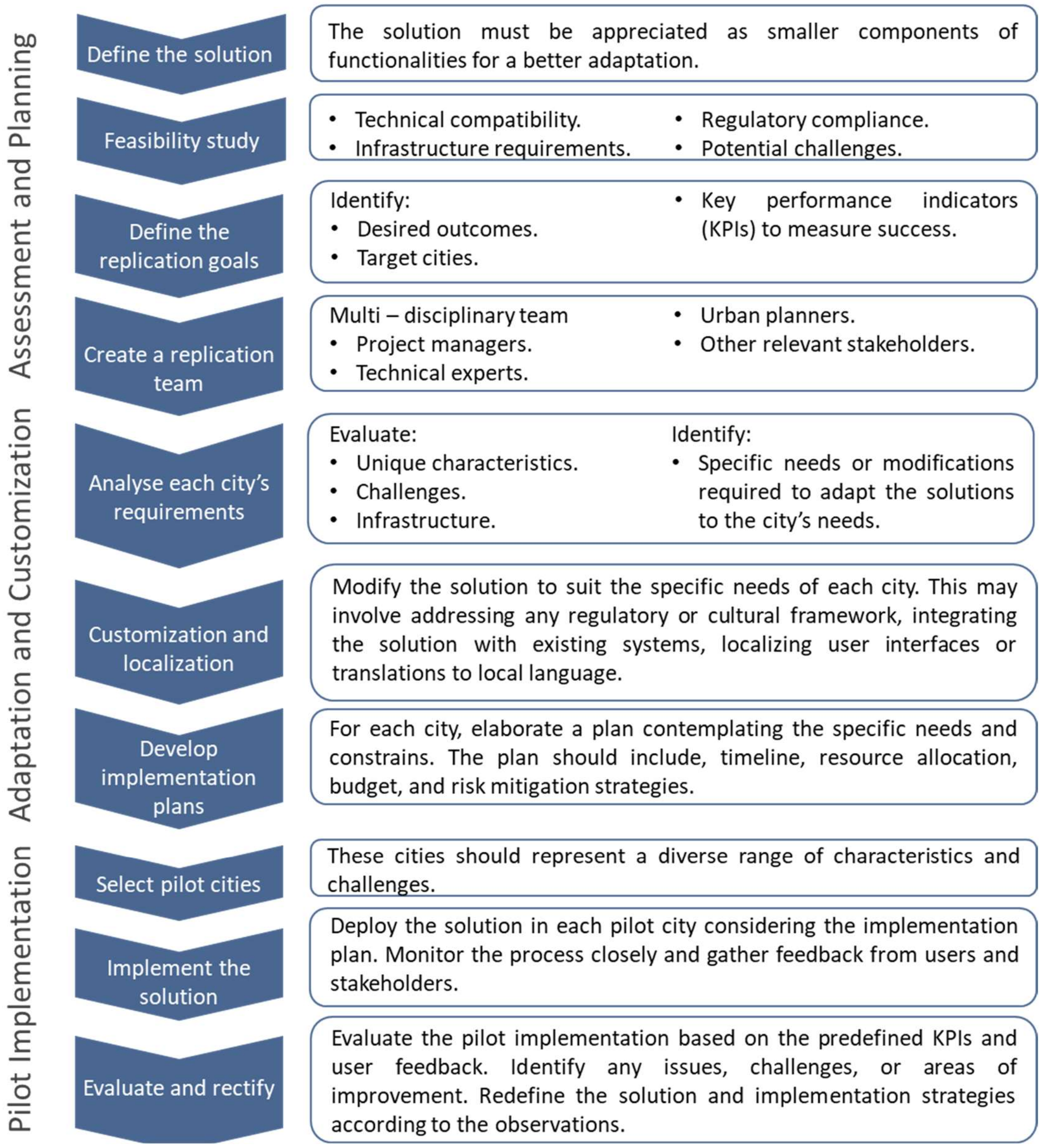
CO2 SAVINGS	UC	1	2	3	4	5	6	7	8
	Impact	Medium	Medium	High	High	Medium	Medium	High	Medium

5. REPLICATION POTENTIAL

5.1. Roadmap for Replication

To achieve a successful replication of the solutions, several points should be considered, as the context of the new place where the solution will be implemented, the objectives of this implementation and the adaptation that the solution should go through to reach the expectations and help to solve the identified problems. Moreover, it is important to maintain a continuous evaluation to improve and re define the implementation of the solution.

