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

Demonstration and monitoring plan

Deliverable 6.1

WP6

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ABBREVIATONS

AELC	Active Energy Loss Change
AeS	Average estimation of savings per stakeholder
BAU	Business-as-Usual
CAIDI	Customer Average Interruption Duration Index
CuSa	Customer satisfaction
DAF	Demand Available Flexibility
DER	Distributed Energy Resources
DFP	Demand Flexibility Potential
DRDD	DR Delivery Deviation
DSO	Distribution System Operators
EB	Energy Box
EC	Energy Consumption
ENS	Energy Not Supplied
EV	Electric Vehicle
FA	Forecasting Accuracy
FAT	Flexibility Actions Taken
FLA	Fault location accuracy
FUSE	Framework for Utilities and Services
IED	Intelligent Electronic Device
II	Improved Interoperability
IMRR	Island Mode Reliability Rate
IRSSR	Investment return for Secondary Substation Refit
KPI	Key Performance Indicator
MDRed	Maximum Demand reduction
NGE	Number of Grid Events
PLRed	Peak Load Reduction
PTT	Protections Tripping Time Improvement
PV	Photovoltaic
RE	Reactive Energy Consumptions
RES	Renewable Energy Sources
RMS	Root Mean Square
RRI	Responsible Research & Innovation
RTO	Research & Technology Organisation
RTU	Remote Terminal Unit
SCRt	Self-Consumption Rate
SERI	Successful event reading index
SMRI	Successful Meter Reading Index
SS	Secondary substation
SSRt	Self-Sufficiency Ratio
SSV	Stabilization of Supply Voltage

TDF	Thermal discomfort factor
TES	Thermal Energy Storage
TOC	Table of Contents
VG	Voltage Change
VLV	Voltage Limits Violations
VTES	Virtual Thermal Energy Storage
WP	Work Package

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EXECUTIVE SUMMARY

The main goal of FLEXIGRID is to allow the distribution grid to operate in a secure and stable manner when a large share of variable generation electricity sources is connected to low and medium voltage grids. To do so, FLEXIGRID proposes a three-level approach aiming at flexibility, reliability, and economic efficiency through the development of innovative hardware and software solutions. These solutions will be demonstrated in four demo-sites across Europe ensuring their interoperability through its integration into an open-source platform able to harmonize the data flow between FLEXIGRID solutions and the real grid.

This document contains the work developed under T6.1 of FLEXIGRID that is concerned with the development of a thorough deployment plan to establish the roadmap for the deployment of the different technologies and services in these four demo-sites of FLEXIGRID.

The deployment plan for each pilot site contains as such:

- The description of each site and its components
- The objectives and aspects to be addressed in each FLEXIGRID pilot and for each FLEXIGRID solution
- The monitoring plan with the detailed trials for each pilot and the respective KPIs that will be monitored and evaluated

The methodological approach for the implementation of T6.1 as a whole was designed with the aim to facilitate and benefit from the productive interaction with multiple other tasks and WPs of the project. A common methodology and a common trial process protocol have been developed to ensure alignment among demo partners and data collection processes considering RRI and Data protection issues as stated in T2.4 and T2.5.

Using the above-described methodology, a detailed trial plan was developed for each of the pilot sites, split into four different stages, the commissioning, the operation, the maintenance and the removal phase of each trial. Within each stage the trials that are going to be conducted in the pilot sites are described in terms of key activities performed, duration, acceptance and success criteria, as well as linked to specific use cases and KPIs to be measured. Details on the maintenance and the removal activities needed for each solution developed within FLEXIGRID and deployed in each demo site are also reported within this deliverable.

The next steps of the WP activities include the deployment and monitoring of all relevant actions in each trial that will be logged in order to periodically check the performance of the monitoring system and measure the defined KPIs in the expected way. Moreover, any corrective measure required to amend any low performance will be applied to ensure that the demonstration objectives are fulfilled.

1. INTRODUCTION

FLEXIGRID is an innovation action project funded by Horizon 2020 EU's which brings together a European consortium of 15 partners led by CIRCE representing all electricity system value chain. 2 Research & Technology Organisations (RTOs) and 2 Universities work together with 5 technology providers, to develop the project solutions and deploy them in 4 demo sites, represented by 3 Distribution System Operators (DSOs) and 2 large companies.

The Project aims at putting into practice new tools to allow the distribution grid to operate in a secure and stable manner when a large share of variable renewable electricity sources is connected to low and medium voltage grids.

The sixth Work Package (WP6) of FLEXIGRID is dedicated at the deployment of the project's solutions in the demo-sites aiming at collecting real data from field devices, evaluate their performance and ultimately aim at improving grid operation. The specific objectives of this WP are:

- To elaborate a plan for the successful deployment of the innovative interventions the four Demo-sites to prove the feasibility and interoperability of the solutions developed.
- To commission all the previously developed solutions and prepare the field for the demonstration activities.
- To carry out the demonstration activities, monitoring the defined KPIs for its ulterior contrast and analysis.
- To analyse the impacts of the Use Cases demonstrated at the four Demo-sites, evaluating their techno-economic, environmental, regulatory and social aspects.

This deliverable report contains the work developed under T6.1 of FLEXIGRID that is concerned with the development of a thorough deployment plan to establish the roadmap for the deployment of the different technologies and services in the four Demo-sites of FLEXIGRID.

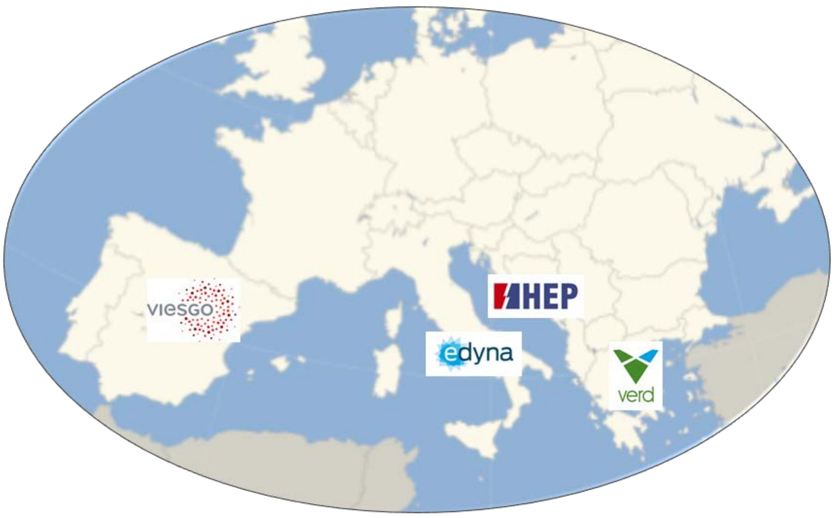


Figure 1 Map of the countries where FLEXIGRID solutions will be deployed (demo-countries) and respective demo leaders

The technologies developed in FLEXIGRID are categorized as hardware and software technologies (developed in WP3 and WP4 respectively) and will be deployed, demonstrated, and evaluated in the FLEXIGRID demo sites as indicated in Table 1. WP5 develops an overarching, horizontal platform solution (the Framework for Utilities and Services-FUSE-platform) which will enable the data acquisition, storage, visualisation, user interfaces and Key Performance Indicators (KPIs) calculation and reporting for all four demonstrators.

Table 1 Hardware and software technologies developed in FLEXIGRID and deployed in the respective demo sites

Demo	Use case	Solutions to be implemented in FLEXIGRID							
		Hardware				Software			
		S1	S2	S3	S4	S5	S6	S7	S8
		Secondary Substation of the future	New generation of smart meters	MV protections hardware	Energy Box	Software module for fault location and self-healing	Software module for forecasting and grid operation	Software module for congestion management	Virtual thermal energy storage model
Spain	1	x	x		x	x	x		
	2			x		x			
Greece	3				x		x		
	4				x			x	
Croatia	5			x		x		x	
	6						x		x
Italy	7	x	x				x		
	8					x	x		

The governance of WP6 has been established to allow each pilot focus on their specific solutions and demo environments and is depicted in Figure 2. A strong link however among all pilot sites is retained, to ensure a concise reporting process as well as coordinated work towards the use of the FUSE platform which will be used by all pilots to execute the respective trials and gather the evidence needed to report the outcomes of the trials.

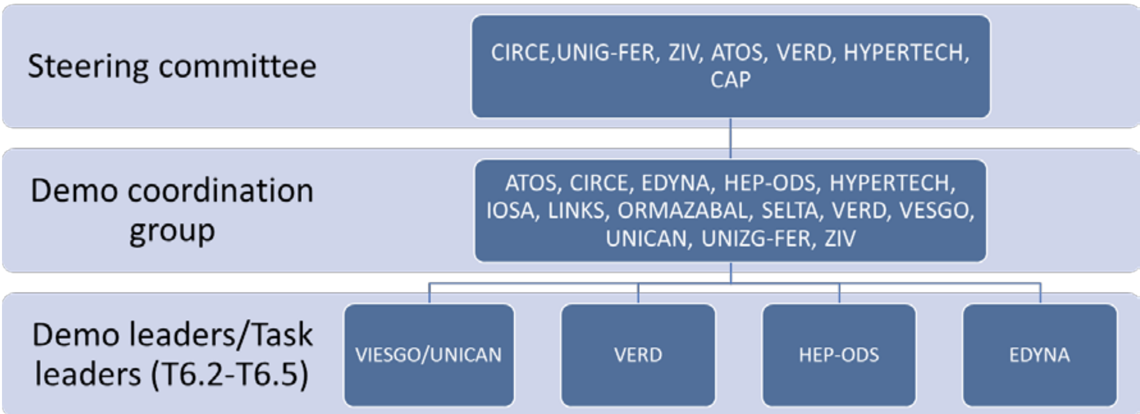


Figure 2 WP6 governance structure

VERD has organized and chaired an internal workshop (that was held online due to the pandemic) to discuss and define the common demonstration and monitoring plan. Common protocols for the demonstration activities were agreed, including the reporting procedures and data collection protocols considering RRI and Data protection issues as stated in T2.4 and T2.5.

Each Demo Site coordinator has established a detailed monitoring plan for their respective pilot, which aims at gathering the data needed to assess the Pilot KPIs during the demonstration.

The resulting monitoring plan contained in detail in this deliverable report includes the deployment, commissioning, operation, maintenance, and removal strategies for the demo sites.

1.1. Links with other tasks

T6.1 has direct and indirect links with a number of other FLEXIGRID tasks. These links are depicted in the following diagram and are analysed as follows.

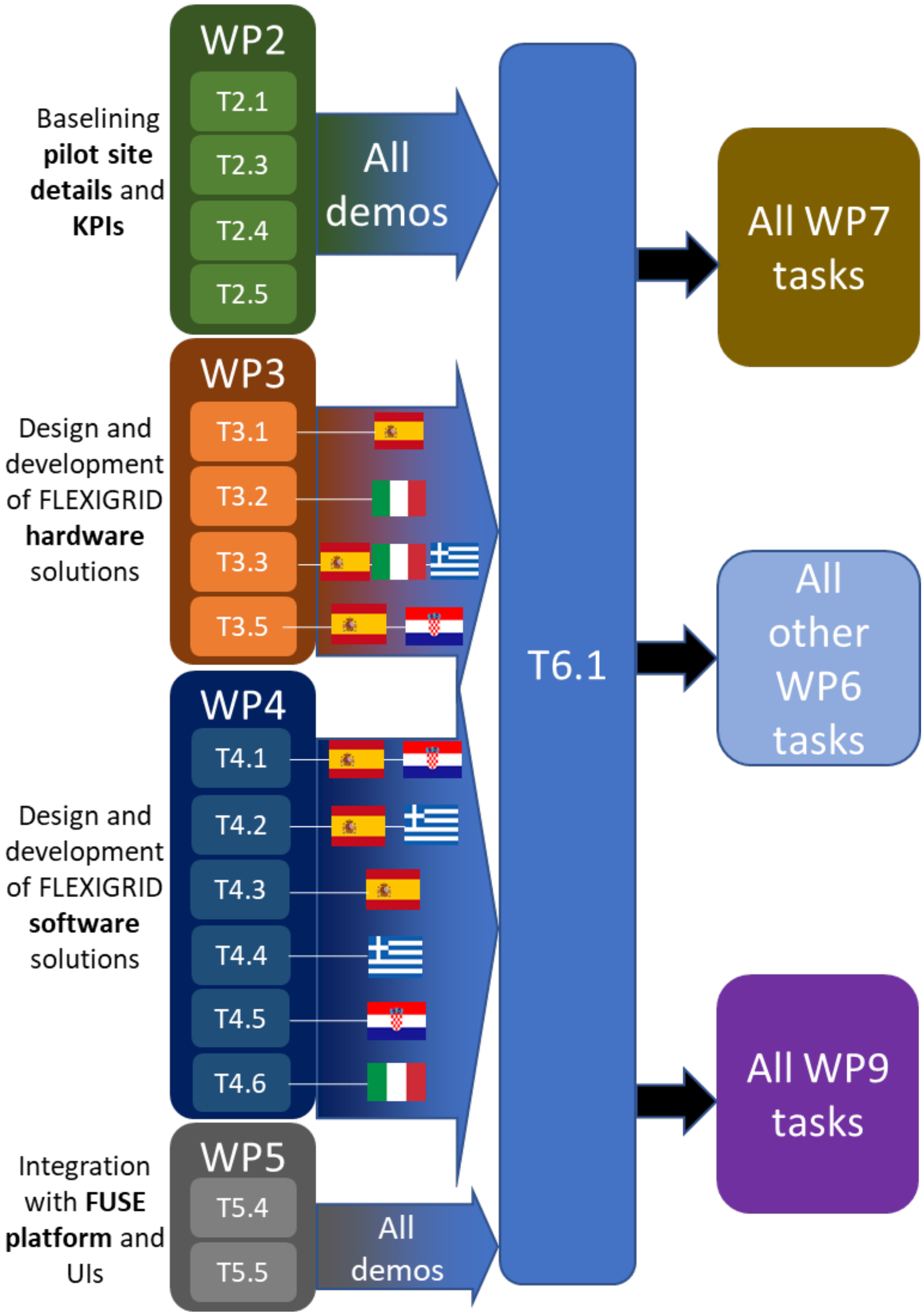


Figure 3 Diagram depicting link of T6.1 with other tasks and work packages

- Link with T2.1: T6.1 utilises as input the findings of the demo sites grid details and characterisation performed under T2.1, in order to develop accurate and detailed commissioning and deployment plans for each demo.
- Link with T2.3: T2.3 drives the demonstration strategy defined in T6.1 throughout the project and after the project lifetime. T6.1 utilises the defined KPIs within this task which are also identified to benchmark FLEXIGRID technologies and services with competitor technologies and current demo-sites situations.
- Link with T2.4: T6.1 utilises the output of this task taking into consideration the Responsible Research Innovation (RRI) protocols therein developed, ensuring that the project considers important aspects such as public engagement, open access, gender, ethics, education, governance and science education, promoting institutional change among partners to adopt RRI approach.
- Link with T2.5: T6.1 utilises the output of T2.5 with regards to the proper handling, management and protection of the customers' research data generated during the project, as well as to the developed data protection plan which ensures that all data collected from the demo cases is treated according to the relevant legislation of each country and of the EU. T6.1 also provides feedback to T2.5 with regards to any possible risks that may arise in order to contribute to the development of any necessary contingency plans to mitigate those risks.
- Link with T3.1: Within this task the Secondary Substation of the future has been designed and developed as a vehicle that includes, among others, operation and control algorithms and functionalities. The software for its smart operation has also been programmed and implemented within this task. T6.1 includes the planning of one of the two Secondary Substation developed by OPA within T3.1 in the Spanish demo site.
- Link with T3.2: T6.1 uses the output of T3.2 with regards to the development of smart meters. Within this task, the type of data exchanged between the data concentrators and the meters for the maintenance of the PLC network topology in the main European deployments, that is, Meters-And-More, G3-PLC and PRIME have been identified. Taking into account these results ZIV has analysed the applicability of automatic learning algorithms, both supervised and unsupervised, to develop potential applications that improve network operation based on the data exchanged between data concentrators and meters. As a result, a new generation of smart meters has been proposed, compared to the commercial ones and will be subsequently deployed and tested in the Italian demo site.
- Link with T3.3: Within this task, an Energy Box to be deployed in the Greek and Spanish demo sites has been developed, along with the adaption of the internal operating systems to execute the modules of each case or application.
- Link with T3.5: The objective of this task is to improve the protection algorithms used in Medium Voltage distribution grids in a scenario with high penetration of renewables by proposing new algorithms for fault tripping. A process of proposal of new protection schemes or algorithms to overcome the problems detected will subsequently take place to ensure the secure operation of the distribution grid. The MV protections hardware designed and developed within this task will be deployed in the Spanish and Croatian demo sites.
- Link with T4.1: T6.1 utilises the output of T4.1 with regards to the development of the ready-to-use tool for optimal operation of the distribution network. The tool will be capable of taking advantage of the available information and communication channels used by SCADA, smart meters, concentrators and other devices in an optimized way. Self-healing and fault locator capabilities will also be developed within this task. To do so, several algorithms will be developed and subsequently tested in the Croatian and the Spanish demo sites.

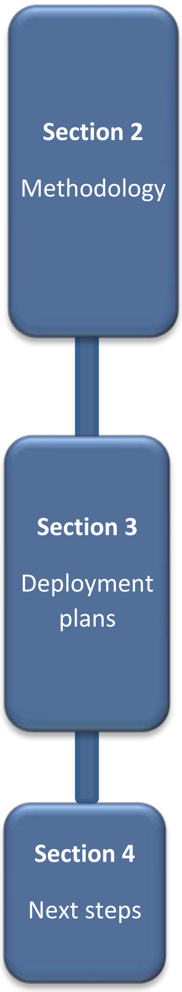
- Link with T4.2: T6.1 utilises the output of T4.2 with regards to the development of appropriate algorithms that will allow for enhanced accuracy of demand and generation forecasting, thus improving visibility over the local grid and enabling accurate definition of flexibility requirements in the mid- and short-term. These algorithms will be tested in the Greek and Spanish demo site.
- Link with T4.3: This task provides the MV distribution grid smart operation algorithms, based on the knowledge of the grid state and the demand, generation and energy price forecasts. Then the flexibility requests upon DSO needs would be sent to the Secondary Substations, where different answers from the downstream connected assets will be as well considered. The answers from downstream levels would be implemented in the EBs deployed in the demo site or by any other IEDs thanks to the FUSE platform. Further to flexibility needs, optimized operation will be sought considering the distribution grid assets and the previous forecasts. This fog computing-based management structures will be developed, deployed and evaluated in the Spanish demonstrator.
- Link with T4.4: T6.1 utilises the output of this task with regards to the provision of fully-fledged flexibility modelling and analytics suite that will enable accurate flexibility forecasting (from field DERs and selected loads) and analysis for the definition of optimized control strategies that will serve different optimization objectives (e.g. system restoration, energy cost minimization). The system developed within T4.4 will facilitate the definition of local micro-VPPs that will aggregate distributed flexibilities based on their suitability for congestion management and peak shaving services, and will be deployed and tested in the Greek demo site.
- Link with T4.5: T6.1 utilises the algorithms defined in T4.5 with regards to the definition and profiling of virtual energy storage component demand flexibility. This task also defines the specifications for the configuration of an intelligent thermal storage software component applicable to various building types independent of their size, use and construction characteristics, which will be deployed and tested in the Croatian demo site.
- Link with T4.6: During this task, a real-time data exchange with the main MV users to collect monitoring data and deliver control signals are carried out, allowing to predict in real time the MV network behaviour and to propose new strategies for the management of active users controlling both, active and reactive power production coming from both domestic and industrial users. T6.1 uses the study for the operation of EDYNA grid in island mode that has been developed which will be done enabling the islanded operation of a portion of MV network, exploiting the support of the MV Distributed Generators displaced the Italian demo site and later allowing the disconnection and reconnection from/to the main power system of the electrical island without power supply interruptions.
- Link with T5.4: This task aims at integrating the different software modules developed during the project as well as developing the specific adapters shown in the lower levels of the IT architecture of the project concept. T6.1 utilises the output of this task with regards to the verification of the correct interoperability and integration of all the elements defined in T5.1 in order to ensure a smooth operation during the demonstration campaign of the project.
- Link with T5.5: T6.1 utilises the output of T5.5 with regards to the provision of the end-user's interfaces made for each one of the pilot cases. Within T5.5, a common web-based interface shall be designed and accompanied by developed visual analytics methods and schemes for making available the most crucial information for the grid manager and its associated partners. Depending on the utilization purpose, the visualization interface will provide both historical and real-time information from the site DE elements (such as generation,

consumption, flexibility) along with potential applied DR strategies and control set-points per prosumer.

