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HEDGE-IoT

Holistic approach towards Empowerment of the Digitalization of the Energy Ecosystem through adoption of IoT solutions

D5.2
Pre-Demo Phase Report

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EXECUTIVE SUMMARY

HEDGE-IoT (Holistic Energy Decentralized Grid for Enhanced IoT) is a project, funded by the European Union's Horizon Europe research and innovation program, that proposes a novel digital framework to explore the intrinsic data value of the energy grid, by deploying IoT assets at different levels of the energy system, from behind-the-meter, up to the Distribution System Operator (DSO) and Transmission System Operator (TSO) level. By deploying these assets, this novel framework positions itself to add intelligence to the edge and cloud layers through advanced AI/ML tools and ensures a cloud/edge continuum by introducing federated and decentralised applications governed by an advanced swarm-based computational orchestration framework. The project will be demonstrated in 6 different countries through pilot sites.

Building on the foundation established in Deliverable D5.1, "Guidelines for Demo Preparation," this report, D5.2, documents the tangible progress and preliminary results from the project's first evaluation cycle (M16–M18).

To ensure consistency and comparability, progress across all pilots is documented using a harmonised reporting template. This framework systematically captures demo-specific inputs on infrastructure readiness, data availability, System Use Case (SUC) implementation status, and progress against Key Performance Indicators (KPIs), providing an accurate and comprehensive snapshot of each demo's capability at this stage.

During this Pre-Demo Phase, the demonstration sites translated plans into tangible actions and preliminary results:

- In **Finland**, the demo infrastructure for next-generation grid automation was advanced by installing Intelligent Electronic Devices (IEDs) that provide real-time data via the IEC 61850 standard, with a preliminary version of a new Hybrid Long Short-Term Memory (HLSTM) algorithm for anomaly detection tested on an edge server.
- The **Greek** demo successfully implemented and tested an end-to-end workflow for local flexibility markets. This included deploying a network of edge-IoT devices in households, validating highly accurate forecasting modules (achieving R^2 scores of 0.77 for demand and 0.89 for production), and operationalising an RL-based dispatch optimisation engine that demonstrated its effectiveness by formulating profitable bids (e.g., achieving an 8.00 kWh energy reduction for just an 8-cent incentive). A key innovation was the development of a Non-Intrusive Load Monitoring (NILM) service that dramatically improved appliance detection accuracy, with the F1-score for dishwashers, for example, leaping from 0.21 to 0.97.
- The **Italian** demo focused on digitalising Energy Communities, testing its ECP Platform with integrated market data and blockchain-based measurement notarisation, and training forecasting models on a dataset of approximately 6,000 customers.

- In the **Netherlands**, significant progress was made on interoperability by deploying a Semantic Interoperability Framework (SIF) to successfully integrate diverse energy assets, including DSO grid meters, PV panels, and EV chargers, with data visualised on smart dashboards.
- The **Portuguese** demo deployed its "EdgeConnect" digital platform and conducted lab tests integrating residential assets with a Home Energy Management System (HEMS), while also beginning the adaptation process for TSO market interoperability based on the IEC 62325 standard.
- The **Slovenian** demo successfully validated in a lab environment that an IoT device can host a Dynamic Thermal Rating (DTR) algorithm at the edge and developed preliminary ML algorithms for anomaly detection and demand forecasting using representative test data.

The Pre-Demo achievements set the stage for the project’s next milestones. This report lays a solid, evidence-based foundation for the project's upcoming Full Demo Phase (M19 – M30), where each pilot will scale up device counts, run the latest WP 3 service release (D3.4), and document results in its demo-specific report series (D5.3–D5.8).