The following is the recommended roadmap for the successful replication of the solutions developed in FLEXIGRID in other areas.



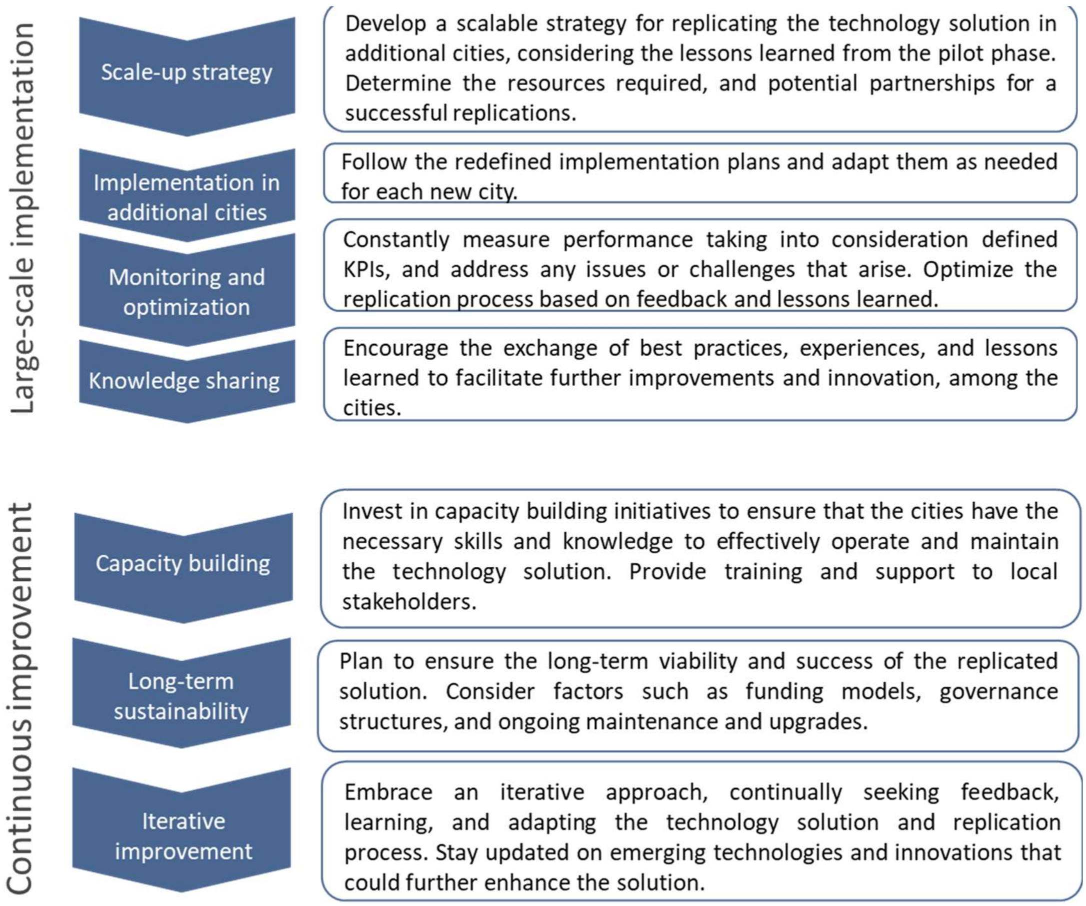


Figure 2. Roadmap for replication.