- Link with the rest of the WP6 tasks: T6.1 provides a thorough deployment plan to establish the roadmap for the deployment of the different technologies and services in the four Demo-sites. Moreover, a detailed monitoring plan to gather the data needed to assess the Pilot KPIs during the demonstration is established by each one of the Demo-Sites coordinators. Common demonstration and monitoring plan and protocols for the demonstration activities are also agreed, including the deployment, commissioning, operation, maintenance, and removal strategies for the demo sites.
- Link with WP7: T6.1 provides insights on how the results of the deployment of the different technologies in the four demo sites can contribute to the impact assessment of the use cases and replication potential in Europe which is analysed within WP7.
- Link with WP9: T6.1 deployment plan also includes suggestions on how the results of the different trials performed in the four demo sites can feed into the various communication and dissemination activities carried out within WP9.

1.2. Structure of the deliverable

This document is structured as follows:



Section 2 describes the methodology followed in this document to establish the deployment plans of the pilot sites as defined by the WP leader. Within this section the delivery plan for D6.1 is presented in detail along with the different steps of the methodology followed by all demo coordinators to establish the trial's deployment plans. In addition to that specific focus has been given to the trials' process plan in order to ensure alignment between all demo sites. Finally, the template for the trials' delivery plan followed by all demo sites is presented.

Section 3 consists of the detailed deployment plans for each pilot divided in the deployment, commissioning, operation, maintenance and removal phase of the deployed solutions within FLEXIGRID. Within this section the use cases, KPIs and data requirements for all demo sites are presented in detail. The five different stages of the deployment plans for each pilot sites are presented along with the individual trials to be performed within each phase. In addition to those, a risk registry is presented for each demo site is presented along with the respective contingency plans.

Section 4 describes the next steps to be followed in this WP. This section includes a summary of the different elements of deliverables D6.2 to D6.14 which will include the results from the trials and KPIs evaluation process until the end of the project.

2. METHODOLOGY

The commencement of the proceedings of T6.1 coincided with the kick-off of WP6 in which the roles of each partner were discussed and agreed. The general methodology for the development of T6.1 was established, and the following delivery plan was agreed and subsequently pursued.

1. Bi-weekly calls were scheduled and conducted starting from the beginning of April 2021 in order to keep track of progress. The calls were scheduled on a monthly basis and involved all demo partners with the addition of the coordination team which includes partners from ATOS, CIRCE, EDYNA, HEP-ODS, HYPERTECH, IOSA, LINKS, ORMAZABAL, SELTA, VERD, VESGO, UNICAN, UNIZG-FER and ZIV.
2. The draft Table of Contents (TOC) was presented to all demo partners during the kick-off meeting and has been finalised and agreed upon in the following month.
3. The largest percentage of the deliverable had been developed by M22 and was presented in the Steering Committee meeting.
4. Several iterations between the demo partners, the WP leader and the coordination team were achieved in order to deliver a comprehensive and completed report.

The delivery plan is presented in Figure 4.

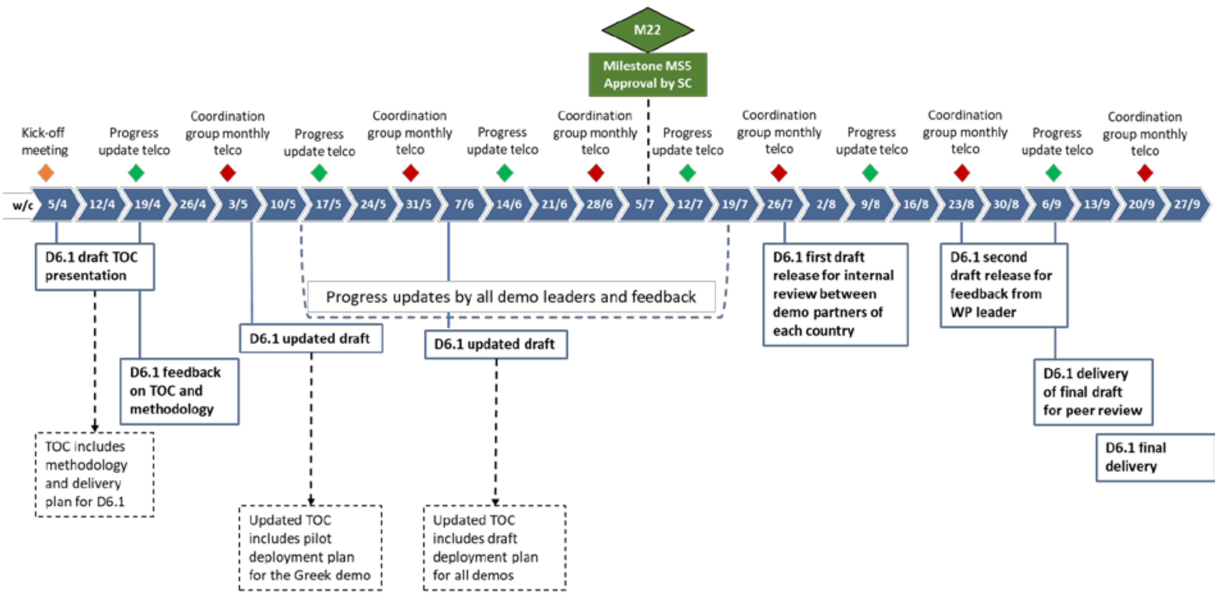


Figure 4 Gantt chart depicting the delivery plan of D6.1

The general methodology for the delivery of the outputs of T6.1 included the following steps:

- **Step 1:** For each pilot, all participating assets and FLEXIGRID solutions have been described in detail while at the same time the use cases and overarching plan for the development of pilot site have been defined
- **Step 2:** For each pilot, the KPIs defined within D2.6 have been finalised and confirmed and have been mapped to the corresponding pilot sites and use cases.
- **Step 3:** This step includes the mapping of data requirements, data collection and validation processes as well as data recipients' definition for each pilot site

- **Step 4:** In this step, which is the most important of the described methodology, all activities and trials to be performed in each stage of the pilot demonstration have been defined in detail. The stages of the pilot demonstration are defined as per below:
  - Deployment
  - Commissioning
  - Operation
  - Maintenance
  - Removal strategies
- **Step 5:** The last step of the methodology was to describe in detail the processes and timings for the trials to be performed in each pilot site as well as define the acceptance and success criteria for all phases and individual trials.

The methodology is depicted in Figure 5.

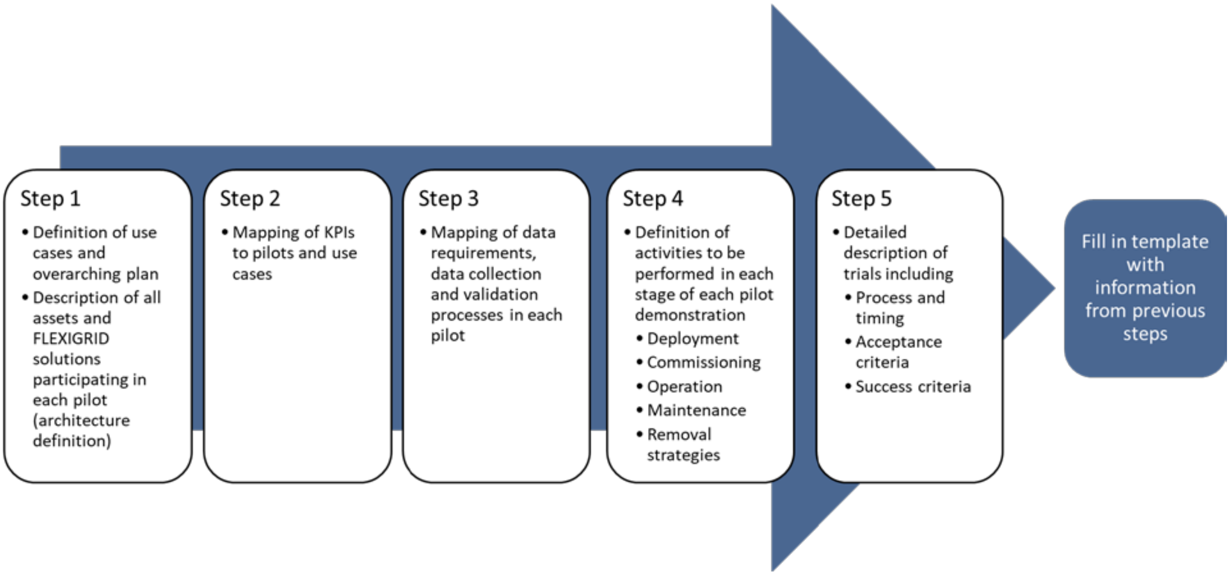


Figure 5 High level flow diagram depicting general methodology for T6.1 delivery

As an output of this process, each demo leader completed an excel spreadsheet which summarizes all information collected during each step of the process.

The evaluation of each trial to be performed in each FLEXIGRID pilot, will be enabled by the accurate reporting of the KPIs. The calculations and visualisation of the KPIs will be performed centrally for the whole project by the FUSE platform and its appropriate interfaces developed in WP5.

Nevertheless, a common trial process protocol has been developed to ensure alignment among demo partners and data collection processes considering RRI and Data protection issues as stated in T2.4 and T2.5. The generic trial process diagram depicted in Figure 6 describes the agreed protocol.

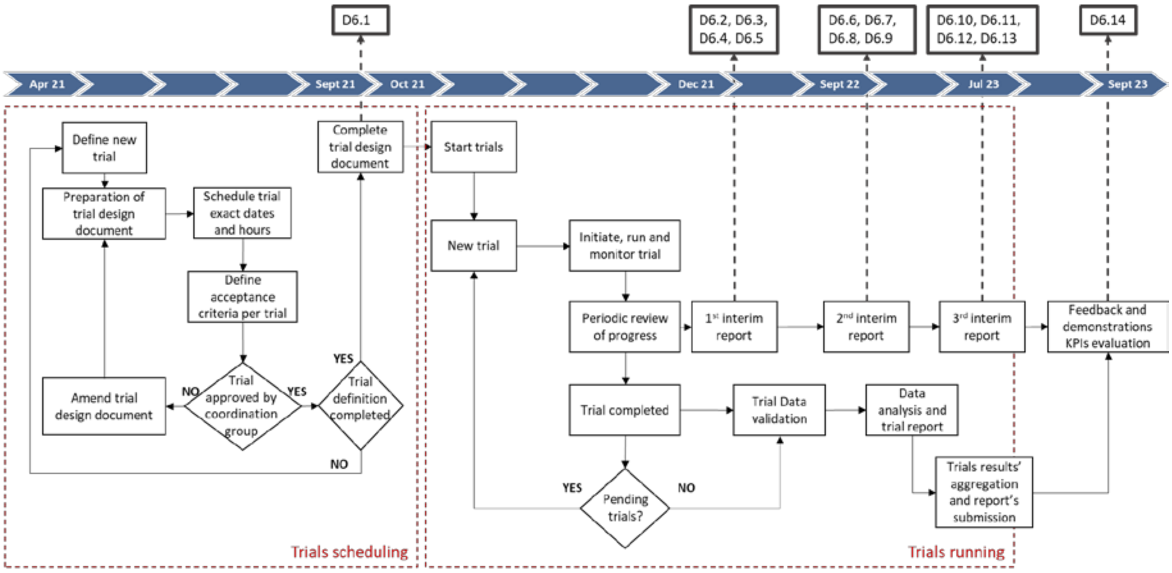


Figure 6 Generic trial process diagram

The trial process protocol has been divided in three phases:

- Phase 1 is defined as the trial scheduling plan
- Phase 2 includes the trials' execution and reporting period
- Phase 3 includes the KPIs evaluation and feedback and demonstration period

Phase 1 has been running in parallel to the proceedings of T6.1 since the initiation of WP6 in April 2021 and up to the delivery of D6.1. The scope of this phase has been to define in detail all the trials that will be performed in each pilot site aiming at all of them being reviewed and approved by the Project's Steering Committee in M22 to satisfy milestone 5 (MS5) of the project.

The first phase begins with the definition of the trials. For each of the defined trials, the responsible demo partners prepare a first draft of the trial design document, define the exact timeline of the trial's running period and the acceptance criteria which define the successful completion of the trial. Each trial design document is compiled into the demo country trial designs. The Demo coordination group reviews the compiled trial documents and the phase concludes when all defined trials for every demo site have been approved by the coordination team and documented in the final trial design document which forms the main part of the present deliverable.

Phase 2 shall include the entire trial period, starting from October 2021 up to June 2023 where all trials shall be completed in all demo sites. The process will start with the initiation of the first trial in each demo site. The trial shall be closely monitored throughout the defined time period allocated to it. Interim reports shall be produced and included in the interim reports of T6.2 to T6.5 in order to review the progress and interim results of each trial. Once a trial is finished, results will be reported and discussed between demo partners via a data validation and analysis process and the next trial will begin according to the defined schedule. All core trials will be expected to be finalized at least 2 months prior to the delivery of the final reports for each demo site (D6.10, D6.11, D6.12, D6.13).

Phase 3 will start as soon as the final round of interim reports for all demo sites have been completed and shall include detailed feedback and results' demonstration sessions aiming at evaluating all KPIs defined in each trial.

In addition to the above generic trial process protocol, a common template was discussed in the internal workshop and subsequently agreed by the demo coordinators, to serve as a streamlined deployment plan to be used for all FLEXIGRID pilots.

This deployment plan template was developed to facilitate the following requirements:

- Validated use cases to be demonstrated in the pilot: the aim of this requirement is to present in detail the use cases to be demonstrated in each pilot and provide the context for the individual trials to be designed and executed in each pilot.
- Provide and validate the final list of KPIs: Following the characterisation of the pilot sites and the initial KPIs list developed in D2.1 and D2.4 respectively, the aim of this requirement is to provide the final list of KPIs for each pilot, as well as to link these KPIs individually to each trial.
- Report on data requirements: The individual data points and data sources needed for the calculation of each KPI, need to be clearly reported and linked to the appropriate use case.

All the above-mentioned requirements have been reported in this deliverable for each demo site. In addition to those, a risk matrix has been created for each site and has been kept updated throughout the period of the demonstrators' planning development.

3. PILOT DEPLOYMENT

Within this section, the deployment plan for each pilot is presented along with the description of the components of each site and the respective objectives and aspects that need to be addressed.

3.1. Spanish Demonstrator

Pilot description and components

The Spanish Demo Site focuses on two important aspects related to the architecture of the smart grids of the future.

There will be a Demo Site for fault location and a Demo Site for the smart secondary substation.

The fault location Demo Site consists of two cases in two different areas:

- Case 1: Artificially generated faults to ground at a predefined location in order to verify general performance and accuracy for different fault resistances to ground.
- Case 2: After successful testing during case 1, the test will shift to the second location where the location system will be validated in a high fault occurrence overhead line

The secondary substation Demo Site will focus on automation of the substation and management of high penetration DER areas. A grid can operate thousands of secondary substations and some of them require special attention. The automation and remote-control capabilities on these facilities can vastly improve the efficiency of the resources of a utility. The savings in time and petrol for the vehicles alone make it worthy to improve these nodes of the grid. The Spanish Demo Site will include a location for a full modern secondary substation and a location for a retrofitted secondary substation. The cost of fully substituting every facility is out of reach, but retrofitting may become a good trade solution for lots of locations. The communications at the secondary substations include a web server for the Control Centre of VIESGO and Energy Box for communications to CIRCE and FUSE.

A diagram for the smart secondary substation is depicted in Figure 8 while Figure 7 shows the diagram for the upgraded conventional secondary substation. There is also a layout of the RES management scenarios, used to analyse protection systems under high RES penetration, in Figure 9.

Table 2 resumes the Use Cases for the Spanish Demo Site.

Table 2 Spanish demo site's respective use cases

Use case (ID)	Name	Main Description
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 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 with 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	Protections 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. As it has been showed in previous BRIDGE projects such as MIGRATE[1] (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.