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ABBREVIATIONS

Abbreviation	Explanation
AI	Artificial Intelligence
API	Application programming interface
BMS	Building Management System
BUC	Business Use Case
CM	Congestion Management
DER	Distributed Energy Resource
DoEAP	Digitalisation of Energy Action Plan
DSO	Distribution System Operation
DTR	Dynamic Thermal Rating
EC	Energy Community
EDC	Eclipse Dataspace Connector
EMS	Energy Management System
EV	Electric Vehicle
FL	Federated Learning
HEMS	Home Energy Management Systems
HLSTM	Hybrid Long Short-Term Memory
IED	Intelligent Electronic Device
IoT	Internet of Things
KPI	Key Performance Indicator
LFM	Local Flexibility Platform
LV	Low Voltage

MQTT	Message Queuing Telemetry Transport
MV	Medium Voltage
PGUI	Power Grid User Interface
QoS	Quality of Service
RES	Renewable Energy Source
RL	Reinforcement Learning
SAREF	Smart Applications REFerence
SCADA	Supervisory Control and Data Acquisition
SIF	Semantic Interoperability Framework
TSO	Transmission System Operator
UI	User Interface

1 INTRODUCTION

1.1 ABOUT THIS DOCUMENT

This document, Deliverable D5.2 – Pre-Demo Phase Report, is part of Work Package 5 (WP5 – Demonstration across Technologies and Scenarios) of the HEDGE-IoT project. It captures the implementation status, infrastructure readiness, and operational progress of each demo site during the project's first evaluation cycle (M16–M18), also known as the Pre-Demo Phase.

D5.2 aims to serve as a reporting platform for all demos, displaying the current deployment status of each demo in relation to the scenarios, system use cases implementation, milestones achieved, and goals established in previous project stages. Doing this ensures that design and deployment activities are in sync, providing the foundation for tracking implementation maturity throughout the HEDGE-IoT project's iterative phases. In particular, this document draws on the deployment planning and baseline setup described in D5.1 - Guidelines for Demo Preparation and integrates feedback and inputs from key technical work packages, notably WP2 - Stakeholders Requirements and System Specifications, WP3-Technological Enablers Specification, Design, and Development. At the same time, the outcomes of this deliverable directly inform the impact, outreach, and replication scalability envisaged in WP6.

This document and its insights also lay the groundwork for subsequent deliverables that will report on the Full Demo and Large-Scale Operation phases, thereby ensuring consistent and comparable progress reporting throughout the project timeline.

1.2 STRUCTURE OF THE DOCUMENT

Chapter 1, provides the context, purpose, and structure of the deliverable, explaining how it fits within the broader objectives of WP5 – Demonstration Across Technologies and Scenarios and the HEDGE-IoT project.

Chapter 2, introduces the harmonised reporting template used to collect and structure inputs from each demonstration site, ensuring consistency for current and future evaluation cycles.

Chapter 3, presents a detailed, demo-by-demo account of the activities undertaken, including infrastructure readiness, SUC implementation, and early-stage testing results.

Chapter 4 provides a cross-cutting operational, technical, and risk assessment based on the collected inputs from all six demonstration sites.

Chapter 5, summarises the key findings of the Pre-Demo Phase and outlines the expectations and next steps for the upcoming Full Demo Phase.

1.3 CONNECTION WITH OTHER WORK PACKAGES

Deliverable D5.2 is interconnected with the activities and outputs of the project's technical and analytical work packages. It serves as a bridge between the foundational specifications and developed technologies that are first validated against a real-world demonstration environment. The following table summarises D5.2's interactions with the project's major technical and analytical work packages. For each WP, Table 1 describes the dependency and specifies how this report contributes to or is informed by its activities.

TABLE 1: INTERDEPENDENCIES BETWEEN THE PRE-DEMO PHASE REPORT AND OTHER WORK PACKAGES

Work Package	Nature of inter-dependency
WP2 – Stakeholder Requirements & System Specifications	WP2 identifies stakeholder needs and produces the functional specifications and Reference Architecture that guide demo deployment.
WP3 – Technological Enablers	WP3 delivers the AI/ML micro-services and edge libraries used in forecasting, optimisation, anomaly detection and DTR/DLR – the technical edge and cloud innovations to be deployed in the demonstrators.
WP4 – Digital Interoperability Framework	WP4's IDS middleware and data-space connectors enable cross-pilot data exchange; D5.2 reports real-world integration, performance and security findings that guide the full framework update in D4.2/D4.3.
WP6 – Impact, Replication & Digitalisation of Energy Action Plan	D5.2 supplies the first evidence-based KPI baselines and user-engagement figures that WP 6 will use to quantify impact, assess replicability and draft the project's contribution to the Digitalization of Energy Action Plan.