5.2. Interoperability – FUSE Platform

The demo-sites carefully chosen in FLEXIGRID cover the entire range of numerous items included in the EU policy and market trends with respect to the enhancement of distribution networks. This wide scope points to guarantee that the proposed solutions, showcased through a thorough and representative demonstration plan, offer high replicability potential.

The project covers a comprehensive scenario of distribution grids' topologies currently existing in Europe: a peri-urban distribution network (Spain), an Island (Greece), an urban district distribution network (Croatia) and a remote valley operating in island mode (Italy).

As a result, the direct impacts achieved by FLEXIGRID solutions in each demo-site can be extrapolated at European level. Moreover, the project includes the fact that all arrangements are interoperable thanks to the FUSE (Framework for Utilities and Services in Energy) platform, which also deals with cyber security aspects under the project. Much obliged to this representativeness of demo cases and assurances of replicability, no potential technical issues are anticipated when these solutions are conveyed in alternative areas.

The achievement of that afore mentioned interoperability relates to FUSE's versatility and ability to adapt to diverse contexts. This software platform architecture presents a set of modules to handle different duties and satisfy modern-day needs related to aspects such as data analytics, data processing, machine learning and even data visualization.

A particularly interesting block is the one devoted to handle connectivity, which provides the functionalities responsible for establishing the path to connect to and receive information from the data sources available at a specific scenario. Through the employment of tailor-made adaptors FUSE supports integration of diverse such data sources, as well as software applications, into a unified data management system, while interoperability is achieved via well-known standards. In the particular case of FLEXIGRID demonstrators, to conduct the required interactions FUSE implements specific adaptors that let proceed with the data ingestion from diverse sources. Hence, solutions based on SFTP (Secure File Transfer Protocol), AMQP (Advanced Message Queuing Protocol), OPC (OLE for Process Control) or REST (Representational State Transfer) APIs (Application Process Interfaces) appear and deliver successful results in those pilot sites.

One of the pathways to confirm the validity of the FLEXIGRID solution and its scientific discoveries is by repeating the research that produced it. The consideration of FUSE as an open-source platform that enables the integration of devices at the edge by fully exploiting data available from local and distributed energy resources to build added value services not only for Utilities companies but also for diverse energy stakeholders is a way to guarantee this pursued replicability. Thanks to its intrinsic nature, that enables device integration, contributes to perform energy assets management duties, puts the focus in data and maximizes interoperability via its various available and tailor-made adaptors, FUSE guarantees the capability to successfully replicate the work conducted in FLEXIGRID use cases in other countries and/or areas.

5.3. Replication Process

5.3.1. UC 1

Technical requirements of the solutions:	The solution requires the installation of the following devices in: MV Secondary substation: - LV Supervision, based on a LV RTU that communicates with LV slaves connected at each of the feeder. The LV Supervision allows the feeder mapping of the meters connected downstream. The LV RTU is installed in a control panel located close to LV boards and the slaves will be installed in the own LV board. - An intelligent OLTC that allows to regulate the low voltage dynamically. - Fully tele controllable MV switches - Router for remote access Energy box: - Router for remote access / Internet connection. - List of protocols and signals for each asset to be connected. - Data format to upload the device information to the cloud platform. Fuse Platform: - Architecture documents of FUSE platform.

	- Documentation of communication protocols apt to work with on site to perform interactions and exchange data. - Description of data sources on site to develop and deploy tailor-made adaptors that guarantee FUSE connectivity. This way, it is possible to establish the path to connect to and receive information from those data sources available at this specific scenario. - Detail on particular needs in the scenario to take advantage of FUSE's versatility and deploy the precise modules suitable in such context.
Ideal environment:	The ideal environment will be a MV distribution network with high RES penetration or with distributed energy resources (DER).
Third-party assistance:	DSOs, aggregators.
Resources needed:	- Servers required to run FUSE platform. A new servers cluster could be required to properly work in each replication site. - Panel for installation (housing) and cable management for EnergyBox including power supply, ethernet cables.
Legal Affairs:	RES must behave according to the grid codes in the specific country. There are specific standards that the equipment inside the substations must fulfil, but this is a common practice for all DSOs. For domestic integration to the flexible grid and as end users are involved, special legal requirements could be needed.
Duration:	At least one year.
Readiness of the technologies:	The technology is ready and tested for installation in other sites.
Warnings:	Prevention against possible cyberattacks.