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

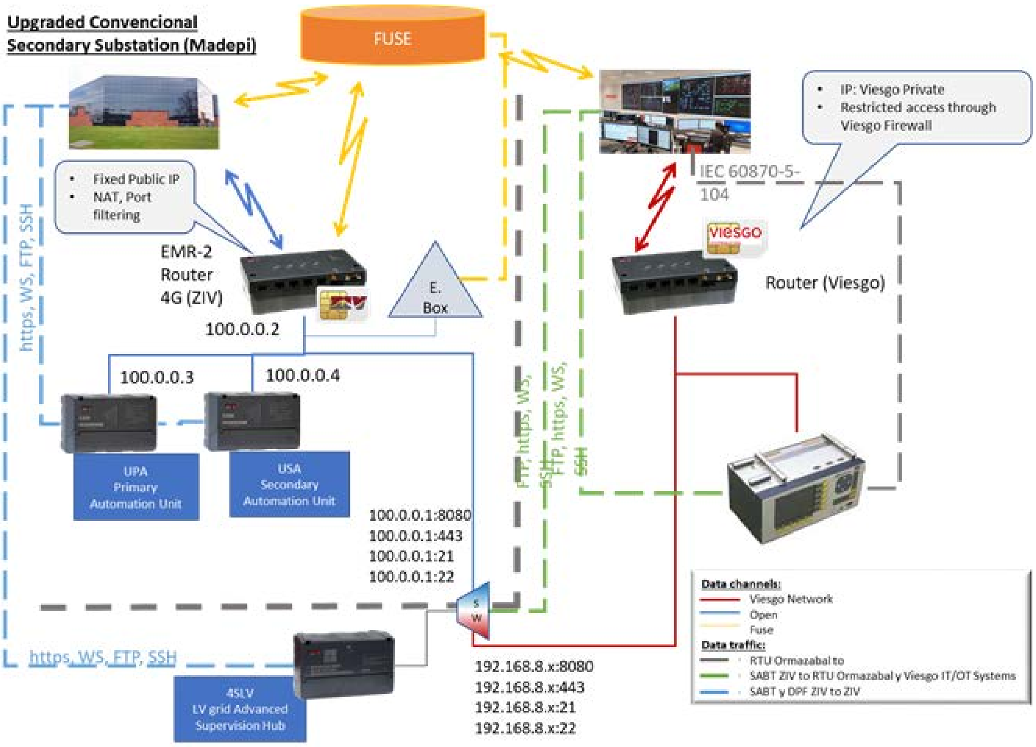


Figure 7 Upgraded Secondary Substation

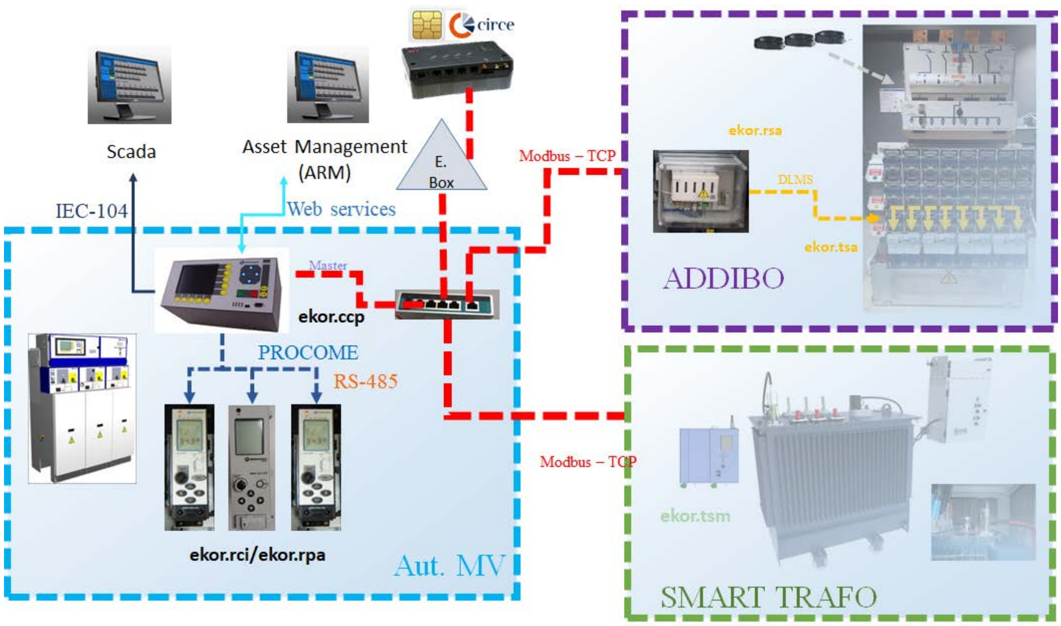


Figure 8 Smart Secondary Substation

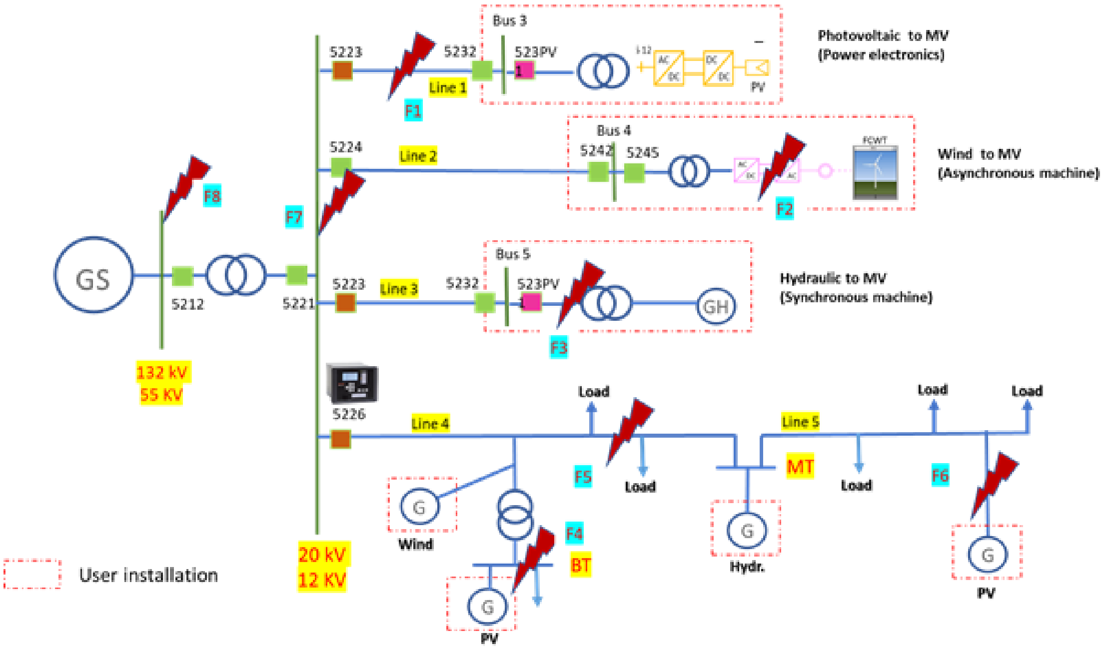


Figure 9 RES scenarios

A set of KPIs, as defined in Table 3 below, will be used to assess the successful deployment of the trials in the Spanish demo site.

Table 3 List of KPIs to be assessed in the Spanish demo site

Name (ID)	Description	Classification	Units	Sampling rate
CAIDI	The Customer Average Interruption Duration Index (CAIDI) represents the average time required to restore service	Core	minutes	once at the end of the monitoring period
Fault location accuracy (on demo site) (FLA)	Accuracy in fault distance determination using FLEXIGRID solutions	Core	meters / %	per fault
Improved Interoperability (II)	Interoperability is the ability of a system (or product) to work with other systems (or products). This is made by exchanging information and services to enable them to operate effectively together (ISO/TS 37151). The indicator assesses the improvement in interoperability in a qualitative manner without going into details.	Core	Number of files sent correctly	1 single / 1 month test

Name (ID)	Description	Classification	Units	Sampling rate
Investment return for secondary substation refit (IRSSR)	Saved money due to the refit of non-smart secondary substations. Avoided costs by employing new proposed solutions vs traditional (e.g. reduction of energy not supplied, improve time to restore service, etc.)	Core	Euros	once
Protections tripping time improvement (PTT)	Effective reduction of tripping time by implementation of new algorithms	Core	ms	DWP6
Protection relay dependability	Number of missing trips / number of internal faults	Core	%	monthly
Protection relay security	Number of missing trips / number of internal faults	Core	%	monthly
Fault passage indicator dependability (Forward)	Number of missing indications / Number of forward faults	Core	%	monthly
Fault passage indicator dependability (Reverse)	Number of false indications / Number of reverse faults	Core	%	monthly
Successful event reading index (SERI)	This KPI has been defined to analyse if all the meters or IED´s are sending their registers	Core	%	monthly
Successful meter reading index (SMRI)	Indicator to evaluate the performance of the metering infrastructure, covering all kind of queries to request meter data	Core	%	monthly
SAIFI	The System Average Interruption Frequency Index (SAIFI) indicates how often the average customer experiences a sustained interruption over a predefined period.	Auxiliary	minutes / %	once at the end of the monitoring period
Feeder mapping successful detection	Percentage of meters that are correctly mapped	Auxiliary	%	1 month

Name (ID)	Description	Classification	Units	Sampling rate
Stabilization of supply voltage (SSV)	Comparative between voltage measurement (Vbt) within the same period in different years to see the voltage stabilization.	Core	Voltage values on BT supervisors and smart meters within limits	monthly
Number of Voltage Limits Violations (VLV)	Variation of voltages in smart meters (registers)	Core	Number of minimum and maximum voltage measurement registers	monthly
LVB board alarms (LVB-BA)	Remote detection of LV faults (fuse failure)	Core	Number of activations	monthly
LBV protection (LVB-P)	Activation of ground current alarm	Core	Number of activations	monthly
Forecasting Accuracy (FA)	Deviation between the forecasted values and the corresponding measurements for the demand/generation by node	Auxiliary	%	30 min

The data that will be collected during the trials' period along with the associated KPIs that are connected to it, is presented in Table 4.

Table 4 List of data collected during the trials for the Spanish demonstration

Data ID	Description	Units	Source component	Final recipient	Relevant KPIs	Collection frequency
M01CT1	Customer's daily consumption/generation profile (load curve)	N/A	Secondary substation	LINKS	FA	TBD
M02CT1	Current measurements (Villabermudo I)	A	Secondary substation	VIESGO	SSV, VLV	monthly
M03CT1	Voltage measurements (Villabermudo I)	V	Secondary substation	VIESGO	SSV, VLV	monthly
M09CT1	Active power measurements (Villabermudo I)	kWh	Secondary substation	VIESGO	SSV, VLV	monthly
M10CT1	Reactive power measurements (Villabermudo I)	kVA	Secondary substation	VIESGO	SSV, VLV	monthly

Data ID	Description	Units	Source component	Final recipient	Relevant KPIs	Collection frequency
M11CT1	Smart transformer control (Villabermudo I)	N/A	Secondary substation	VIESGO	SSV, VLV	monthly
M12CT1	Smart transformer status (Villabermudo I)	N/A	Secondary substation	VIESGO	SSV, VLV	monthly
M13CT1	Smart transformer alarms & errors (Villabermudo I)	N/A	Secondary substation	VIESGO	SSV, VLV	monthly
M14CT1	BT voltage measurements (Villabermudo I)	V	Secondary substation	VIESGO	SSV, VLV	monthly
M02CT1	BT current measurements (Villabermudo I)	A	Secondary substation	VIESGO	SSV, VLV	monthly
M15CT1	BT active power measurements (Villabermudo I)	kWh	Secondary substation	VIESGO	SSV, VLV	monthly
M16CT1	BT Reactive power measurements (Villabermudo I)	kVA	Secondary substation	VIESGO	SSV, VLV	monthly
M17CT1	LVB status (Villabermudo I)	N/A	Secondary substation	VIESGO	II, LVB-BA	monthly
M18CT1	LVB alarms & errors (Villabermudo I)	N/A	Secondary substation	VIESGO	II, LVB-P	monthly
M04CT1	Wind speed	m/s	Weather station	LINKS	FA	1 min (on weather station)
M05CT1	Wind direction	ºDeg	Weather station	LINKS	FA	1 min (on weather station)
M06CT1	Temperature	ºC	Weather station	LINKS	FA	1 min (on weather station)
M07CT1	Solar radiation	W/m^2	Weather station	LINKS	FA	1 min (on weather station)
M08CT1	Rain	mm	Weather station	LINKS	FA	1 min (on weather station)
C09CT1	Load (forecast)	kW	Forecast software	VIESGO	FA	TBD

Data ID	Description	Units	Source component	Final recipient	Relevant KPIs	Collection frequency
C010CT1	Generation (forecast)	kW	Forecast software	VIESGO	FA	TBD
C11CT1	Load error (abs error)	kW	Forecast software	VIESGO	FA	TBD
C12CT1	Load error (rel error)	%	Forecast software	VIESGO	FA	TBD
C13CT1	Generation (abs error)	kW	Forecast software	VIESGO	FA	TBD
C14CT1	Generation (rel error)	%	Forecast software	VIESGO	FA	TBD
M01CT2	Customer's daily consumption/generation profile (load curve)		Secondary substation	LINKS	FA	TBD
M02CT2	Current	A	Secondary substation	VIESGO	SSV, VLV	monthly
M03CT2	Voltage	V	Secondary substation	VIESGO	SSV, VLV	monthly
M04CT2	Wind speed	m/s	Weather station	LINKS	FA	1 min (on weather station)
M05CT2	Wind direction	ºDeg	Weather station	LINKS	FA	1 min (on weather station)
M06CT2	Temperature	ºC	Weather station	LINKS	FA	1 min (on weather station)
M07CT2	Solar radiation	W/m^2	Weather station	LINKS	FA	1 min (on weather station)
M08CT2	Rain	mm	Weather station	LINKS	FA	1 min (on weather station)
C09CT2	Load (forecast)	kW	Forecast software	VIESGO	FA	TBD
C010CT2	Generation (forecast)	kW	Forecast software	VIESGO	FA	TBD
C11CT2	Load error (abs error)	kW	Forecast software	VIESGO	FA	TBD
C12CT2	Load error (rel error)	%	Forecast software	VIESGO	FA	TBD

Data ID	Description	Units	Source component	Final recipient	Relevant KPIs	Collection frequency
C13CT2	Generation (abs error)	kW	Forecast software	VIESGO	FA	TBD
C14CT2	Generation (rel error)	%	Forecast software	VIESGO	FA	TBD
M01FL1	Fault data		CIRCE TDR device	VIESGO	FLA	one time / fault
M02FL1	Distance to fault (measured)	m	CIRCE TDR device	VIESGO	FLA	one time / fault
M03FL1	Distance to fault (real)	m	Manual	VIESGO	FLA	one time / fault
C01FL1	Distance to fault (abs error)	m	Calculated	VIESGO	FLA	one time / fault
C02FL1	Distance to fault (rel error)	%	Calculated	VIESGO	FLA	one time / fault
M01ZIV1	Energy values from LV supervision boards	kWh	VIESGO	ZIV		
M02ZIV1	Energy values from meters	kWh	VIESGO	ZIV	SMRI	
M03ZIV1	Feeder mapping algorithm output	N/A	Smart meter	ZIV	Feeder mapping succesfull detection	one time / atemp
M04ZIV1	Fault passage indication	N/A	ZIV fault passage device	ZIV	Fault Passage (Forward and Reverse	one time / fault
M05ZIV1	Feeder relay trips	N/A	Feeder relay	ZIV	PTT	one time / trip

Pilot objectives and aspects to address

The main objectives of this pilot are the following:

- Testing and calibration of the fault locators and their posterior evaluation under real conditions. The aim of this new devices is to effectively reduce the time and effort invested in locating faults.
- Installing and operating a fully automated secondary substation. This new technology will allow for fast reaction to changes in the grid and so provide with the means to improve the general behaviour of the grid, especially under high RES share. Automation, and remote supervision and control also mean almost eliminating the need to send personnel to those substations and so reducing cost and fuel emissions.

- Testing protections, self-healing algorithms for use under high RES share, so allowing for a deeper integration, and increasing of renewable energies presence.

Pilot monitoring plan

The pilot's monitoring plan is divided in five phases as per below:

1. Deployment
2. Commissioning phase
3. Operation phase
4. Maintenance phase
5. Removal phase

More details on the operations and trials included in each phase are provided in the subsections below.

Deployment

The deployment phase will start the first month of WP6 activity (M19) and it will last until M23, when the last components will be installed. Particularly for the Spanish demo site the deployment will include the following:

- Smart transformer (Smart Secondary Substation)
- ADDIBO (LV supervision equipment for Smart Secondary Substation)
- Ekor (MV control equipment for Smart Secondary Substation)
- Energy box (Smart Secondary Substation network (2), Upgraded Secondary Substation (1) and Toranzo network)
- Fault locator (Smart Secondary Substation)
- Feeder protection (Upgraded Secondary Substation)
- LV supervision board (Upgraded Secondary Substation)
- LV supervision RTU (Upgraded Secondary Substation)

Commissioning

The deployment phase will run up to M27 and it will overlap with the operation phase for some components.

Operation

The operation phase of the Spanish demo site includes different trials which are detailed in the following tables.

Table 5 Spanish demo trial #1: Smart transformer self on load commutation

Trial name	Self transformer self on load commutation
Description	The new smart transformer should be able of on load self-commutation to the proper values
Duration	Demonstration period where the system will be monitored and data will be collected both during high demand and low demand seasons
Acceptance criteria	1.Data received and connected to SCADA 2.Interoperability with SCADA and Arm Systems 3.Comparison with data collected in a reference period

Trial name	Self transformer self on load commutation
Success criteria	Quality and supply events Voltage and Intensity graphics Control integrated in utility system
Relevant use cases	UC1
Relevant KPIs	Improved Interoperability (II) SAIFI SSV VLV

Table 6 Spanish demo trial #2: ADDIBO performance

Trial name	ADDIBO performance
Description	LVB supervised
Duration	Demonstration period where the system will be monitored and data will be collected both during high demand and low demand seasons
Acceptance criteria	1.Data received and connected to SCADA 2. Interoperability with Scada and Arm Systems 3. Comparison with data collected in a reference period
Success criteria	Quality and supply events Voltage and Intensity graphics Control integrated in utility system
Relevant use cases	UC1
Relevant KPIs	Improved Interoperability (II) SAIFI LVB-BA LVB-P

Table 7 Spanish demo trial #3: Web services functionality

Trial name	Web services functionality
Description	MV RTU new functionality
Duration	Demonstration period where the system will be monitored and data will be collected both during high demand and low demand seasons
Acceptance criteria	1.Data received and connected to SCADA 2. Interoperability with Scada and Arm Systems

Trial name	Web services functionality
Success criteria	Quality and supply events Voltage and Intensity graphics Control integrated in utility system
Relevant use cases	UC1
Relevant KPIs	Improved Interoperability (II)

Table 8 Spanish demo trial #4: Energy Box performance

Trial name	Energy Box performance
Description	The ability to integrate equipment into the FLEXIGRID project network is tested
Duration	During the entire test stage at WP6
Acceptance criteria	1.Data received from CTs assets 2. Connection to FUSE
Success criteria	Implemented the ability to integrate equipment to the FUSE network, effective sending of telemetry
Relevant use cases	UC1
Relevant KPIs	Improved Interoperability (II)

Table 9 Spanish demo trial #5: Feeder mapping detection

Trial name	Feeder mapping detection
Description	The feeder mapping algorithm should determine the feeder and phase of all the meters fed by the secondary substation
Duration	Demonstration period where the system will be monitored and data will be collected using the LV supervision system
Acceptance criteria	% of meters correctly mapped > 85%
Success criteria	% of meters correctly mapped > 95%
Relevant use cases	UC1
Relevant KPIs	Feeder mapping successful detection

Table 10 Spanish demo trial #6: CIRCE fault locator training

Trial name	CIRCE fault locator training
Description	Determine fault location with known faults in Luena/Toranzo
Duration	8 months (may vary depending on the results)
Acceptance criteria	The system determines the distance within an error range that effectively locates the fault
Success criteria	The system shows consistent results between the calculated distance and the simulated fault distance
Relevant use cases	UC2
Relevant KPIs	Fault Location Accuracy (FLA)

Table 11 Spanish demo trial #7: CIRCE fault locator verification

Trial name	CIRCE fault locator verification
Description	Determine fault location with unknown faults in Meira
Duration	7 months (may vary depending on the training phase)
Acceptance criteria	The system determines the distance within an error range that effectively locates the fault
Success criteria	The system reduces the time it takes to locate network faults
Relevant use cases	UC2
Relevant KPIs	Fault location Accuracy (FLA) CAIDI (modified version)

Table 12 Spanish demo trial #8: Flexibility test algorithm (optimal operation + emergency)

Trial name	Flexibility test algorithm (optimal operation + emergency)
Description	Allows to control the assets in the network, adjusting its operation to present and future conditions
Duration	3 weeks
Acceptance criteria	Provides effective settings to avoid network congestion and optimally configures network performance under normal operating conditions
Success criteria	Reduces or eliminates congestion, increases self-consumption
Relevant use cases	UC1

Trial name	Flexibility test algorithm (optimal operation + emergency)
Relevant KPIs	Forecast Accuracy (FA) Flexibility action taken (FAT) Generation Available flexibility (GAF) Line Overload Occurrence (LOO)

Table 13 Spanish demo trial #9: Self-healing test algorithm

Trial name	Self-healing test algorithm
Description	Detects the faulted section of the network and sends the appropriate closing command to restore the service
Duration	3 weeks
Acceptance criteria	Consistently detects faulty sections
Success criteria	Reduces network outage time
Relevant use cases	UC2
Relevant KPIs	CAIDI VS BaU

Table 14 Spanish demo trial #10: ZIV feeder protection relay performance

Trial name	ZIV feeder protection relay performance
Description	Detects the faulted section of the network and sends the appropriate closing command to restore the service
Duration	2 weeks (distributed along 18 months)
Acceptance criteria	No false trip and no missed trip
Success criteria	No false trip and no missed trip
Relevant use cases	UC2
Relevant KPIs	Protection relay security and dependability

Table 15 Spanish demo trial #10: ZIV fault passage indicator performance

Trial name	ZIV fault passage indicator performance
Description	The fault passage indicator should maintain a good security (no false indication) and dependability (no missed indication)
Duration	2 weeks (distributed along 18 months)

Trial name	ZIV fault passage indicator performance
Acceptance criteria	No false trip and no missed trip
Success criteria	No false trip and no missed trip
Relevant use cases	UC2
Relevant KPIs	Fault passage indicator security and dependability

Maintenance

The Spanish demo site is to test several of the solutions of the FLEXIGRID project. Those solutions, which are shown in Figure 10, will require several degrees of supervision.

- The secondary substation is fully digitalized with several signals to inform about alarms, errors or malfunctions. This allows for constant monitoring and also maintenance on demand.
- Smart meters and the Energy Box are going to be tested under controlled conditions and so maintenance is going to be part of the testing.
- ZIV protection relays and MV RTUs do not include replaceable parts that may be subject to maintenance. Their design guarantees correct operation throughout its useful life, both because there are no elements that wear out (beyond the limits set by design) or lose characteristics over time. The relays include self-monitoring features, which detect a high percent of the errors that could appeared. Moreover, a periodic check of the relay recordings (oscillography, events, etc.) is planned during the demo. This will act as maintenance sessions.

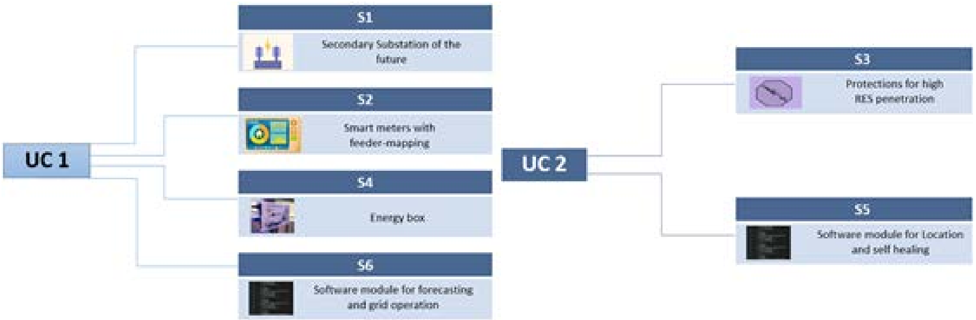


Figure 10 Spanish Demo solutions per Use Case

Removal

At the end of the operation phase, it will be made sure that all equipment deployed on the demo site as part of the FLEXIGRID project will be removed and returned to the solution developer in all the cases that apply. This does not include the new smart secondary substation, which will stay operational.

Pilot plan timeline

The information above is summarized in the following timeline. The schedule also includes the maintenance and removal of the equipment.

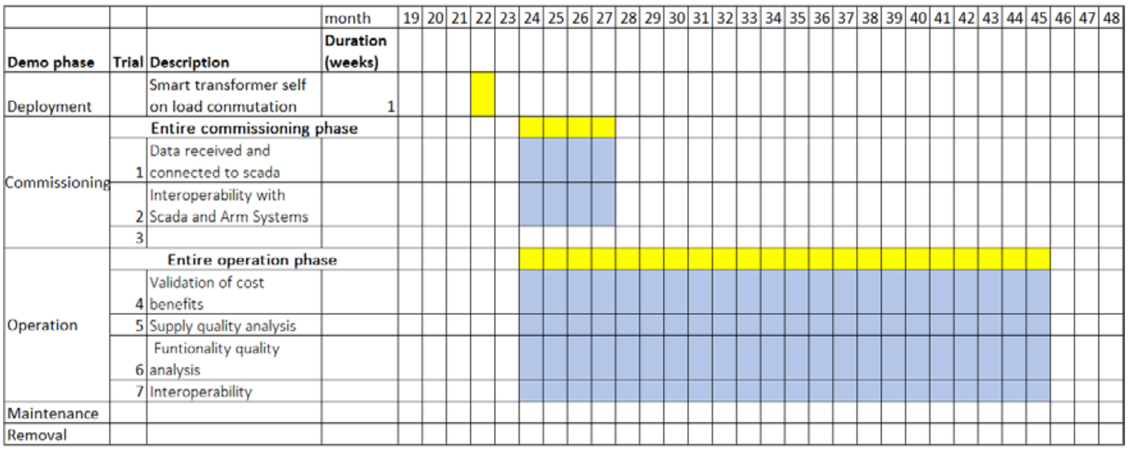


Figure 11 Smart Transformer timeline

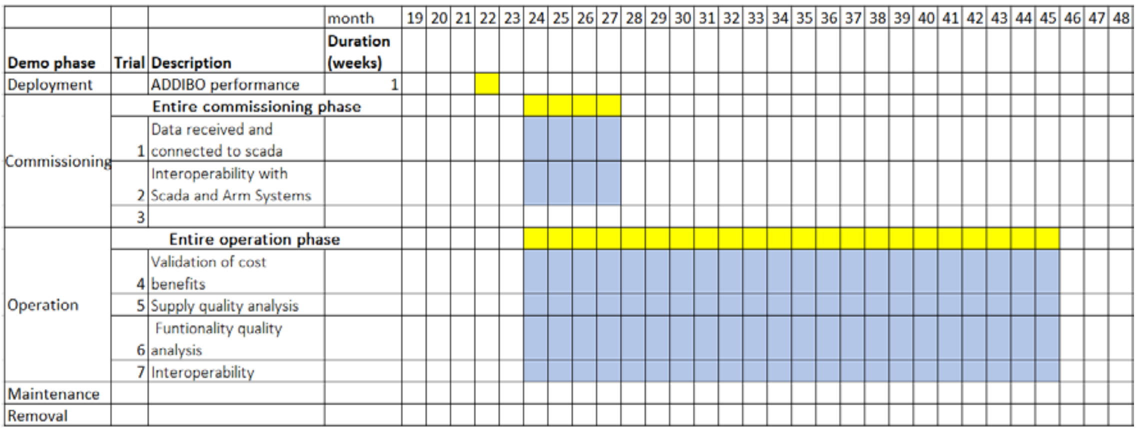


Figure 12 Low Voltage Supervision timeline

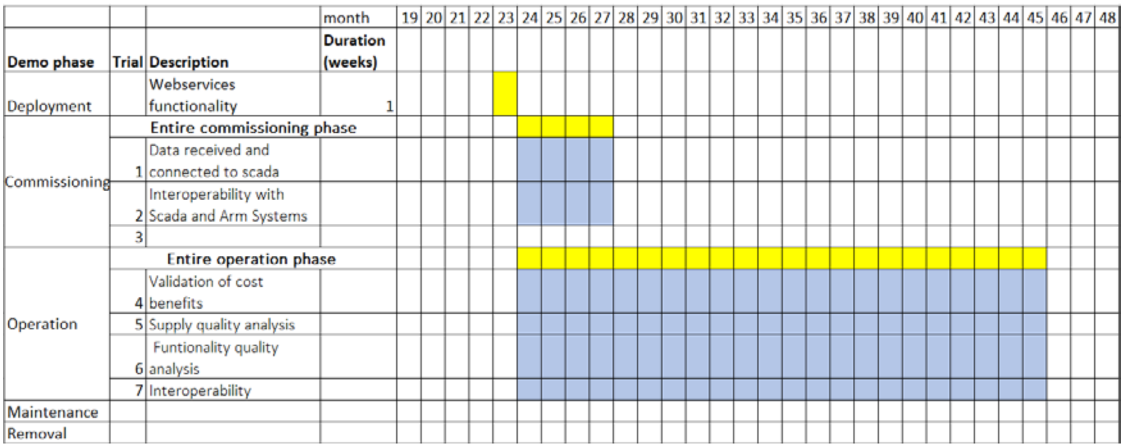


Figure 13 Web Services for Secondary Substation timeline

Demo phase	Trial	Description	Duration (weeks)	M19	M20	M21	M22	M23	M24	M25	M26	M27	M28	M29	M30	M31	M32	M33	M34	M35	M36	M37	M38	M39	M40	M41	M42	M43	M44	M45	M46	M47	M48
Deployment	1	EnergyBox installation (2 x Villabermudo Network - For Flexibility Algorithm)	1				■																										
	2	Energy Box installation (1 x Reparto Madepi - For Retrofit)	1				■																										
	3	Villabermudo Simulation deployment (Flexibility)	1				■																										
	4	Toranzo Simulation deployment (Self-Healing)	1				■																										
	5	TDR installation (Fault Locator - Toranzo)	4													■	■																
	6	TDR installation (Fault Locator - Bretoña)	4																					■	■								
	7	Fault passage indicator installation in CR Madepi	1							■																							
	8	LV Supervision installation in CR Madepi	1							■																							
	9	Feeder relay installation in primary substation	0,5							■																							
	10	Forecast software readiness	1					■																									
Commissioning	1	Validation of successful integration of the Energy Box (2 X Villabermudo)	1								■																						
	2	Validation of successful integration of the Energy Box (1 X Madepi)	1																		■	■							■	■			
	3	Validation of successful integration of the TDR (Toranzo)	4						■																								
	4	Villabermudo Simulation integration test (Flexibility + EnergyBox on field)	1						■																								
	5	Villabermudo Simulation integration test (Flexibility - LF SaaS using OPC)	0,5						■		■																						
	6	Villabermudo Simulation integration test (Flexibility to FUSE - List of Signals)	0,5						■		■																						
	7	Toranzo Simulation integration test (Self-Healing to FUSE - List of signals)	0,5										■																				
	8	Fault passage indicator test in CR Madepi	1										■																				
	9	LV Supervision test in CR Madepi	1										■																				
	10	Feeder relay test in primary substation	0,5																														
	11	Forecast software validation	0,5											■						■										■			

Figure 14 Remaining activities timeline (1 of 2)

Operation	6	Retrofit testing	TBD
	7	Flexibility test algorithm (optima	3
		Self-Healing test algorithm	3
		TDR fault detection on field	4
		Fault passage indicator operation check in CR Madepi	2 (distributed along 18 months)
		LV Supervision operation check in CR Madepi	2 (distributed along 18 months)
		Feeder relay operation check in primary substation	2 (distributed along 18 months)
Maintenance	1	2 X Energy Box - Villabermudo	0,5
	2	1 X Energy Box - Reparto Madepi	0,5
	3	TDR - Toranzo	2
	4	TDR - Bretoña	2
	5	Fault passage indicator in CR Madepi	0,5
	6	LV Supervision in CR Madepi	0,5
	7	Feeder relay in primary substation	0,5
Removal	1	Removal of the on-site installed equipment (2 X Energy Box - Villabermudo)	0,5
	2	Removal of the on-site installed equipment (1 X Energy Box - Reparto Madepi)	0,5
	3	Removal of the on-site installed equipment (TDR - Toranzo)	0,5
	4	Removal of the on-site installed equipment (Feeder relay primary substation)	0,5
	5	Removal of the on-site installed equipment (FPI Madepi)	0,5
	6	Removal of the on-site installed equipment (LV Supervision Madepi)	0,5

Figure 15 Remaining activities timeline (2 of 2)

Risk registry

In order to be able to keep track of the risks and carefully organise any contingency plans that might be needed during the trials' deployment, a risk registry has been created and is presented in Table 16.

The probability and impact ranking of each risk is in reverse order (with 1 being the highest and 3 being the lowest in terms of severity).

Table 16 Risk registry for the Spanish demo site

#	Risk description	Impact description	Impact	Probability	Mitigation actions and contingency plans
1	Difficulties in accessing to the information available in the grid and the already deployed IEDs due to the lack of communication means	No impact	1	1	Task 2.1 set the boundary conditions of the four demo-sites in order to avoid future problems when deploying the Use Cases. Additionally, T5.1 will define the needed communications to have access to all the data from field. The deployment of new sensors and IEDs is also envisioned to solve this issue.
2	COVID-19 (Spanish demo): Demo site inaccessible for partners	Delays and possible errors during the design of the Smart Secondary Substation. No impact expected any more.	1	2	A virtual visit to prepare the installation and formation plan to understand the purpose of Spanish pilot.
3	In Spanish demo site (Viesgo), definition of the functionality of the Webservices in development, referring to MV RTU, ekor.tsm and ekor.tsa (MV control equipment) and standardization of the product.	Unexpected functionalities required.	1	3	Functionality update in Spanish demo site during the demonstration

#	Risk description	Impact description	Impact	Probability	Mitigation actions and contingency plans
4	Restricted outside access to Spanish demo site (Viesgo) IT network	Delays and general difficulties in data sent to partners	2	3	Energy box with self-communications outside Spanish demo site (Viesgo) IT network. Self-communications for ZIV devices
5	Slight delay expected in the development of the fault location equipment by CIRCE. It is not expected to be a problem	General delays. Milestone not affected	2	3	Extra effort to reduce the delay
6	Energy Box may have to operate within simulation with batch data from the grid	Real time access to VIESGO may not be available	1	3	Real time communication ONLY with the Energy box without direct access to VIEGO equipment

3.2. Greek Demonstrator

Pilot description and components

As previously described in D2.1, the Greek Demo Site consists of a vacation resort in Thasos with a 400kVA substation and a number of bungalows, three of which are equipped with PV and batteries. The substation load is monitored along with a double EV charging point which is also installed on the site.

The hotel comprises a number of loads that are mainly individual lodge loads, offices and other auxiliary services (e.g. reception building, restaurant, etc.), however, this dedicated 400kVA substation supplies only residential bungalows and the double EV charging point. The Total PV generation is 50kWp. The available energy storage is composed by 3 Lithium-ion batteries with a combined total peak capacity of 24.9 kWh and an 80% depth of discharge. With regards to metering devices, Schneider PM2200 energy analysers are available and connected at the substation and they measure the total substation load and the dedicated charging point. The measured capabilities include 4-quadrant energy, power quality, demand and true Root Mean Square (RMS). Individual smart meters are connected to the inverters of the bungalows and measure local parameters of the loads, the PV production and the batteries.

A representation of the architecture of the pilot is depicted in Figure 16.

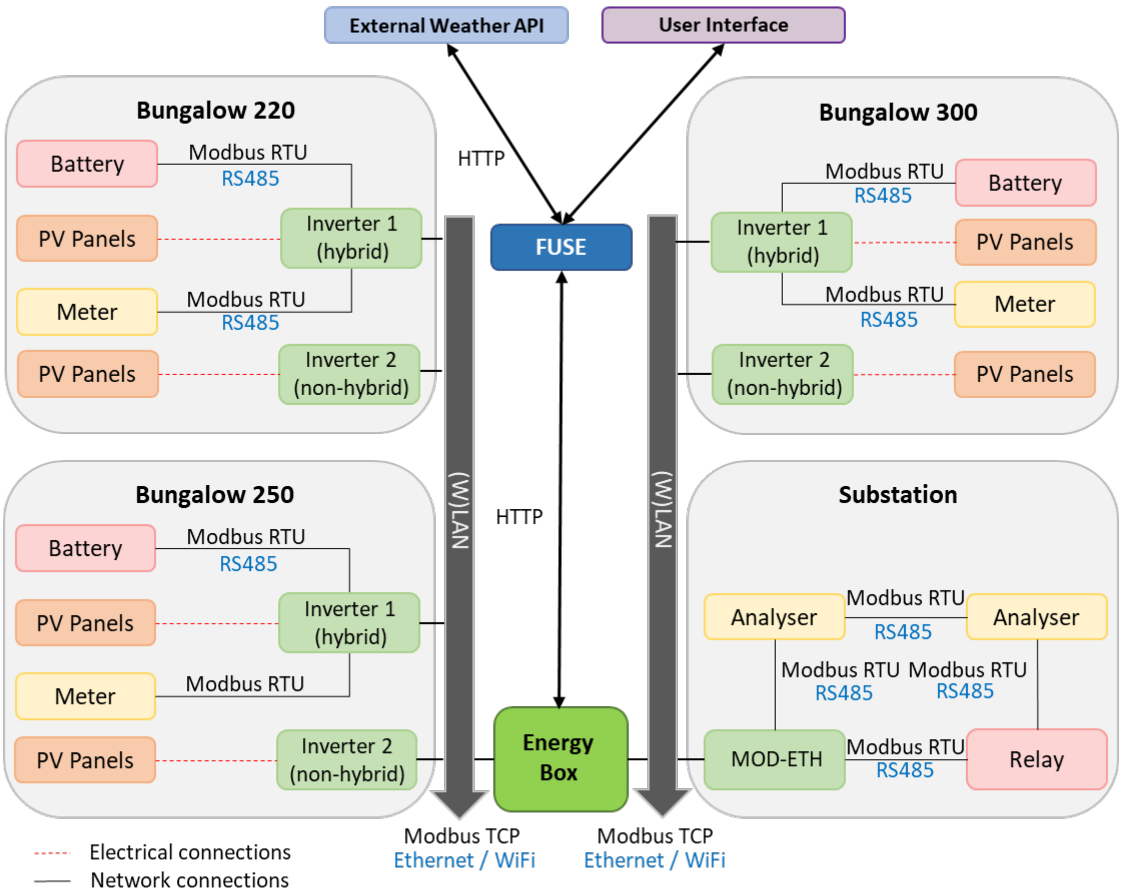


Figure 16 Greek demo site architecture of components

The hotel is fully equipped with an optical fibre local network (that reaches every bungalow) which is supplied by appropriately hierarchically distributed access points. Each monitored and controllable device (i.e. the inverters, the energy analysers, the energy meters and the control relay for the EV charging point) are networked locally. Their communication with the private cloud storage within FUSE is enabled via the installed Energy Box and appropriate software components/connectors developed in WP5.