5.3.2. UC 2

Technical requirements of the solutions:	The solution requires the installation of the following devices in: MV Primary substation: - Feeder protection relay with improved protection algorithms for high-RES penetration. - Router for remote access. MV Secondary substation: - Fault passage indicators: including protection algorithms to cope with MV networks with high RES. They are installed in a control panel located in the MV switchgear. - LV Supervision, based on a LV RTU that communicates with LV slaves connected at each of the feeder. The LV Supervision allows the feeder mapping of the meters connected downstream. The LV RTU is installed in a control panel located close to LV boards and the slaves will be installed in the own LV board. - Router for remote access.
Ideal environment:	The ideal environment will be a MV distribution network with high-RES penetration in which the fault contribution comes from these sources.

Third-party assistance:	DSOs, EPCs
Resources needed:	Machinery: test set or multimeters that allow doing tests and measurements in the field. People: technical people from the utility or EPC capable of doing the installation and SAT. The equipment providers (ZIV, CIRCE, etc) would give support remotely or locally if required. Training: a brief training about the installation and commissioning must be done by the equipment providers (ZIV, CIRCE, etc). Labs: the equipment has already been tested in the lab, so no extra testing is required.
Legal Affairs:	RES must behave according to the grid codes in the specific country. There are specific standards that the equipment inside the substations must fulfil, but this is a common practice for all DSOs.
Duration:	At least one year.
Readiness of the technologies:	The technology is ready and tested for installation in other sites.
Warnings:	No warnings detected yet.

5.3.3. UC 3 & UC 4

Technical requirements of the solutions:	There are no specific technical requirements for the replication of the solution in another environment. What's needed is for enough space to be available for the installation of the different assets (PV, battery, EV chargers) and communication systems to be established, as described in section 4.1.2. The required technical documentation for the replication includes: - Single line diagrams of the local electrical infrastructure including LV feeders initiating from the local LV/MV substation, intermediated switching gear or sub-boards, loads, generation and storage units of the infrastructure where the solution(s) will be deployed). - Communications diagram (local network topology with IPs and modbus IDs per device included in the topology). - Architecture documents of FUSE platform. - Documentation of communication protocols to perform interactions. - Documentation of ER6 and ER7 solutions. - Documentation of Data model. - Equipment manuals and modbus registers documentation (inverters, meters, batteries).
Ideal environment:	Any inhabited environment (houses, offices, buildings of any use) with enough space available for the installation of DER.
Third-party assistance:	Local installers for PV, batteries and network configuration should be available in the beginning of the replications process.
Resources needed:	The required resources for the replication include: - Servers require to run solutions ER6 and ER7 (LINKS to add server capacity). - Servers required to run FUSE platform. New servers cluster in each replication site.

	- Personnel required to maintain all ERs (LINKS, ATOS and CIRCE to comment on personnel needed). One person devoted part-time to maintain ER9 in replication site. - Support from local technical personnel for installation and equipment maintenance.
Legal Affairs:	For the replication of the solution there needs to be a specific regulatory framework in place to allow for the installation of the PV and batteries in commercial environment. As an example, the regulatory framework of net-metering currently applied in Greece allows for the installation of PVs in commercial environments and the reduction of the energy consumed from the grid according to the system's generation. Additionally, in order to fully exploit the potential of the developed solutions, the regulatory framework pertinent to power network connections, should allow flexible assets -such as a battery- to export active or reactive energy to the grid in the context of a regulated Demand Response Market Scheme ran by the Network operators. Contrary to the above requirement, the current regulatory framework in Greece allows for the batteries to be installed only behind-the-meter and it is prohibited to export energy to the grid.
Duration:	The necessary time to replicate the solution would be 4 to 6 months.
Readiness of the technologies:	The solutions deployed in the Greek demo are considered ready to be used but better results could be achieved if the following parameters are improved: - Further training of the forecasting algorithms for load and PV forecasting algorithms with recent actual data.
Warnings:	A number of pre-trial manual devices control sessions were realized, focusing mainly on understanding the capabilities and limitation on battery and reactive power controllability through the inverters, utilizing the SunSpec Modbus Standard that is adopted by Fronius inverters installed on-site (https://sunspec.org/sunspec-modbus-initiative/). This process resulted in the conduction of important learning points which needed to be reflected on the respective device control routines followed by LINKS (algorithms output) and CIRCE (energy box programming). The process described above triggered the modification of LINKS' algorithm output format and subsequently the re-alignment of all affected JSON files and relevant processes (adaptations in FUSE's data model and in CIRCE's setpoints retrieval and control actions). Similar actions should be considered if the solutions are to be replicated in other projects in order to align integration activities with the technical specifications and communication capabilities of the equipment that will be installed.

5.3.4. UC 5

Technical requirements of the solutions:	Established communication with relays and other equipment. Relays. Testing the equipment before the final installation.
Ideal environment	MV distribution networks with the occurrence of unwanted events.

	Substations. MV lines.
Third-party assistance	Assistance needed from a DSO.
Resources needed	Installation of devices (e.g., relays), communication and IoT equipment.
Legal Affairs	Agreement of critical consumers in the testing network.
Duration	It depends on the completion of the auditing and procurement procedures, afterwards the solution requires testing in the laboratory environment, testing the data exchange after the installation at the pilot location. A minimum duration of the testing once the equipment is installed at the location should be 12 months, 18 months is preferable testing period.
Readiness of the technologies	Relays are delivered and before the instalment on the pilot location they will be tested in the laboratory environment.
Warnings	Possibility of unnecessary relays tripping. Problems with the communication between different parties. Errors in the exchange of data. Delays during the procurement phase. Incorrect installation and commissioning of the devices.

5.3.5. UC 6

Technical requirements of the solutions:	Stable and high quality/speed internet connection at the pilot site. End users with electricity-based heating cooling systems and Electric Water Heaters. Establishment of the communication that will ensure the data exchange.
Ideal environment	Single occupant homes. Small offices.
Third-party assistance	Assistance needed with the installation of appliances and the communication equipment.
Resources needed	Appliances, communication and IoT equipment.
Legal Affairs	GDPR compliance.
Duration	It depends on the completion of the auditing and procurement procedures, afterwards the solution requires the collection of the data which requires a minimum of several weeks. After the solutions testing and commissioning, the integrated testing solution should be 12 months minimum.
Readiness of the technologies	Appliances are installed at one location. Communication infrastructure is installed at one location.
Warnings	Complete incorrect the auditing templates to identify the appropriate IoT devices to be installed. Delays during the procurement phase. Incorrect installation and commissioning of the communication and IoT devices.

5.3.6. UC 7

Technical requirements of the solutions:	Hydroelectrical plant; Biomass Sources; Photovoltaics; Wind power.
Ideal environment:	Highly hydraulic and sunny environment.
Third-party assistance:	DSOs with certain amount of capacity.
Resources needed:	Electrical equipment, training, labs.
Legal Affairs:	Be the owner of the production facilities or regulate with the owners the responsibilities and comply with the regulations of your country (in Italy CEI0-16).
Duration:	1 year.
Readiness of the technologies:	Existing equipment on the market.
Warnings:	As much availability of electrical measurements as possible and as quickly as possible.