The local network is secured and encryption is employed.

In the Greek demo site 2 main use cases will be addressed as described in Table 17.

Table 17 Greek demo site's respective use cases

Use case (ID)	Name	Main Description
Use case 3	Holistic energy system optimization & emulation for commercial and residential customers	1. Develop different algorithms, processes and systems to manage the local energy use in the network. 2. Under normal operation, the total local energy system will be optimized towards minimizing energy costs. 3. Under abnormal network conditions specific critical loads will be supplied by battery systems whose storage capacity will be locally supplied by renewable energy (island mode operation). To test the performance of the grid management algorithms in a LV grid, the energy system fed by a determined SS will be emulated using novel concepts. The use of distributed energy resources in a shared manner will be assumed by multiple consumers and prosumers with or without low carbon assets, to derive the business case for a community energy system and provide recommendations for streamlined approach to operation of this kind of systems.
Use case 4	Microgrid congestion management and peak shaving	1. Analyze the requirements and develop appropriate processes for: a. peak shaving at the substation level to reduce network charges and losses stabilizing where possible the output from variable renewable sources; b. congestion management at the substation level to support the upstream distribution network by means of active and reactive power support. 2. Both approaches will seek to appropriately dispatch the distributed resources (demand response, storage, generation, EVs) of the local grid maintaining quality of supply and comfort of infrastructure to users while optimizing energy flows towards improving network utilization. 3. Commercial approach development of peak shaving processes to maximize the value for the customer using market information in evolving tariff environments. Flexibility management development at the distribution system level with support from commercial customers as an aggregated resource.

A set of KPIs as defined in Table 18 below will be used to assess the successful deployment of the trials in the Greek demo site.

Table 18 List of KPIs to be assessed in the Greek demo site

Name (ID)	Description	Classification	Units	Sampling rate
Average estimation of savings per stakeholder (AeS)	Total savings from avoided energy consumption or purchase (depending on concerned stakeholder) over the sum of that avoided energy.	Core KPI	Euros	30 minutes
CAIDI	The Customer Average Interruption Duration Index (CAIDI) represents the average time required to restore service.	Core KPI	minutes	1 month
CO_2 tones saved (CO_2Sv)	Amount of CO2 reduction due to substitution of fossil power generation by additional RES units inside the distribution network under analysis (Using FLEXIGRID solution)	Core KPI	tones CO_2	30 minutes
Demand Available Flexibility (DAF)	The amount of load that can be shifted temporally. Needs specification dependent on the method used to provide an incentive (RTP, remote operation of customer assets or other options)	Auxiliary KPI	kW	10 minutes
Energy Consumption (EC)	Total energy consumed in a period	Auxiliary KPI	kWh	10 minutes
Energy Not Supplied (ENS)	The amount of energy that normally would be delivered, but now is not because of an outage	Auxiliary KPI	kWh	10 minutes
Flexibility Actions Taken (FAT)	Number of flexibility actions taken to reduce demand, load control, network configuration, etc. in a period	Auxiliary KPI	number	10 minutes

Name (ID)	Description	Classification	Units	Sampling rate
Forecasting Accuracy (FA)	Deviation between the forecasted values and the corresponding measurements for the demand/generation by node	Core KPI	%	30 minutes
Number of Grid Events (NGE)	Number of events that change the network, as lines aperture, tripping of protection in substations, OLTC operation.	Core KPI	number	# per period
Peak load reduction (PLRed)	This KPI shows the reduction in the maximum electricity demand. The KPI is the difference between the two peaks, the power peak with respect to the baseline and the power peak with respect to the Demand Response event with the FLEXIGRID solutions.	Core KPI	kW and %	1 month
Reactive Energy Consumption (RE)	Total reactive energy consumed in a period	Core KPI	KVARh	10 minutes
Self-Consumption Rate (SCRt)	It Is the ratio of consumed renewable energy over the sum of all renewable electricity generated on site.	Core KPI	%	10 minutes
Successful Meter Reading Index (SMRI)	Indicator to evaluate the performance of the metering infrastructure, covering all kind of queries to request meter data	Auxiliary KPI	number	10 minutes
Self-sufficiency ratio (SSRt)	It is the ratio of total power provided by RES consumed locally and total power required by local demand in a period	Core KPI	%	10 minutes

Name (ID)	Description	Classification	Units	Sampling rate
Successful event reading index (SERI)	This KPI has been defined to analyze if all the meters or IED´s are sending their registers. This KPI aims at evaluating the data collection/data acquisition process	Core KPI	%	# per sampling period

The data that will be collected during the trials' period along with the associated KPIs that are connected to it, is presented in Table 19.

Table 19 List of data collected during the trials for the Greek demonstration

Data ID	Description	Units	Source component	Final recipient	Relevant KPIs	Collection frequency
Sub_Unmasked _Apparent_Load	Total load excluding PVs, batteries and EVs	KVA	SSATOT, B220F, B220FH, B250F, B250FH, B300F, B300FH	ATOS	EC, PLRed, AeS, ENS, SERI	10 minutes
Sub_Unmasked _Active_Load	Total load excluding PVs, batteries and EVs	KW	SSATOT, B220F, B220FH, B250F, B250FH, B300F, B300FH	ATOS	EC, PLRed, AeS, ENS, SERI	10 minutes
Sub_Apparent _Load	Total substation load	KVA	SSATOT	ATOS	EC, PLRed, AeS, ENS, SERI	10 minutes
Sub_Load	Total substation load	KW	SSATOT	ATOS	EC, PLRed, AeS, ENS, SERI	10 minutes
PV_tot	Total PV production	W	B220F, B220FH, B250F, B250FH, B300F, B300FH	LINKS	SMRI, AeS, CO2Sv, SCRt, SERI	10 minutes
PV1_220	PV1 production (bungalow 220)	W	B220F	LINKS	SMRI, AeS, CO2Sv, SCRt, SERI	10 minutes

Data ID	Description	Units	Source component	Final recipient	Relevant KPIs	Collection frequency
PV2_220	PV2 production (bungalow 220)	W	B220FH	LINKS	SMRI, AeS, CO2Sv, SCRt, SERI	10 minutes
PV1_250	PV1 production (bungalow 250)	W	B250F	LINKS	SMRI, AeS, CO2Sv, SCRt, SERI	10 minutes
PV2_250	PV2 production (bungalow 250)	W	B250FH	LINKS	SMRI, AeS, CO2Sv, SCRt, SERI	10 minutes
PV1_300	PV1 production (bungalow 300)	W	B300F	LINKS	SMRI, AeS, CO2Sv, SCRt, SERI	10 minutes
PV2_300	PV2 production (bungalow 300)	W	B300FH	LINKS	SMRI, AeS, CO2Sv, SCRt, SERI	10 minutes
Load_bung_tot	Total load of all bungalows	W	B220SM, B250SM, B300SM	ATOS	EC, PLRed, AeS, ENS, SERI	10 minutes
Load_220	Load of bungalow 220	W	B220SM	ATOS	EC, PLRed, AeS, ENS, SERI	10 minutes
Load_250	Load of bungalow 250	W	B250SM	ATOS	EC, PLRed, AeS, ENS, SERI	10 minutes
Load_300	Load of bungalow 300	W	B300SM	ATOS	EC, PLRed, AeS, ENS, SERI	10 minutes
EV_load	Load of EV charger	KW	SSAEV	ATOS	EC, FAT	10 minutes
EV_Apparent _load	Load of EV charger	KVA	SSAEV	ATOS	EC, FAT	10 minutes

Data ID	Description	Units	Source component	Final recipient	Relevant KPIs	Collection frequency
EV_Apparent _Peak_Demand	Peak demand of EV charger	KVA	SSAEV	ATOS	EC, FAT	10 minutes
EV_Peak_ Demand	Peak demand of EV charger	KW	SSAEV	ATOS	EC, FAT	10 minutes
Bat_SOC_tot	Total current storage State of Charge	%	B220FH, B250FH, B300FH	ATOS	EC, DAF, PLRed, AeS, ENS, FAT, RE, SMRI, SSRt, SERI	10 minutes
Bat_SOC_220			B220FH	ATOS	EC, DAF, PLRed, AeS, ENS, FAT, RE, SMRI, SSRt, SERI	10 minutes
Bat_SOC_250			B250FH	ATOS	EC, DAF, PLRed, AeS, ENS, FAT, RE, SMRI, SSRt, SERI	10 minutes
Bat_SOC_300			B300FH	ATOS	EC, DAF, PLRed, AeS, ENS, FAT, RE, SMRI, SSRt, SERI	10 minutes
Bat_min_ SOC_tot	Total storage minimum State of Charge	%		ATOS	EC, DAF, PLRed, AeS, ENS, FAT, RE, SMRI, SSRt, SERI	batch

Data ID	Description	Units	Source component	Final recipient	Relevant KPIs	Collection frequency
Bat_min _SOC_220			B220FH	ATOS	EC, DAF, PLRed, AeS, ENS, FAT, RE, SMRI, SSRt, SERI	batch
Bat_min _SOC_250			B250FH	ATOS	EC, DAF, PLRed, AeS, ENS, FAT, RE, SMRI, SSRt, SERI	batch
Bat_min _SOC_300			B300FH	ATOS	EC, DAF, PLRed, AeS, ENS, FAT, RE, SMRI, SSRt, SERI	batch
Bat_nom_tot	Total nominal storage capacity	kVA	B220FH, B250FH, B300FH	ATOS	EC, DAF, PLRed, AeS, ENS, FAT, RE, SMRI, SSRt, SERI	batch
Bat_nom _SOC_220		kVA	B220FH	ATOS	EC, DAF, PLRed, AeS, ENS, FAT, RE, SMRI, SSRt, SERI	batch
Bat_nom _SOC_250		kVA	B250FH	ATOS	EC, DAF, PLRed, AeS, ENS, FAT, RE, SMRI, SSRt, SERI	batch

Data ID	Description	Units	Source component	Final recipient	Relevant KPIs	Collection frequency
Bat_nom _SOC_300		kVA	B300FH	ATOS	EC, DAF, PLRed, AeS, ENS, FAT, RE, SMRI, SSRt, SERI	batch
Tot_Inv_Cap	Total capacity of all hybrid inverters	KW				batch
Sub_Apparent _Load_Forecast	Forecast of Substations' Unmasked Load	kVA		LINKS	FA	10 minutes
PV_tot_forecast	Forecast of PV production (total)	KW		LINKS	FA	10 minutes

Pilot objectives and aspects to address

Within this pilot, the involved partners will primarily test the developed algorithms and processes required for enhanced accuracy and generation forecasting and scheduling in LV networks with flexible DER resources. The aim of these algorithms is to enable operation of LV networks under various operational conditions including normal and abnormal grid states as well as under different operational objectives, such as cost minimization and peak shaving.

More specifically, the key objectives of the pilot's trials will be to:

- Achieve up to 35% reduction of the energy costs of the demo site during the trial period
- Achieve up to 25% reduction of the emissions related to the operation of the energy systems of the demo site during the trial period
- Achieve up to 100% reduction of customer minutes lost for the site's critical loads
- Achieve up to 20% reduction of the network charges of the demo site during the trial period
- Contribute to the distribution network congestion management of up to 10% while developing requirements and processes for future flexibility markets
- Unlock the potential for energy communities
- Clarify the business case for energy communities and define optimal arrangements based on various ownership regimes

Pilot monitoring plan

The pilot's deployment plan is divided in five phases as per below:

1. Deployment
2. Commissioning phase
3. Operation phase
4. Maintenance phase
5. Removal phase

More details on the operations and trials included in each phase are provided in the subsections below.

Deployment

The deployment phase will run during the first month of the WP execution (M19), during which the deployment and integration of all hardware and software solutions on site will be confirmed and finalised. Particularly for the Greek demo site the deployment will confirm the following:

- Installation and integration of the Energy Box on site
- Finalisation of PV and load forecasting algorithms
- Finalisation of microgrid congestion management algorithms

Commissioning

Commissioning phase will run for 2 months (M20-M21), during which three trials will be conducted, all aiming at verifying the successful integration of the hardware solution on-site as well as the validation of the software solutions deployed.

The trials are described in the tables below.

Table 20 Greek demo trial #1: Validation of successful integration of the Energy Box on site

Trial name	Validation of successful integration of the Energy Box on site
Description	During this trial we will validate the successful integration of the Energy Box within the demo site in communication with LINKS and ATOS in order to confirm that data flows are managed correctly by the FUSE platform
Duration	1 week
Acceptance criteria	Data received and stored with no problems
Success criteria	No missing data points
Relevant use cases	n/a
Relevant KPIs	n/a

Table 21 Greek demo trial #2: Validation of PV forecasting algorithms

Trial name	Validation of PV forecasting algorithms
Description	During this trial we will validate the PV forecasting algorithms built by LINKS by comparing forecasting results to real data from the site
Duration	1 week
Acceptance criteria	1. Data received and stored with no problems 2. Reception of forecasted and real time values at the same timestamp
Success criteria	Error margin between -10% and +10% deviation of forecasted and real data
Relevant use cases	Use case 3
Relevant KPIs	n/a

Table 22 Greek demo trial #3: Validation of load forecasting algorithms

Trial name	Validation of load forecasting algorithms
Description	During this trial we will validate the load forecasting algorithms built by LINKS by comparing forecasting results to real data from the site
Duration	1 week
Acceptance criteria	1. Data received and stored with no problems 2. Reception of forecasted and real time values at the same timestamp
Success criteria	Error margin between -10% and +10% deviation of forecasted and real data
Relevant use cases	Use case 3
Relevant KPIs	n/a

Operation

The operation phase will run for a period of 20 months (M24-M44), during which six different trials will be conducted. The results of the trials will be reported in three distinct deliverables, D6.3 with the initial results (M27), D6.7 with interim results (M36) and D6.11 with the final results (M45) of each trial.

The trials are described in the tables below.

Table 23 Greek demo trial #4: Validation of cost reduction benefits

Trial name	Validation of cost reduction benefits
Description	During normal operation, cost related KPIs will be monitored and evaluated in order to measure the economic benefits of the RES and storage installation in the demo site. The actual electricity consumption of the site will be measured and compared to the site's electricity demand. The electricity savings due to the PV and battery operation will be translated into energy costs in order to understand the level of cost savings. CO_2 emissions' savings will also be calculated during the trial period.
Duration	Multiple periods where the system will be monitored and data will be collected both during high demand and low demand seasons (M24-M26, M30-M35, M38-M39, M42-M45)
Acceptance criteria	1. Data received and stored with no problems 2. Able to have at least one set of data for each representative period (high, medium, load demand) 3. Able to calculate respective KPIs
Success criteria	up to 35% reduction in energy costs for the trial period up to 25% reduction of CO2 emissions
Relevant use cases	Use case 3
Relevant KPIs	AeS, EC, FA, SCRt

Table 24 Greek demo trial #5: Validation of the reduction of network charges

Trial name	Validation of the reduction of network charges
Description	During normal operation cost related KPIs will be monitored and evaluated in order to measure the economic benefits of the RES and storage installation with regards to the network charges in the demo site.
Duration	Multiple periods where the system will be monitored and data will be collected both during high demand and low demand seasons (M24-M26, M30-M35, M38-M39, M42-M45)
Acceptance criteria	1. Data received and stored with no problems 2. Able to have at least one set of data for each representative period (high, medium, load demand) 3. Able to calculate respective KPIs
Success criteria	up to 20% reduction of network charges
Relevant use cases	Use case 4
Relevant KPIs	EC, NGE, PLRed, SSRt

Table 25 Greek demo trial #6: Black-out support

Trial name	Black-out support (Simulation of islanded operation)
Description	During this trial we will manually create an island situation (artificial black-out) in the demo site in order to assess whether critical loads can be supplied by the battery which will have been charged by the local PV generation. The power loss will be evaluated to last for about 10min, 20min and 30min periods where we will closely monitor the response of the battery and assess its capacity to serve the critical loads
Duration	Two trial periods in low demand seasons in order to avoid business interruptions caused by the trials (M27, M40).
Acceptance criteria	Each trial will last for up to 2-3 days where someone will need to be on-site and artificially create power loss conditions in the site's network
Success criteria	1. Data received and stored with no problems 2. Able to have at least one set of data for each representative period (high, medium, load demand)
Relevant use cases	Use case 3
Relevant KPIs	CAIDI, ENS, NGE, SCRt

Table 26 Greek demo trial #7: Peak shaving operation (active power support)

Trial name	Peak shaving operation (active power support)
Description	During this trial we will set the battery to respond to a peak shaving operation. The maximum peak demand that could be drawn from the grid on a daily basis will be manually set at a given kVA and from that point the battery will be requested to discharge in order to reach the required capacity. When demand is lower than the set peak point, energy will be drawn from the grid to charge the battery. The trial will be conducted three times using different capacity limits for low and for medium demand seasons.
Duration	Two trial periods one in low demand season and one in medium demand season in order to avoid business interruptions caused by the trials (M28-M29, M36-M37)
Acceptance criteria	1. Data received and stored with no problems 2. Trials conducted for all respective time periods 3. Able to calculate respective KPIs
Success criteria	No events recorded where the power drawn from the grid surpassed the peak demand set points

Trial name	Peak shaving operation (active power support)
Relevant use cases	Use case 4
Relevant KPIs	RE, EC, PLRed

Table 27 Greek demo trial #8: Peak shaving operation (reactive power support)

Trial name	Peak shaving operation (reactive power support)
Description	As per trial #7, during this trial we will set the battery to respond to a peak shaving operation, only this time also using reactive power support. The maximum peak demand that could be drawn from the grid on a daily basis will be manually set at a given kVA and from that point the battery will be requested to discharge in order to reach the required capacity. When demand is lower than the set peak point, energy will be drawn from the grid to charge the battery. The trial will be conducted two times using different capacity limits for low and for medium demand seasons. All operations will also be conducted with reactive power support in order to quantify the contribution of the reactive power support under peak shaving operations
Duration	5 days on M27 and 5 days on M39
Acceptance criteria	1. Data received and stored with no problems 2. Trials conducted for all respective time periods 3. Able to calculate respective KPIs
Success criteria	TBD
Relevant use cases	Use case 4
Relevant KPIs	PLRed, RE

Table 28 Greek demo trial #9: Simulation of network congestion management (Demand Response)

Trial name	Simulation of network congestion management (Demand Response)
Description	During this trial we will simulate network conditions where demand response services could be provided by the on-field devices to assist with the network congestion management In order to do so, we need to artificially set a demand limit where the demand response devices on site will understand that the network cannot provide more power at a specific time hence the batteries will need to discharge to or the loads will need to be disconnected in order not to exceed this set point
Duration	TBD

Trial name	Simulation of network congestion management (Demand Response)
Acceptance criteria	1. Data received and stored with no problems 2. Trials conducted for all respective time periods 3. Able to calculate respective KPIs
Success criteria	TBD
Relevant use cases	Use case 4
Relevant KPIs	DAF, FAT

Maintenance

As discussed in previous sections, in the Greek demo site 4 of the 9 solutions developed within FLEXIGRID will be deployed as shown in Figure 17.