5.3.7. UC 8

Technical requirements of the solutions:	Hydroelectrical plant; Biomass Sources;
Ideal environment:	Highly hydraulic and sunny environment.
Third-party assistance:	DSOs with certain amount of capacity.
Resources needed:	Electrical equipment, training, labs.
Legal Affairs:	Be the owner of the production facilities or regulate with the owners the responsibilities and comply with the regulations of your country (in Italy CEI0-16).
Duration:	1 year.
Readiness of the technologies:	Existing equipment on the market.
Warnings:	As much availability of electrical measurements as possible and as quickly as possible.

Additional comment: The replication in this use cases is very difficult to assess. Since many factors such as distribution network, geological area, connected producers, to name but a few, influence the replication. It must be assessed on a case-by-case basis if replication is economically viable and if it would have the same impact.

6. CONCLUSIONS & RECOMMENDATIONS

The FLEXIGRID project proposes to improve the distribution grid operation making it more flexible, reliable, and cost-efficient. For this, 8 technological solutions have been developed and analyzed in specific use cases considering the most common distribution grid problems in Europe. These use cases were demonstrated in 4 demo-sites to evaluate different scenarios and the potential of replicability in other European countries and/or areas.

Deliverable 7.1 helps to understand the barriers and requirements to achieve a successful replicability and scalability of each solution. There are many barriers that should be considered as regards technical, financial, legal and regulatory aspects, knowledge collaboration, and cultural and language obstacles. All of them are common in European projects such as FLEXIGRID and may arise when trying to replicate the project's solutions in new sites. Understanding these barriers is crucial for developing strategies to overcome them and facilitating the widespread adoption of the solutions.

Moreover, for a better understanding of the replication potential and the impact of each of the solutions an analysis of the use cases has been done, considering different aspects such as: positive aspects of implementing the solutions, pre-requisites, constraints that may affect the implementation and/or replication, variations that may occur, and TRL advances on the solutions during the project.

To evaluate the impact of the use cases some Key Performance Indicators were defined, such as:

1. Improved stability and flexibility via the reduction of SAIDI and SAIFI.
2. Curtailment decreases thanks to the improvement of the observability and control over the grid.
3. Reduction of the reinforcement of interconnections and investments needed to maintain the quality and stability of the grid.
4. Improve the capability to manage future energy loads.
5. CO2 emissions savings.

These indicators reflect the project's commitment to enhancing grid performance, sustainability, and energy efficiency.

The impact of the use cases in each of these indicators was first predicted before the project started. After the demos were developed the impacts were measured again. In this deliverable a comparison between the prediction and the actual impact was held. The results show that for almost all the KPIs, except number 3, the actual impact measured is different from the predictions, in some cases the result has been higher than the one predicted and, in some others, lower. As regards KPIs the highest impacts are related to improve the capability to manage future energy loads and to obtain CO_2 saving. The use cases with higher impact are, UC 3, UC 4, UC 6, and UC 7.

As it can be seen in the deliverable the replication potential is high if a correct plan is developed. To achieve this, the roadmap for replication and all the aspects analyzed for each of the use cases should be considered. It is important to have in mind the resources needed to proceed with the replication of each solution, not only technical requirements but also assistance.

Moreover, when choosing the potential place to hold the replication, the context should be considered, bearing in mind the ideal environment and legal affairs, among other aspects. When planning the replication strategy, the duration of it and the readiness of the technology should also be considered. There are some solutions that even after the project finishes will still not be ready for market implementation and will need further tests and developments before starting the replication.

Furthermore, it is important to highlight that the project covers a wide range of distribution grid configurations currently present in Europe: a peri-urban distribution network (VIESGO, Spain), an Island (VERD, Greece), an urban district distribution network (HEP, Croatia) and a remote valley operating in island mode (EDYNA, Italy). Even though this does not guarantee a successful replication in other sites, it helps to increase the probability of obtaining fortunate results, as the impacts obtained in FLEXIGRID's use cases can be extrapolated to other European countries. The FUSE platform and its versatility and ability to adapt to diverse contexts sustains this idea of high interoperability of the solutions.

To conclude, this deliverable serves as a valuable guide to understand the replication process and analyze future replication efforts. It gives stakeholders an idea of the challenges and opportunities associated with implementing FLEXIGRID's solutions in diverse European regions.