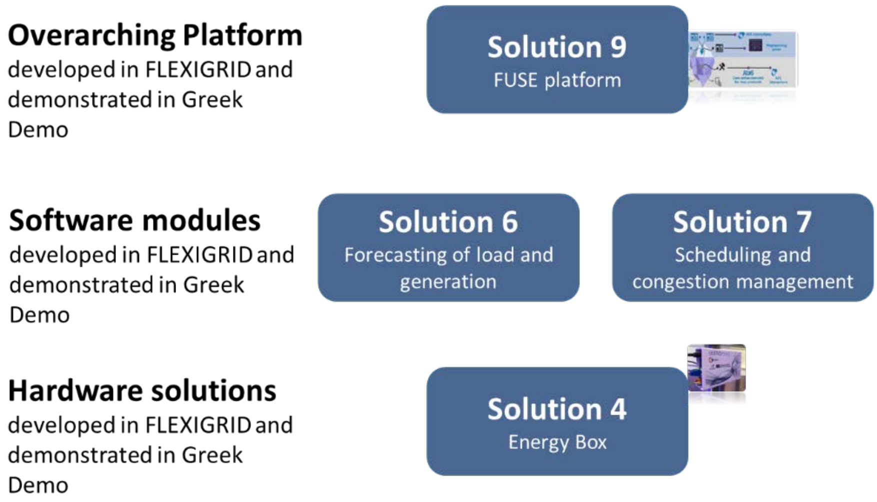


Figure 17 FLEXIGRID solutions deployed in the Greek demo site

These solutions will require ad hoc maintenance activities during the demonstration period as per below:

- FUSE platform

Regarding maintenance activities, ATOS will be responsible to verify the proper integrity and security of FUSE platform on a regular basis, while keeping it updated throughout the execution of the pilot activities. On occurrence of failure, ATOS will react and find out the reason behind these failures via the checking of the information supplied by the platform.

- Forecasting of load and generation algorithm

On occurrence of failure to respond, and randomly check of logs. The duration depends on issue. Updating to new version may occur after each validation stage.

- Scheduling and congestion management algorithm

On occurrence of failure to respond, and randomly check of logs. The duration depends on the issue. Module will be upgrade to new version may occur after each validation stage.

- Energy Box

The Energy Box is going to be tested under controlled conditions and so maintenance is going to be part of the testing. Should any communication issue occurs, it will be solved remotely by CIRCE and if there is any physical problem, CIRCE will send a new one to substitute the damaged one.

Removal

At the end of the operation phase, we will make sure that all equipment deployed on the demo site as part of the FLEXIGRID project will be removed and returned to the solution developer.

For the Greek demo site, IOSA will facilitate the removal of the Energy Box from the demo site on an agreed adequate week between M47 and M48. The Energy Box will subsequently be returned to CIRCE.

Pilot plan timeline

The above-described plan is also presented in the timeline below.

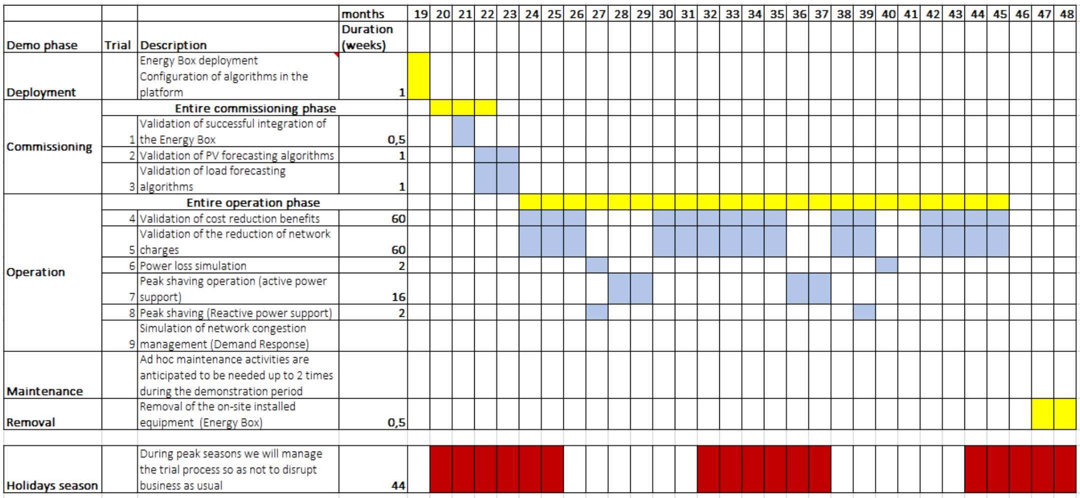


Figure 18 Timeline for the trials' deployment plan in the Greek demo

Risk registry

In order to be able to keep track of the risks and carefully organise any contingency plans that might be needed during the trials' deployment, a risk registry has been created and is presented in Table 29.

The probability and impact ranking of each risk is in reverse order (with 1 being the highest and 3 being the lowest in terms of severity).

Table 29 Risk registry for the Greek demo site

#	Risk description	Impact description	Impact	Probability	Mitigation actions	Contingency plans
1	Unexpected problems in the demo start-up	Trials could be delayed	2	3	The duration of starting-up tasks for the demo has been calculated taking into account possible problems	Allow enough time for the solutions' validation and integration in the demo site
2	Trials affecting BAU of the demo site (hotel's operation)	Some trials could affect the normal operation of the hotel having significant economic impact on the owners' business	3	1	Most trials have been scheduled to take place during low demand periods.	We will closely monitor the impact of the trials to the hotel's normal operating conditions and re-schedule them accordingly should we see any issues

3.3. Croatian Demonstrator

Pilot description and components

As previously described in D2.1, the Croatian Demo-site focuses on the problems of the distribution network of the future in a populated and urban area.

HEP-ODS plans, operates and maintains the distribution grid of medium voltage (MV) grid (30 kV, 20 kV and 10 kV) and low voltage (LV) grid (0.4 kV). The grid includes 14 substations of 30/10(20) kV and 2463 substations of 10(20)/0.4 kV and 9000 km of grid (LV and MV). The Croatian Demo Site is located in Zagreb. The geodesic coordinates are 45º 48' 3.88" N 15º 58' 36.8" E.

Zagreb is the capital city of Croatia and it is located in the North-East of the country. Its population is around 1 million people, which means one quarter of the population of the country. This means that improving the energy efficiency of this city may have a huge impact on the efficiency of the whole country. Figure 19 and Figure 20 show the deployment views of the substations taking part in the Croatian demonstrator.

The Croatian pilot location is represented by a single LV customer who is equipped with a smart-meter and is able to establish communication with the HEP-ODS platform and exchange the necessary data through Hypertech cloud and FUSE platform, using AMQP and HTTPS protocols. Calculations made in the HEP-ODS platform are based on the consumption data collected from smart meters and from collected weather data, that are used in necessary predictions. After the calculations, in a case of need, the signals are sent to the end-user's controllable devices. Based on the signals, the controllable devices change the behaviour and help in the network conditions improvement.

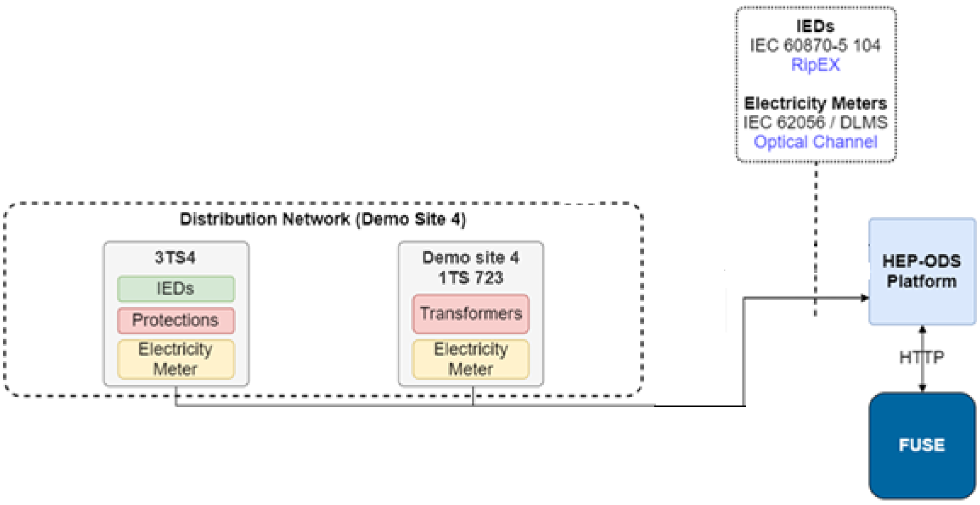


Figure 19 Deployment view of the substations taking part in the Croatian demonstrator.

The Croatian demo site consists of one location, a residential apartment equipped with smart metering infrastructure is the flexibility provider located at Demo Site 4.

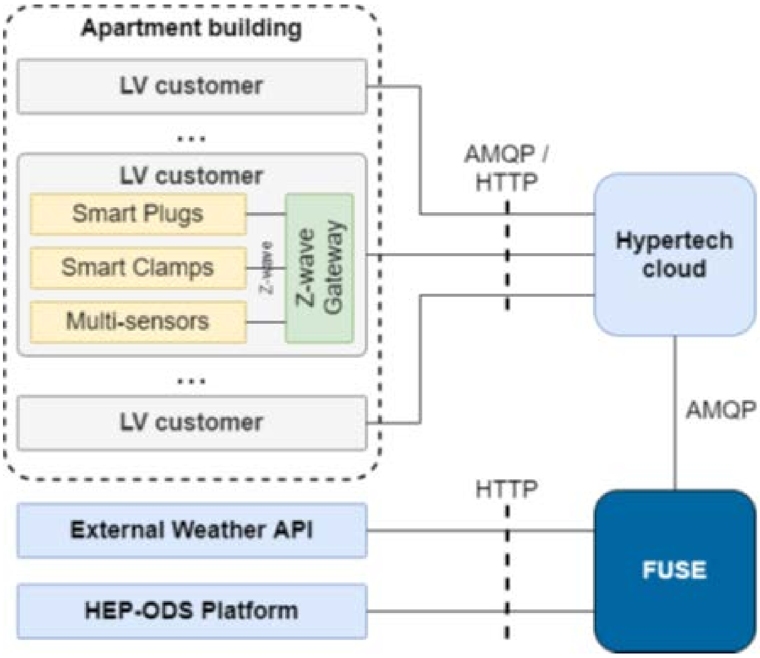


Figure 20 Deployment view of the substations taking part in the Croatian demonstrator.

In the Croatian demo site two main use cases will be addressed as described in Table 30.

Table 30 Croatian demo site's respective use cases

Use case (ID)	Name	Main Description
Use case 5	Coordinating distribution network flexibility assets & protections schemes in urban districts	A ready-to-use tool for optimal selection of distribution network operating points by utilizing flexibility services for provision of distribution-level ancillary services (network peak reduction, voltage stability, N-1 criterion); defining optimal topology for operation of the distribution network based on switching states of the distribution network topology (reducing losses, maximizing reliability of supply for end users, enhancing resilience of the network, enabling provision of flexibility from network users); defining optimal set points of on-load tap changers for distribution-level transformers, providing voltage led demand response. The initial step in the tool development will be an assessment of technical demand response capability of actual distribution network of Elektra Zagreb by employing optimisation models, driven by different objective functions for providing flexible services while maintaining required technical constraints. An automatic reconfiguration of the MV distribution protection system will be done. A reconfiguration affects only the status of the switching devices in an MV network, but also the settings of protection relay setting after a reconfiguration will be analysed due to the possible change of current direction, e.g., a distributed generation is located on another MV circuit after a reconfiguration. Adjustable optimization tool from previously developed. The flexibility of the protection system set-up will improve reliability protection schemes will be based on the utilization of information provided by devices deployed along the grid (SCADA system) and results of the of supply, reliability of flexibility service provision as well resilience of the distribution network.
Use case 6	Virtual Energy Storage for urban building	FLEXIGRID will provide models, techniques and optimisation algorithms to provide a smart VTES-coupled heating solution combining optimally TES and P2H technologies. Dynamic building thermal inertia models will be configured to reflect the thermal behaviour of buildings under varying usage constraints (e.g. operations, occupancy) and building envelope characteristics. These will be further associated with the respective device' s operation (i.e. heat pumps) to enable the optimal TES and P2H coordination towards estimating the amount of context-aware flexibility that can be offered by specific heating/cooling loads. In addition, comprehensive parametric models of thermal storage equipment, e.g., water heaters including their thermal properties (e.g., capacity, "discharge rate") and electrical response characteristics (e.g. response time, rated and actual power/energy consumption, ramp up/down times) will be developed to define their thermal storage capacity and flexibility considering daily schedules and preferences.

A set of KPIs as defined in Table 31 below will be used to assess the successful deployment of the trials in the Croatian demo site.

Table 31 List of KPIs to be assessed in the Croatian demo site

Name (ID)	Description	Classification	Units	Sampling rate
Average estimation of savings per stakeholder (AeS)	Total savings from avoided energy consumption or purchase (depending on concerned stakeholder) over the sum of that avoided energy.	Core KPI	Euros	Once
Customer satisfaction (CuSa)	Satisfaction rating (define the rating range, e.g. from 1 to 5 with 5 being extremely satisfied and 1 being extremely dissatisfied) in Questionnaires	Core KPI	Questionnaires	Once
	The amount of potential Demand Flexibility reflects the amount of energy consumption reduction participating Customers (i.e. End Users) could potentially accept and apply	Core KPI	MW	15 minutes
Demand Flexibility Potential (DFP)	The amount of potential Demand Flexibility reflects the amount of energy consumption reduction participating Customers (i.e. End Users) could potentially accept and apply	Core KPI	MW	15 minutes
DR Delivery Deviation (DRDD)	The difference between the DR the Customer has committed to deliver and the DR that the Customer actually delivered	Core KPI	MWh	15 minutes
(Forecasting Accuracy) FA	Deviation between the forecasted values and the corresponding measurements (used for model validation)	Core KPI	W	15 minutes

Name (ID)	Description	Classification	Units	Sampling rate
Maximum Demand reduction (MDRed)	This KPI shows the reduction in the electricity demand during a DR event. The KPI is actually the difference between two peaks, the power peak with respect to the baseline and the power peak with respect to the Demand Response event with the FLEXIGRID solutions	Core KPI	%	Once per event
Thermal discomfort factor (TDF)	Assessing the people's satisfaction with the thermal environment during events. Computed as the average temperature outside the comfort limits during one event.	Core KPI	Celsius	Once per event
Voltage Change (VG)	This KPI shows the reduction or the increase of voltage in a case when the flexibility is activated. It is calculated as the deviation between voltage values at the node in a case without flexibility and nodal voltage in a case when the flexibility is activated.	Core KPI	Volt	15 Minutes
Active Energy Loss Change (AELC)	A difference of active energy losses between a case when there is a flexibility and a case when the flexibility is not available. This KPI shows the positive impact of network activities on active losses reduction during one day.	Core KPI	MWh	Once per day
Maximum Demand reduction	The maximum difference of the demand change caused by the activated flexibility, calculated once per month.	Core KPI	MWh	Once per month

Name (ID)	Description	Classification	Units	Sampling rate
Peak load reduction (PLRed)	This KPI shows the reduction in the maximum electricity demand. The KPI is actually the difference between the two peaks, the power peak with respect to the baseline and the power peak with respect to the Demand Response event with the FLEXIGRID solutions	Core KPI	%	One year
CAIDI	The Customer Average Interruption Duration Index (CAIDI) represents the average time required to restore service.	Core KPI	-	One year
Number of Grid Events (NGE)	Number of events that change the network, as lines aperture, tripping of protection in substations, OLTC operation.	Core KPI	-	One year
Protections tripping time improvement (PTT)	Effective reduction of tripping time by implementation of new algorithms	Core KPI	ms	DWP6

The information requirements for the demonstration of use cases 5 and 6 in the Croatian pilot site are broken down to two categories, data and output requirements, and are summarized in the following two tables.

Table 32 List of Data Requirements to be assessed in the Croatian demo site

Data ID	Description	Units	Source component	Final recipient	Relevant KPIs	Collection frequency
Space unique Id	The unique identifier of the space	Dimensionless	-	Virtual Energy Storage (VES) module	-	Once

Data ID	Description	Units	Source component	Final recipient	Relevant KPIs	Collection frequency
Energy / power consumption	Consumption for each space/apartment /building, received from smart meters	W / Wh	Meter	VES module	AES, DFP, DRDD, FA, MDRed	1 Min
PIR motion sensor activations	Occupancy sensors reporting a binary value (0 or 1)	Binary	Sensor	VES module	-	5 Min
Indoor temperature	Space indoor temperature	°C	Sensor	VES module	DFP, FA, TDF	1 Min
Indoor relative humidity	Space indoor relative humidity	%	Sensor	VES module	DFP, FA, TDF	1 Min
Luminance	Luminance of space if relevant sensor is installed	Lux	Sensor	VES module	DFP, FA, TDF	1 Min
Outdoor air temperature	The outdoor air temperature of the space's area	°C	Sensor or web service	VES module	DFP, FA, TDF	15 Min
Global solar radiation	The global solar radiation of the space's area	W/m2	Sensor or web service	VES module	DFP, FA, TDF	15 Min
HVAC status	The HVAC status {0,1} of the DER system that heats/cools the space	Binary	Thermostat /Gateway	VES module	DFP, DRDD, FA, MDRed	1 Min
HVAC mode	The HVAC mode {Heat, Cool, Fan} of the DER system that heats/cools the	Categorical	Thermostat /Gateway	VES module	DFP, DRDD, FA, MDRed	1 Min

Data ID	Description	Units	Source component	Final recipient	Relevant KPIs	Collection frequency
HVAC thermostat setpoint temperatures	The HVAC thermostat setpoint temperatures in of the DER system that heats/cools the space (measured and received from the LEM/LFM Repository) for a dataset consisting of samples	°C	Thermostat /Gateway	VES module	DFP, DRDD, FA, MDRed	1 Min
HVAC power consumption	The HVAC power consumption	W	Meter	VES module	AES, DFP, DRDD, FA, MDRed	1 Min
Space occupancy	The space occupancy (estimated by the Occupancy Profiling model)	Binary	VES module	VES module	DFP, FA, TDF	1 Min
Electric Water Heater (EWH) status	The EWH status {0,1} of the device	Binary	Thermostat /Gateway	VES module	DFP, DRDD, FA, MDRed	1 Min
EWH power consumption	The EWH power consumption	W	Meter	VES module	AES, DFP, DRDD, FA, MDRed	1 Min
Model Fit Metrics	Root Mean Square Error (RMSE) and Mean Absolute Percentage Error	Dimensionless	VES module	VES module	FA	-

Data ID	Description	Units	Source component	Final recipient	Relevant KPIs	Collection frequency
Baseline thermal comfort bounds	Lower and upper bounds of space air temperature that indicate the comfort zone of occupants for periods of time that the space is occupied	°C	VES module	VES module	AES, DFP, DRDD, FA, MDRed	15 Min
Flexibility thermal comfort bounds	Extended lower and upper bounds of space air temperature that indicate the comfort zone of occupants for periods of time that the space is occupied	°C	VES module	VES module	AES, DFP, DRDD, FA, MDRed	15 Min
Consumption Curve	The power of consumption at each node and time step	W	Meter			15 Min
Active power	the data for Peak Load Reduction	%	*IEDs/ Others*	UC5	PLRed	daily
Service interruption event timestamp	Service interruption event timestamp	-	Various	UC5	CAIDI	One year
Restoration command timestamp	Restoration command timestamp	-	Various	UC5	CAIDI	One year
Number of interrupted customers	Number of interrupted customers	-	Various	UC5	CAIDI	One year
Registered event	Registered event	-	IEDs / Others	UC 5	NGE	monthly

Data ID	Description	Units	Source component	Final recipient	Relevant KPIs	Collection frequency
IED configuration files	IED configuration files	-	IEDs/ Catalogs	UC5	PTT	DWP6
Protection Operation time	Protection Operation time	ms	IEDs/ Simulations	UC5	PTT	DWP6

Table 33 List of command/outputs employed in the Croatian demo site for UC6

Command/ Output ID	Description	Units	Source component	Final recipient	Relevant KPIs	Collection frequency	Validation process
Flexibility forecast	The forecasted flexibility timeseries for an asset /space	W	VES module	HEP-ODS Platform	AES, DFP, DRDD, FA, MDRed	15 Min	-
HVAC control status	Command to operate HVAC	Binary	VES module	HVAC Device	DFP, DRDD, FA, MDRed	15 Min	Validate via dedicated communication /control tests
HVAC control mode	Command to operate HVAC	Categorical	VES module	HVAC Device	DFP, DRDD, FA, MDRed	15 Min	Validate via dedicated communication /control tests
HVAC control setpoint	Command to operate HVAC	ºC	VES module	HVAC Device	DFP, DRDD, FA, MDRed	15 Min	Validate via dedicated communication /control tests
EWH control status	Command to operate EWH	Binary	VES module	EWH Device	DFP, DRDD, FA, MDRed	15 Min	Validate via dedicated communication /control tests
Consumption Request	Request to follow a consumption timeseries for HVAC and/or EWH	W	HEP-ODS Platform	VES module	AES, DFP, DRDD, FA, MDRed	15 Min	Validate via dedicated communication /control tests

Pilot objectives and aspects to address

Our goal is to increase the flexibility and reliability of the distribution network. By implementing the developed solutions (S3, S5, S6, S7 and S8), the goal is to achieve protection against high penetration of renewable energy sources, fault detection and self- healing network, forecasting and congestion management in the network and achieving optimization of thermal energy storage.