7. REFERENCES

Kouraki , E., Sandberg, C., & van Herk, S. (s.f.). *Replication Guidelines Open source solutions for Public Service Delivery.* European Union.

8. ANNEX

8.1. ANNEX 1

FLEXIGRID Impact Assessment and Replication Potential
Deliverable 7.1 - Work Package 7
Leader: CIRCE

DEMO # – (COUNTRY)

Part I Questionnaire to evaluate the impact of the Use Cases of the FLEXIGRID Demos

UC X

Positive aspects

Positive impacts that will come through the development of the use case for the specific location.

Pre-Requisites

The identification of the prerequisites for each potential (to-be-installed) use case is a vital step towards its applicability to other countries. Physical, technical, or other factors might act as prerequisites for the installation of each use. Each partner, from each point of view, has to provide a list of the prerequisites for each UC, a short justification, and any quantifications related (if related). Prerequisites might be related to a specific installation area or might be referring to the country in general.

Example:

Number	*1*
Title	*Biomass Sources*
Description	*Biomass sources are necessary for the implementation of UC1. The biomass sources that can be used are a) wood processing residues, b) municipal waste, c) energy crops (bagasse, sugarcane).*
Quantification	• *Annual production >500ton/yr (or GWh);* • *Volatiles >70%;* • *Storage area>400m^2*

Number	
Title	
Description	
Quantification	

Constrains

Each use case application might be subject to limitations and constraints in potential demo-site or country. The reasons for these constraints might be legal, environmental or of any other domain. As laws are different in each country, generic references based on experience and/or European Legislation are enough for the purposes of this document.

Example:

Number	*1*
Title	*Photovoltaic roof installation*
Description	*Photovoltaics cannot be installed in areas that have been characterized as traditional settlements.*
Quantification	*Can be installed in distances >1km.*
Number	*2*
Title	*Desalination in Natura area*
Description	*RO Desalinations cannot be installed in Natura areas, as the brine may have a negative effect on the local ecosystem*
Quantification	*Can be installed in distances >10km;* *Can be installed in Low capacities <20m^3/day.*

Number	
Title	
Description	
Quantification	

Variability

Each UC is composed by several components that are entitled to perform a specific task and to deliver a certain result. Within the variability template, the possibility of using different components is examined that can deliver the same result. The usage of different components might be better instead of the original component in terms of efficiency or just the original component might not be able to be replicated in other areas.

Example:

Number	*1*
Original Component	***Photovoltaics***
Alternative Components	• *Wind turbine*
Description	*Renewable energy production unit*
Justification	*Wind turbines can be used when the solar potential is not adequate and in large-scale replications*

Number	*2*
Original Component	***Electrical battery Lead Acid***
Alternative Components	• *Electrical battery Li-Ion* • *Small Hydro storage* • *Redux flow battery*
Description	*Energy Storage Unit*
Justification	• *Li-Ion can be used when there is a shortage in installation space and charging speed is an issue* • *Hydro storage can be used when a significant altimeter difference exists, large storage is needed, and high charge/discharge cycles are foreseen.*

Number	
Original Component	
Alternative Components	
Description	
Justification	

TRL Advances

(Please develop a paragraph with the latest advance on the TRL of the solutions applied in the use case)

UC X

Positive aspects

Positive impacts that will come through the development of the use case for the specific location.

Pre-Requisites

The identification of the prerequisites for each potential (to-be-installed) use case is a vital step towards its applicability to other countries. Physical, technical, or other factors might act as prerequisites for the installation of each use. Each partner, from each point of view, has to provide a list of the prerequisites for each UC, a short justification, and any quantifications related (if related). Prerequisites might be related to a specific installation area or might be referring to the country in general.

Constrains

Each use case application might be subject to limitations and constraints in potential demo-site or country. The reasons for these constraints might be legal, environmental or of any other domain. As laws are different in each country, generic references based on experience and/or European Legislation are enough for the purposes of this document.