Pilot monitoring plan

The pilot's deployment plan is divided in five phases as per below:

1. Deployment
2. Commissioning phase
3. Operation phase
4. Maintenance phase
5. Removal phase

Deployment

With respect to the realization of UC6, it is scheduled that all activities necessary and leading to the initiation of the actual deployment phase will be completed by M23 of the project. In particular, the detailed steps and associated deadlines are the following:

- Full technical characterization and final selection of pilot sites and assets (M22)
- Generation of Bill of Materials (M23).

Upon successful completion of the above the deployment phase is initiated with respective steps:

- Equipment procuring (M23 – M27)
- Training workshops for installation, commissioning, operation and maintenance (M23-M25)
- Installation (M25-M28)

Commissioning

We expect the implementation phase in the coming period.

Related to UC6, the commissioning phase, along with any relevant trials required during this phase, will run in parallel with the installation activities, between M25 and M28 of the project.

There are four trials that are associated with the commissioning phase for UC6, planned to be executed between M26 and M28, as shown in the detailed time plan in a following section. Below we present the details of each such trial.

Related to UC5, the commissioning phase, along with any relevant trials required during this phase, will run in parallel with the installation activities and is expected between M28 and M31 of the project.

Table 34 Croatian demo trial #1: Validate establishment of necessary data streams

Trial name	Validate establishment of necessary data streams
Description	The purpose of this trial is to validate whether the installed infrastructure and communication framework are able to create and distribute the required data from the demonstration site to the VES module
Duration	1 month
Acceptance criteria	Data received and stored with no problems
Success criteria	<5% missing data points
Relevant use cases	Use Case 6
Relevant KPIs	-

Table 35 Croatian demo trial #2: Validate thermal modelling framework and accuracy

Trial name	Validate thermal modelling framework and accuracy
Description	In this trial, we will evaluate the accuracy of the fitted models which allow the mathematical characterization of the following: space occupancy, thermal comfort, building thermal modelling, HVAC and EWH device modelling
Duration	1 month
Acceptance criteria	Model identification and fitting performed. Accuracy on test set within defined margins.
Success criteria	Error margin between -10% and +10% deviation of forecasted and real data
Relevant use cases	Use Case 6
Relevant KPIs	DFP, DRDD, FA, TDF

Table 36 Croatian demo trial #3: Validate Flexibility forecasting accuracy

Trial name	Validate Flexibility forecasting accuracy
Description	The purpose of this trial is to evaluate the ability and accuracy of the flexibility forecasting algorithm, both in terms of baselining as well as in terms of available upwards and downwards regulation
Duration	1 month

Trial name	Validate Flexibility forecasting accuracy
Acceptance criteria	Accuracy on test set within defined margins.
Success criteria	Error margin between -10% and +10% deviation of forecasted and real data
Relevant use cases	Use Case 6
Relevant KPIs	DFP, DRDD, FA, TDF

Table 37 Croatian demo trial #4: Validate control framework

Trial name	Validate control framework
Description	Here, the goal is to validate the ability to control HVAC and EWH devices via the exposed control signals, so as to follow a predefined consumption curve
Duration	1 month
Acceptance criteria	Ability to send control signals to devices. Accuracy of forecasted vs real consumption within defined margins.
Success criteria	Error margin between -10% and +10% deviation of forecasted and real data
Relevant use cases	Use Case 6
Relevant KPIs	DFP, DRDD, FA, MDRed, TDF

Table 38 Croatian demo trial #5: Validate network reconfiguration

Trial name	Validate network reconfiguration
Description	In this trial, we observe a number of network topology changes in order to improve technical parameters of a network (active power losses, voltage magnitude).
Duration	1 month
Acceptance criteria	Technical parameters are improved with a network reconfiguration
Success criteria	Successful topology changes (network events) > 90%
Relevant use cases	Use Case 5
Relevant KPIs	CAIDI, NGE

Table 39 Croatian demo trial #6: Validate relays tripping

Trial name	Validate relays tripping
Description	The goal of this trial is to determine if an unnecessary relay tripping occurs during a network reconfiguration
Duration	1 month
Acceptance criteria	Network is reconfigured without unnecessary relays tripping
Success criteria	Number of wrong relays tripping during reconfiguration < 5%
Relevant use cases	Use Case 5
Relevant KPIs	NGE, PTT

Operation

The operation phase will run for a period of 20 months (M24-M44).

For UC6, the operation phase will go from M29 to M44 of the project. One trial has been defined for this phase, which is detailed below.

For UC5, the operation phase is expected to run between to M44 of the project.

Table 40 Croatian demo trial #7: Participation of VES assets on congestion management scenarios through demand modification

Trial name	Participation of VES assets on congestion management scenarios through demand modification
Description	The operational scenario will consist of the following steps: • Each day at a certain time, the day-ahead flexibility available from the VTES-enabled assets will be computed from the VES module. • This flexibility forecast will be communicated to the HEP-ODS platform. • The HEP-ODS platform will inform the VES module whether there is the need for utilizing flexibility from the assets, and if so, how much and when • Upon receipt of this message, the VES module with compute the necessary control signals to be sent to the devices, so as to follow the predefined baseline or modified consumption curve. Upon implementation of the control, consumption and temperature measurements will be recorded in order to compare with the forecasted values and compute the necessary KPIs.
Duration	M29-M44

Trial name	**Participation of VES assets on congestion management scenarios through demand modification**
Acceptance criteria	Able to calculate respective KPIs
Success criteria	User acceptance greater that 75%. Flexibility forecasting accuracy greater than 80%. Demand modification accuracy greater than 80%.
Relevant use cases	Use Case 6
Relevant KPIs	AES, CuSa, DFP, DRDD, FA, MD, TDF

Table 41 Croatian demo trial #8 An algorithm-based network reconfiguration

Trial name	**An algorithm-based network reconfiguration**
Description	The operational scenario will consist of the following steps: • Each day an algorithm will be ran to determine an optimal topology • In order to minimize losses or improve voltage magnitude, an algorithm will propose new network topology • A proposal will be communicated with HEP-ODS platform If the change is necessary, the status of switching state of will be changed, and the new topology will be determined
Duration	M29-M44
Acceptance criteria	Able to calculate respective KPIs
Success criteria	The number of successful topology changes is higher than 90%. CAIDI after reconfiguration is better for at least 5% compared to current one. There is no unnecessary relays tripping.
Relevant use cases	Use Case 5
Relevant KPIs	CAIDI, NGE, PTT

Maintenance

In the Croatian demo site 5 of the 9 solutions developed within FLEXIGRID will be deployed as shown in Figure 21.

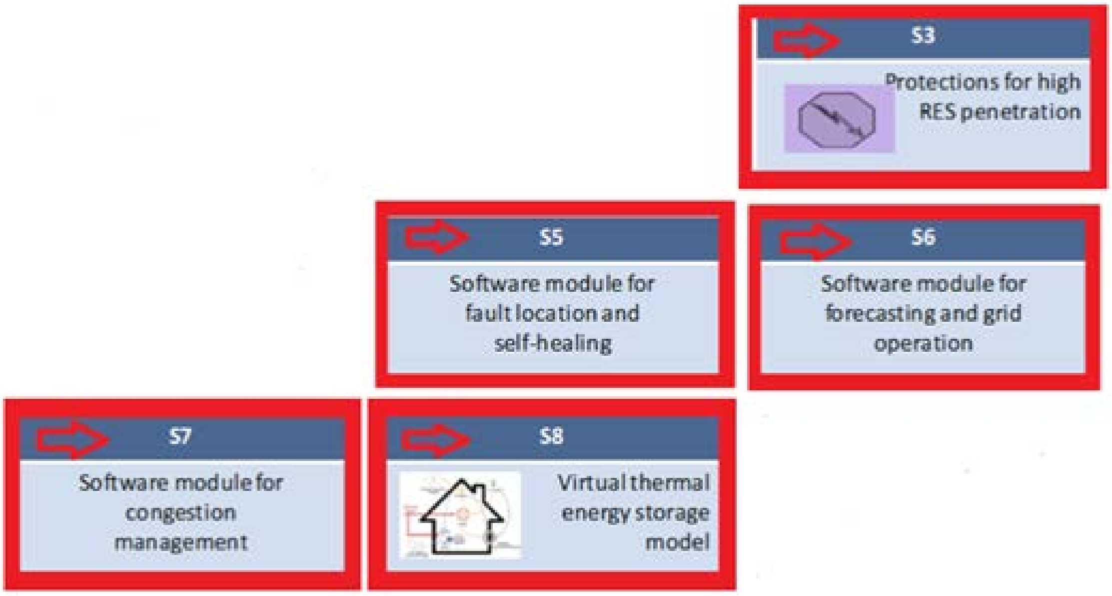


Figure 21 Solutions developed within FLEXIGRID

Maintenance activities for the VTES module will run in parallel and for the complete duration of the operational phase. They are to be performed in an impromptu basis, whenever an issue is identified in the monitoring process and it is not resolved automatically through the built-in automated system recovery tools.

Maintenance activities for the software modules deployed in the Croatian demo site, have already been described in the previous sections under the Spanish and the Greek demo site's activities.

Removal

The equipment that HEP installs at its own expense, we (HEP) will not be removed. Removal in the last months of the project for the equipment we (HEP) receive from other partners.

Any equipment installed at the pilot premises with respect to UC6 will remain there upon completion of the project.

Pilot plan timeline

The timelines for the realization of UC5 and UC6 are shown respectively in Figure 22 and Figure 23 below:

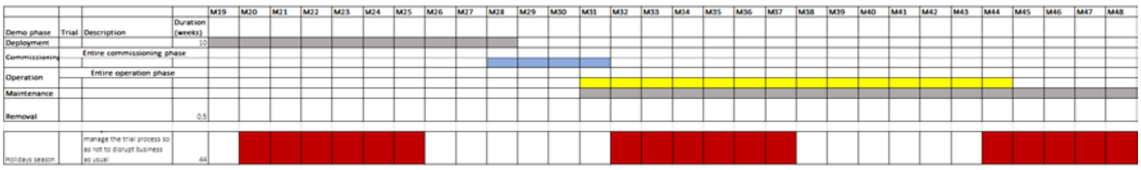


Figure 22 Timeline for the realisation of UC5

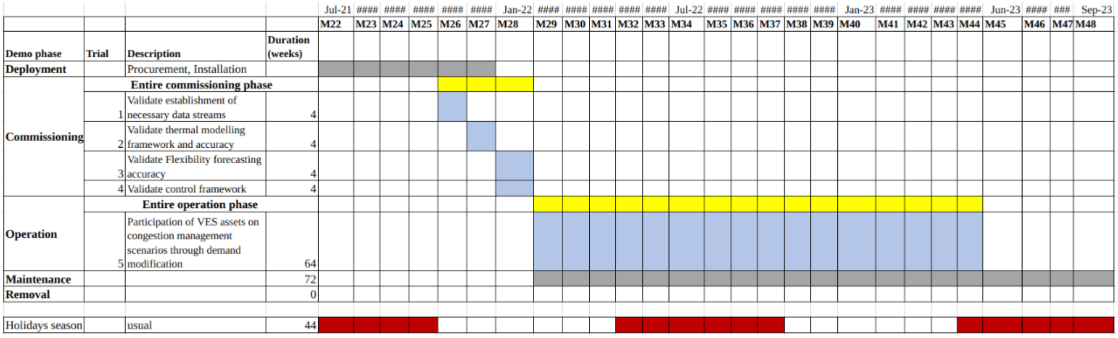


Figure 23 Timeline for realisation of UC6

Risk registry

As per the previous demos, the probability and impact ranking of each risk in Table 42 below is in reverse order (with 1 being the highest and 3 being the lowest in terms of severity).

Table 42 Risk registry for the Croatian demo site

#	Risk description	Impact description	Impact	Probability	Mitigation actions	Contingency plans
1	COVID-19	Access to customer / participants' premises is prohibited due to confinement measures associated with the COVID-19 crisis. Data cannot be obtained from customers as installation of necessary kit is difficult due to confinement measures	2	3	Regular engagement with participants, monitoring of local COVID-19 measures (in countries where pilot sites are located), plan all participant communication and engagement activities, as well as solution deployment activities at customer premises, with build-in time float. Use historical, proprietary data for training models deployed in Task 4.5 in case data from customers are not easily obtained at the early stages of WP6.	Use historical, proprietary data

#	Risk description	Impact description	Impact	Probability	Mitigation actions	Contingency plans
2	Unexpected problems in the demos start-up of demos	-	3	3	The duration of starting-up tasks for demos have been calculated taking into account possible problems when the solutions start for its first time.	-

3.4. Italian Demonstrator

Pilot description and components

As previously described in D2.1, the Italian Demo Site consists in the MV grid connected to the Sarentino primary substation, in South-Tyrol. This grid is characterized by a high penetration of dispersed generation, mostly hydroelectric plants, and few connections with the rest of the grid: only a HV line and a MV line. In case of several events, it can happen that both the lines are out of service, with very big problems for the power supply of the costumers. Same problems are present at the end of the MV lines, where there are no alternative feeders for emergency supplies.

Furthermore, the presence of a lot of dispersed generations in very long MV lines, creates some problems in load-flows and voltage.

The scope of the pilot is the realization of a dispatching platform to manage portions of this grid in islanded mode in case of emergency, with the use of the existing MV hydroelectric plants, and to regulate the reactive power of these plants in normal condition to control the voltage in MV grid and the exchanges of reactive power with the HV grid.

A representation of the architecture of the pilot is depicted in Figure 24.

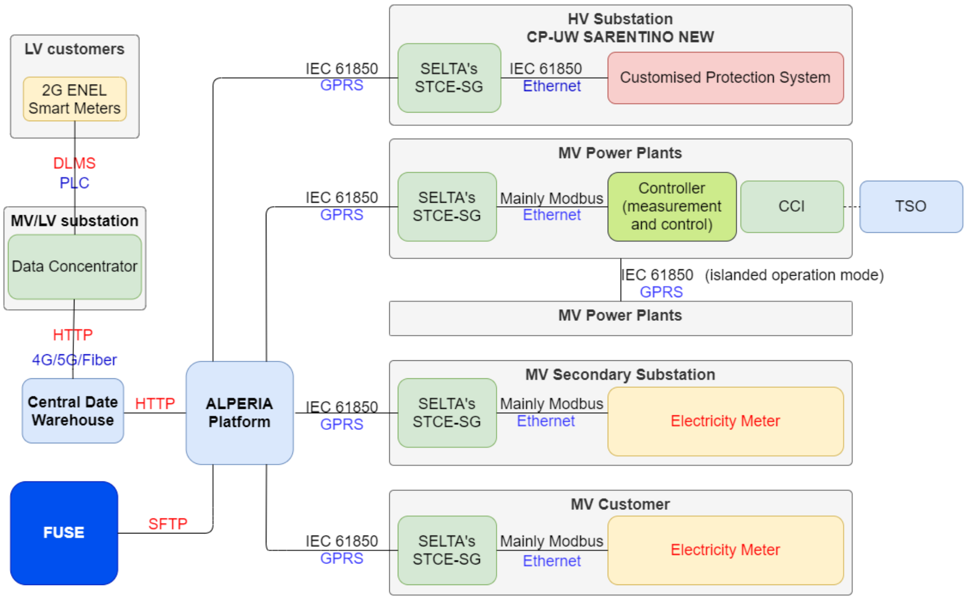


Figure 24 Italian demo site architecture of components

To have many measures from the grid a STCE-SG provided by SELTA will be installed in a lot of MV secondary substation, both transformation MV/LV and MV costumer substation. In the hydroelectric plants involved in the pilot the STCE will be interfaced with the controller of the plant to regulate the generator.

The whole process of the dispatching platform will be managed by a Smart Grid Controller, located at the SCADA system in ALPERIA.

In the Italian demo site 2 main use cases will be addressed as described in Table 43.