Variability

Each UC is composed by several components that are entitled to perform a specific task and to deliver a certain result. Within the variability template, the possibility of using different components is examined that can deliver the same result. The usage of different components might be better instead of the original component in terms of efficiency or just the original component might not be able to be replicated in other areas.

TRL Advances

(Please develop a paragraph with the latest advance on the TRL of the solutions applied in the use case)

Part II Direct Impact Index

The description for each of the indicators is in the main document (D7.1) also attached in the email.

1) **Improved stability and flexibility via the reduction of SAIDI and SAIFI.**

Direct impact of use cases on indicator at the beginning of the project:

SAIDI & SAIFI	UC	1	2	3	4	5	6	7	8
	Impact	Medium	Low	High	Medium	High	Medium	High	Low

Direct impact of use cases on indicator at the end of the project:

(Please, fulfil this table with updated information (low, medium, high) if the impact has change, ***please indicate why****)*

SAIDI & SAIFI	UC	1	2	3	4	5	6	7	8
	Impact								

2) **Curtailment decrease thanks to the improvement of the observability and control over the grid**

Direct impact of use cases on indicator at the beginning of the project:

CURTAILMENT	UC	1	2	3	4	5	6	7	8
	Impact	Medium	Low	High	High	Low	High	High	Medium

Direct impact of use cases on indicator at the end of the project:

(Please, fulfil this table with updated information (low, medium, high) if the impact has change, ***please indicate why****)*

CURTAILMENT	UC	1	2	3	4	5	6	7	8
	Impact								

3) **Reduction of the reinforcement of interconnections and investments**

Direct impact of use cases on indicator at the beginning of the project:

REINFORCEMENTS	UC	1	2	3	4	5	6	7	8
	Impact	Low	Low	Low	High	High	High	High	Medium

Direct impact of use cases on indicator at the end of the project:

(Please, fulfil this table with updated information (low, medium, high) if the impact has change, ***please indicate why****)*

REINFORCEMENTS	UC	1	2	3	4	5	6	7	8
	Impact								

4) Capability to manage future energy loads

Direct impact of use cases on indicator at the beginning of the project:

MANAGE LOADS	UC	1	2	3	4	5	6	7	8
	Impact	Low	High	Low	High	Low	High	Medium	Medium

Direct impact of use cases on indicator at the end of the project:

(Please, fulfil this table with updated information (low, medium, high) if the impact has change, ***please indicate why****)*

MANAGE LOADS	UC	1	2	3	4	5	6	7	8
	Impact								

5) CO2 emissions savings

Direct impact of use cases on indicator at the beginning of the project:

CO2 SAVINGS	UC	1	2	3	4	5	6	7	8
	Impact	Medium	Medium	High	High	High	High	High	Medium

Direct impact of use cases on indicator at the end of the project:

(Please, fulfil this table with updated information (low, medium, high) if the impact has change, ***please indicate why****)*

CO2 SAVINGS	UC	1	2	3	4	5	6	7	8
	Impact								

Part III Questionnaire to evaluate the replication potential of the use cases:

This table must be filled out for each of the use cases, or if it does not apply, for the demo in which the use case is developed in general.

Technical requirements of the solutions:	*Please fulfil with the technical documentation o requirements is needed to replicate the solution in another environment.*
Ideal environment:	*Please fulfil with the necessary environment that will allow an ideal replicability*
Third-party assistance:	*Who is needed to replicate the solution in other countries? Are they inside or outside of the consortium? Example: DSOs with certain amount of capacity.*
Resources needed:	*Machinery, persons, training, labs…*
Legal Affairs:	*Must there be some kind of specific regulation/normative for the recreation of the solution?*
Duration:	*Time or deadlines necessary to replicate the solutions*
Readiness of the technologies:	*Level of development of the technology / solution, ideal for its replicability*
Warnings:	*Lessons learned during the implementation of the demos to take into account for the replication*