Table 43 Italian demo site's respective use cases

Use case (ID)	Name	Main Description
Use case 7	Dispatching platform for MV generation	Analogously to UC1, an update of the functionalities of the Secondary Substations will be done through the implementation of a device provided by SELTA in different MV/LV substations. Additionally, a different generation of Smart Meters of third generation 3G (already commercially available) for each MV and LV costumers will be deployed (20.000). Real time monitoring of the loads on the MV producers will be carried out. This will serve to provide the implementation of a dispatching platform involving the main MV active users connected to the pilot network. The platform will allow for the monitoring of the electrical quantities of the users, which can be of interest for the power system's management (from the DSO, but also the TSO, perspective): voltage and current amplitudes at the user's point of connection with the external grid, active and reactive power exchanged, etc. Moreover, the possibility to control the user's active and reactive power production to improve the operation of the network will be investigated. In this framework, for example, the dispatching platform developed in the project could be used to manage congestions along MV lines and/or to provide voltage capabilities to the DSO. These monitoring and control functionalities could be implemented both in real-time and in advance, estimating the state of the network in the next hours/days through suitable forecasting algorithms.
Use case 8	Mountainous valley grid operating in island mode	In this use case, the operation of a portion of MV network in islanded mode (i.e., disconnected from the main power system) will be studied and tested on field. The islanded operation will be made possible through the use of the active power control capabilities of Distributed Generators displaced on the MV network in the area of the experiment (e.g. hydro power plants). To this purpose, issues relevant both to the power balancing control and to the voltage profiles controls will be deepened in the pilot. Proper selection of the portion of network to be enabled to the islanded operation is key, since the generator(s) having in charge the frequency and voltage control of the electrical island must supply all local loads and provide them enough with flexibility to manage all potential power fluctuations. Proper control logics needs to be developed, taking into account the dynamic aspects of the control. In addition, power fluctuations of load/generation aggregate have to be predicted in advance by proper forecasting algorithms.

A set of KPIs as defined in Table 44 below will be used to assess the successful deployment of the trials in the Italian demo site.

Table 44 List of KPIs to be assessed in the Italian demo site

Name (ID)	Description	Classification	Units	Sampling rate
CAIDI	The Customer Average Interruption Duration Index (CAIDI) represents the average time required to restore service.	Core KPI	minutes	1 month
Exchange of Information with sub-DSOs (ExI)	Number of new information exchanges with sub-DSOs	Core KPI	number	once
Island mode reliability rate (IMRR)	Effective time operation in an islanded mode divided by period of time that should had been operating in islanded mode because a grid failure	Core KPI	%	1 hour
Number of Voltage Limits Violations (VLV)	Number of times than voltage in a node exceeds (under or over) the tolerance limit (usually 5%) for more than 2 seconds in a period of time.	Core KPI	number	Day
Rate of successful switching operations to reconnect to grid (SSG)	Number of successful reconnections to grid divided by number of all attempts to reconnect to grid in a year	Core KPI	%	month

Name (ID)	Description	Classification	Units	Sampling rate
SAIDI	Is the average duration of all interruptions per utility customer during the period of analysis. Here, the total customer minutes of interruption are added together and divided by the total number of customers in the system.	Core KPI	minutes	once
Switching success ratio to islanded mode (SSR)	Number of successful switching operations to islanded mode divided by the total number of switching attempts to islanded mode in a year	Core KPI	%	month
Estimation Accuracy P	Deviation between the estimated power values and the corresponding measurements for the demand/generation by node (all the no-measured nodes)	Auxiliary KPI	kW	1/4 hour
Estimation Accuracy V	Deviation between the estimated voltage values and the corresponding measurements by node (all the measured nodes)	Auxiliary KPI	kV	1/4 hour

The data that will be collected during the trials' period along with the associated KPIs that are connected to it, is presented in Table 45.

Table 45 List of data collected during the trials for the Italian demonstration

Data ID	Description	Units	Source component	Final recipient	Relevant KPIs	Collection frequency
Grid	Static Grid topology and characteristics (length of conductors, voltages, power of TRs, number and power of costumers and producers…)	various	SCADA/EDYNA database	SGC	SAIDI, CAIDI	on variation
Hyst-Pw	Historical measures for loads and productions MV and LV	kW - kVAr	EDYNA meters	SGC	Exl, Estimation Accuracy V, Estimation Accuracy P	Yearly
Swi-pos	Switch position for whole switch present in the EDYNA grid	boolean	SCADA	SGC	IMRR, SSG SSR	on variation
TR-P	Active power of HV TRs	MW	SCADA	SGC	IMRR; VLV, SSG, SSR	4 s
TR-Q	Reactive power of HV TRs	MVAr	SCADA	SGC	IMRR, VLV, SSG, SSR	4 s
Grid-P	Active Power in significant points of the grid	kW	SCADA	SGC	IMRR, VLV, SSG, SSR	4 s
Grid-Q	Reactive Power in significant points of the grid	kVAr	SCADA	SGC	IMRR, VLV, SSG, SSR	4 s
Grid-V	Voltage in significant points of the grid	kV	SCADA	SGC	IMRR, VLV, SSG, SSR	4 s
Grid-I	Current in significant points of the grid	A	SCADA	SGC	IMRR, VLV, SSG, SSR	4 s

Data ID	Description	Units	Source component	Final recipient	Relevant KPIs	Collection frequency
PCR-P	Active Power for each installed PCR	kW	PCR	SGC	IMRR, VLV, SSG, SSR, Exl	4 s
PCR-Q	Reactive Power for each installed PCR	kVAr	PCR	SGC	IMRR, VLV, SSG, SSR, Exl	4 s
PCR-PF	Power Factor for each installed PCR	number	PCR	SGC	IMRR, VLV, SSG, SSR, Exl	4 s
PCR-V	Voltage for each installed PCR	kV	PCR	SGC	IMRR, VLV, SSG, SSR, Exl	4 s
PCR-I	Current for each installed PCR	A	PCR	SGC	IMRR, VLV, SSG, SSR, Exl	4 s
CAP	Capability for each power plant	kW - kVAr	PCR	SGC	IMRR, VLV, SSG, SSR, Exl	4 s
PG-state	State of General Protection of the power plants involved in the pilot (open - close)	boolean	PCR	SGC	IMRR, VLV, SSG, SSR, Exl	4 s
SPI-state	State of Interface Protection of the power plants involved in the pilot (open - close)	boolean	PCR	SGC	IMRR, VLV, SSG, SSR, Exl	4 s
Nr-gen	Number of generators in service (for the power plants involved in the pilot)	Number	PCR	SGC	IMRR, VLV, SSG, SSR, Exl	4 s
SwP-pos	Position of the generator switch (for the power plants involved in the pilot)	boolean	PCR	SGC	IMRR, VLV, SSG, SSR, Exl	4 s

Data ID	Description	Units	Source component	Final recipient	Relevant KPIs	Collection frequency
Av-island	Availability of the power plant to support the islanded mode (for the power plants involved in the pilot)	boolean	PCR	SGC	IMRR, VLV, SSG, SSR, Exl	4 s
Av-PF	Availability of the power plant to Power Factor regulation (for the power plants involved in the pilot)	boolean	PCR	SGC	IMRR, VLV, SSG, SSR, Exl	4 s
Av-P	Availability of the power plant to Active Power regulation (for the power plants involved in the pilot)	boolean	PCR	SGC	IMRR, VLV, SSG, SSR, Exl	4 s
Av-Q	Availability of the power plant to Reactive Power regulation (for the power plants involved in the pilot)	boolean	PCR	SGC	IMRR, VLV, SSG, SSR, Exl	4 s
An-Reg	Regulation anomaly (for the power plant)	boolean	PCR	SGC	IMRR, VLV, SSG, SSR, Exl	In case of event
An-Msr	Anomaly in the grid analyser (for the measures at the connection point for plant not involved in the pilot)	boolean	PCR	SGC	IMRR, VLV, SSG, SSR, Exl	In case of event
An-SGC	SGC Anomaly	boolean	SGC	PCR	IMRR, VLV, SSG, SSR, Exl	In case of event

Pilot objectives and aspects to address

Within this pilot, the involved partners will primarily test the developed algorithms and processes required for the management of the grid in islanded mode. For this scope, one production plant will act as master, and the other connected to the same portion of grid will act as slave. The master will regulate the frequency in the island with its controller, and the Smart Grid Controller will send appropriate set-points to the slaves to maintain the master in a good point of functionality.

Furthermore, the correct automatic acquisition of the whole data of the grid (characteristics, states, and measures) by the SGC will be tested. This point is very important for the correct operation of the dispatching platform.

Pilot monitoring plan

The pilot's deployment plan is divided in five phases as per below:

1. Deployment
2. Commissioning phase
3. Operation phase
4. Maintenance phase
5. Removal phase

More details on the operations and trials included in each phase are provided in the subsections below.

Deployment

The deployment phase will run during 30 weeks from M19 to M33, during which the deployment and integration of all hardware and software solutions on site will be confirmed and finalised. Particularly for the Italian demo site the deployment will confirm the following:

- Installation of 20 STCE-SG(PCR) in the chosen MV substations
- Installation of CT and VT where necessary
- Installation of the server SGC
- Modifications to the hydroelectric plant to communicate the set-points
- Installation of 2 MV switch breaker
- Installation of optic fibre

Commissioning

Commissioning phase will run for 12 months (M20-M31), during which four trials will be conducted, all aiming at verifying the successful integration of the hardware solution on-site as well as the validation of the software solutions deployed.

The trials are described in the tables below.

Table 46 Italian demo trial #1: Check of the correct communication

Trial name	Check of the correct communication
Description	1 week for each component - 2 months total
Duration	The data from and to the PCR are correct

Trial name	Check of the correct communication
Acceptance criteria	Loss of communication < 5% of the time
Success criteria	TBD
Relevant use cases	UC7 - UC8
Relevant KPIs	SSR

Table 47 Italian demo trial #2 Measurement acquisition

Trial name	Measurement acquisition
Description	The measures are read and sent
Duration	2 weeks for each component - 2 months total
Acceptance criteria	The PCR is able to read the measures from the field
Success criteria	Loss of data or incorrect measures < 5% of the time
Relevant use cases	UC7 - UC8
Relevant KPIs	SSR

Table 48 Italian demo trial #3 Automatic load of the static grid data

Trial name	Automatic load of the static grid data
Description	Check of the automatic loaded grid data in the SGC
Duration	2 weeks
Acceptance criteria	The grid data in the SGC are correct
Success criteria	Errors < 1 % of the total grid data
Relevant use cases	UC7 - UC8
Relevant KPIs	SSR

Table 49 Italian demo trial #4 Information exchange between SGC - SCADA via OPC

Trial name	Information exchange between SGC - SCADA via OPC
Description	Correct data exchange with the use of OPC
Duration	2 months
Acceptance criteria	The communication between SCADA and SGC is correct
Success criteria	loss of data < 0,1 %
Relevant use cases	UC7 - UC8

Trial name	Information exchange between SGC - SCADA via OPC
Relevant KPIs	ExI

Operation

The operation phase will run for a period of 14 months (M32-M45), during which 5 different trials will be conducted. The results of the trials will be reported in three distinct deliverables, one with initial results (M27), one with interim results (M36) and one with the final results (M45) of each trial.

The trials are described in the tables below

Table 50 Italian demo trial #5 Real time load-flow

Trial name	Real time load-flow
Description	Check of the correctness of the results of the load-flow
Duration	2 months
Acceptance criteria	The results of the load-flow correspond to the real measures on the grid
Success criteria	The difference between the calculated values and the real values is < 10 %
Relevant use cases	UC7 - UC8
Relevant KPIs	FA

Table 51 Italian demo trial #6 Limits violation (voltage, load)

Trial name	Limits violation (voltage, load)
Description	Control of the values of voltage and load
Duration	1 year
Acceptance criteria	The values are not out of the limit
Success criteria	The values of voltage out ± 5 % Vn and load > $load_{max}$ are < 1 % of the total
Relevant use cases	UC7 - UC8
Relevant KPIs	VLV

Table 52 Italian demo trial #7 DER management

Trial name	DER management
Description	Correct management of the Dispersed Energy Resources
Duration	1 year
Acceptance criteria	The resources offered by the plant are used correctly

Trial name	DER management
Success criteria	The services requested to the plants do not create problem to the plant or to the grid < 1%
Relevant use cases	UC7 - UC8
Relevant KPIs	VLV

Table 53 Italian demo trial #8 Islanded mode management

Trial name	Islanded mode management
Description	Part of MV grid managed in islanded mode without problems
Duration	1 year
Acceptance criteria	The grid is stable without violations on voltage, frequency, load.
Success criteria	No failure in the islanded mode. Voltage and frequency inside the limits
Relevant use cases	UC8
Relevant KPIs	IMRR, SSG, SSR

Table 54 Italian demo trial #9 Sending set-point

Trial name	Sending set-point
Description	The set-point sent by the SGC is correctly acted by the plant
Duration	1 year
Acceptance criteria	Each command is successful
Success criteria	< 5 % of the total set-point sent is not successful
Relevant use cases	UC7 - UC8
Relevant KPIs	SSR

Maintenance

For the maintenance of the Italian pilot scheduled works are not planned. In case of damage or failure in same component an appropriate intervention of repair will be done.

For these unexpected activities 5 weeks of works are planned in the budget.

Removal

Activities of removal are not planned: if the pilot will give the expected results, it will remain operative with the whole devices installed. Furthermore, for most equipment, the cost of installation/deinstallation are greater than the cost of the device.

Pilot plan timeline

The above-described plan is also presented in the timeline below.

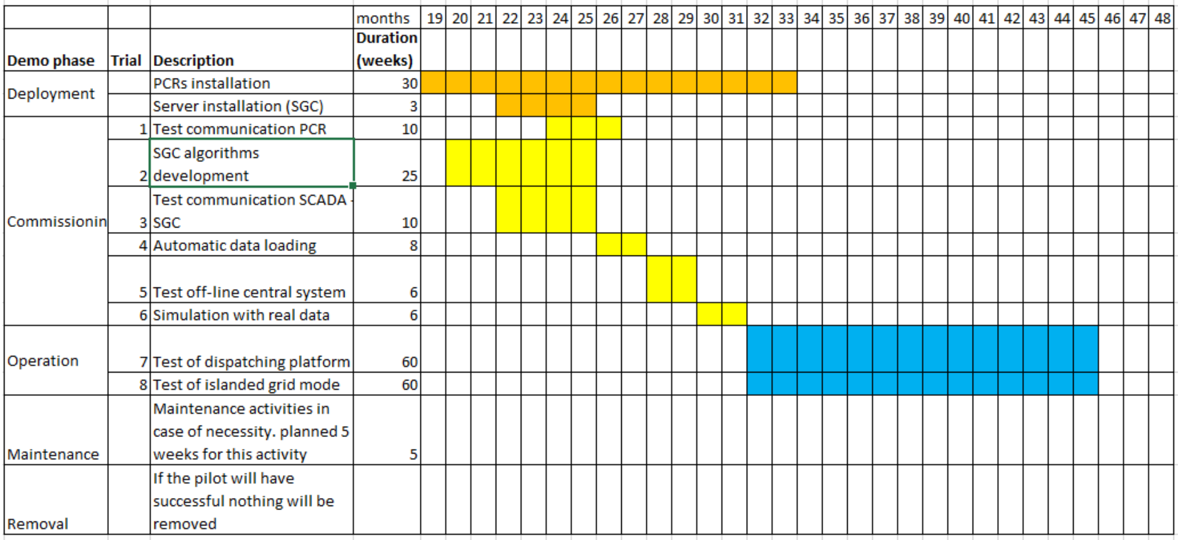


Figure 16 Italian Pilot timeline

Risk registry

In order to be able to keep track of the risks and carefully organise any contingency plans that might be needed during the trials' deployment, a risk registry has been created and is presented in Table 55.

The probability and impact ranking of each risk is in reverse order (with 1 being the highest and 3 being the lowest in terms of severity).

Table 55 Risk registry for the Italian demo site

#	Risk description	Impact description	Impact	Probability	Mitigation actions and contingency plans
1	Difficulties in accessing to the information available in the grid and the already deployed IEDs due to the lack of communication means	No impact	1	1	Task 2.1 will set the boundary conditions of the four demo-sites in order to avoid future problems when deploying the Use Cases. Additionally, T5.1 will define the needed communications to have access to all the data from field. The deployment of new sensors and IEDs is also envisioned to solve this issue.

#	Risk description	Impact description	Impact	Probability	Mitigation actions and contingency plans
2	Delay in the development of new telecontrol devices (Plant Central Regulators) that are part of FLEXIGRID ER1b	It refers to Italian Demo, UC7 and UC8. The impact is modest and can bring just few months of delay.	1	2	Supply commercially available devices until the final devices are ready to replace. This is planned currently to occur in M28 of the project without affecting the demonstration plan which needs to be finalized on M45
3	Difficulties in real test on field due of the islanded grid operation	For Italian Demo and UC8. We refer to the equipment involved in the island mode grid operation, the system in general. The problem is generated by the difficulties in the coordination with all the electrical users involved.	2	2	The dispatching platform (Italian Demo - UC7) will be equipped by the simulation tools, with the purpose to simulate the real operation, considering dynamics of the grid; if so, no control actions could send to real grid and then no problem in quality of service will create.
4	Public interfaces providing means to control hardware in production systems could expose undetected vulnerabilities and ease cyber-attacks.	A remote malicious user with the ability to control real grid operations could lead to catastrophic results.	1	1	The software modules able to control the real grid will be tested locally on the pilot. Both the inputs and the outputs will be successively stored within the cloud and interconnected with FUSE to enable data visualization and KPI estimations.

#	Risk description	Impact description	Impact	Probability	Mitigation actions and contingency plans
5	Difficulties in accessing to the information available in the grid and the already deployed IEDs due to the lack of communication means	No impact	1	1	Task 2.1 will set the boundary conditions of the four demo-sites in order to avoid future problems when deploying the Use Cases. Additionally, T5.1 will define the needed communications to have access to all the data from field. The deployment of new sensors and IEDs is also envisioned to solve this issue.

4. NEXT STEPS

This work summarized the deployment plan for the four demo-sites of FLEXIGRID project which are used to prove the feasibility and interoperability of the solutions developed within the project. The present report includes a monitoring plan to gather the data during the demonstration campaign which consists of the deployment, commissioning, operation, maintenance, and removal strategies for each one of the demo sites.

This report sets the foundation for the reporting of the detailed design, modelling, engineering and development of the Use Cases that will be implemented in the four demo sites and will be carried out within tasks 6.2 to 6.5.

During the operation phase, in each demo site, all relevant actions will be logged while the performance of the monitoring system will be periodically checked to assess that the defined KPIs are being measured in the expected way. Moreover, any corrective measure required to amend any low performance will be applied to ensure that the demonstration objectives are fulfilled. The KPIs defined in task 2.3 will be measured at the beginning and at the end of the demonstration phase by the Use Cases supervisors and Demo-sites coordinators to assess the impacts achieved by using the FLEXIGRID technologies and services in the four Demo-sites, while providing feedback for its final improvement.

At the end of these tasks, Use Cases supervisors and Demo-site coordinators will provide their feedback and main conclusions regarding the implementation of the different solutions in the Demo-Sites. The impacts of each real pilot implementation will be assessed, measuring in particular the achieved improvement of the predictions, the resilience, and the flexibility of the solutions tested within FLEXIGRID. This evaluation will be carried out within task 6.6 and the impact assessment will be reported in D6.14.