2 METHODOLOGY

Deliverable D5.1 – Guidelines for Demo Preparation laid the groundwork for organising the pilot activities of the HEDGE-IoT project. It defined the technical components to be deployed at each demonstration site, mapped the System Use Cases (SUCs) to be addressed, identified the associated Key Performance Indicators (KPIs), and presented the initial deployment plans. Through this, D5.1 created a common baseline, linking each pilot to the technical developments in WP3 and aligning them with the use case scenarios developed in WP2.

Building directly on this foundation, Deliverable D5.2 – Pre-Demo Phase Report captures the implementation status and operational progress of each demo during the project's first evaluation cycle (M16–M18). This reporting phase serves to validate the initial plans from D5.1 against real-world activities, providing early insight into technical readiness, service deployment, and stakeholder engagement.

The HEDGE-IoT project follows a phased implementation framework moving from design and specification to pre-demo deployment, full demo execution, and eventual impact evaluation. Within this structure, D5.2 acts as a checkpoint, ensuring continuity between planning and implementation, and preparing the ground for subsequent assessments (D5.3–D5.10).

To systematically monitor and report the progress across all demos, a **harmonised reporting template** was developed and distributed to partners as reported on deliverable D5.1 – Guidelines for Demo Preparation (available also in APPENDIX I). This template was designed to serve two key purposes:

- **Vertical traceability** – tracking progress at the level of each System Use Case (SUC), including service readiness, deployment and implementation steps, and risk identification.
- **Horizontal consistency** – enabling comparison across demos and aligning individual pilot efforts with common WP3 services and technical deliverables.

The template ensures structured, consistent input from all demo sites. It reflects each demo's real-world execution status and provides a shared reference point for future evaluation cycles. The resulting reporting framework consists of four main content sections:

- Pre-Demo Phase Activities Summary
- Infrastructure, Assets and Data Availability
- Pre-Demo Results (including SUC implementation and milestone tracking)
- Pre-Demo Evaluation (requirements and KPI progress)

Starting with the **Pre-Demo Activities Summary**, this section captures a high-level overview of the activities conducted during the Pre-Demo Phase. It serves as a bridge between planning (D5.1) and execution, allowing each demo to describe its progress with respect to:

- The preparatory milestones reached (e.g., site setup, partner alignment).
- The WP3 services or components initially tested and/or integrated within the demo activities.
- The stakeholders engaged during this phase.

Subsequently and given that a successful IoT-enabled demonstration depends heavily on the availability of physical and digital infrastructure, the Infrastructure, Assets and Data Availability section has been structured around two core aspects:

- **Assets and infrastructure**: Describing the key systems (e.g., edge nodes, sensors, control interfaces) deployed or planned at this stage. The asset table captures deployment level, function, and current usage.
- **Data availability**: Documenting the datasets already being collected, simulated, or prepared for use during the pre-demo phase.

This overview provides context for interpreting the rest of the technical and operational details of the demo's progress. After establishing the summary of the pre-demo phase activities and the physical and cyber assets included within each demo and addressed during the pre-demo phase, the pre-demo results are then presented where the focus is placed on the concrete actions and integration efforts made for each SUC of each demo during the aforementioned period. Each SUC is described through a structured table covering four sections:

- **Overview Section**: The Overview subsection provides a concise overview of each System Use Case (SUC) as implemented during the Pre-Demo Phase. It begins with the SUC Summary, which explains the use case's purpose and operational objective within the demo context, ensuring clarity on what the SUC is designed to achieve. The Target(s) field identifies the functional or technical targets set explicitly for the current evaluation cycle (M16–M18), allowing for a focused check on the pre-demo goals. The Expected Milestones draw from D5.1 and highlight key technical accomplishments that were anticipated by this phase. The Actions Implemented field summarises the actual work completed to date — including design, development, integration, or testing — helping to present declared progress in real technical effort.
- **Requirements Section**: The Requirements subsection captures the foundational conditions that underpin each SUC. The Assumptions field records key operational or contextual conditions that were expected to hold true for the SUC's deployment — for instance, network connectivity, stakeholder availability, or data access. This is essential for interpreting whether any delays are due to invalidated assumptions. Dependencies include both internal and external services, platforms, or components that the SUC relies on. This field supports coordination across demos and WPs by making integration points visible. Risks highlight known technical or organisational challenges that could impede progress.
- **Readiness Section**: The Readiness subsection reflects the technical and operational preparedness of each SUC including deployment diagrams, deployment preparation and deployment assessment. The Deployment Diagram field references the diagrammatic representation of which components are deployed and tested during the Pre-Demo Phase. This helps visualise the scope and boundaries of implementation. Deployment Preparation captures the specific actions taken to configure the demo environment, engage stakeholders, and ensure all prerequisites are met. The Deployment Assessment provides a brief qualitative evaluation of the demo's readiness, summarising progress made, known issues, and how any identified risks are being addressed.
- **Validation Activities Section**: The Validation Activities subsection records the verification actions undertaken to date and their alignment with the planned testing path, including the previous, current and future cycles. The Previous Cycle field (optional) allows demos to report on any early-stage lab or internal testing that occurred before M16. While not

mandatory, this offers additional context on incremental development. The Current Cycle focuses on the main activities undertaken during the official Pre-Demo Phase and reflects how these align with prior planning or recommendations. Finally, the Future Cycle field outlines the next steps for advancing the SUC, including technical extensions, testing plans, or new stakeholder engagement — supporting continuity towards the Full Demo Phase and its corresponding reporting in subsequent deliverables.

Furthermore, the **milestones and progress** are revisited from D5.1 and compared against real progress with the intention to capture:

- Any early completions, delays, or deviations.
- Steps that were partially fulfilled or that transitioned into new schedules.
- SUC-level advancements tracked across months and partner-specific activities.

Lastly, in the **pre-demo evaluation section**, this section complements the activity tracking by evaluating two critical aspects: requirement fulfilment and KPI assessment.

Starting with the requirements evaluation, the requirements initially outlined in D5.1 include updates to the demo's functional, technical, and operational requirements, including acceptance criteria to determine completeness, the indication of the responsible testing partners, and a progress column reporting the progress achieved during the pre-demo phase of each demo, to record whether each requirement has been addressed in practice and at what stage it is at by M18. Moreover, the KPIs to be measured by each demo — with their descriptions, associated SUCs, baselines, and targets — are consolidated into a dedicated table. A new Progress column has been added to reflect the current measurement status at M18.

Moreover, this KPI framework contributes to preparatory work for future tasks, which will evaluate how HEDGE-IoT services align with the **Digitalisation of Energy Action Plan** (**DoEAP**). The early reporting establishes a baseline for the eventual technological, economic, and societal analysis, ensuring that the impact assessment is grounded in real-world demonstration activity.

3 EXECUTION ACTIVITIES IN PRE-DEMO PHASE

3.1 DEMO 1 – DEMONSTRATION OF NEXT-GENERATION GRID AUTOMATION WITH IOT AND EDGE/CLOUD DATA TO IMPROVE DISTRIBUTION GRID RESILIENCY [FINLAND]

3.1.1 Pre – Demo Phase Activities Summary

This section presents a structured summary of the activities that the Finnish Demo conducted during the Pre-Demo Phase (M16–M18). It expands upon the demo deployment template introduced in Chapter 2, which functions as a reference for monitoring the development of each demonstrator. The status of the pre-demo targets, the WP3 services utilised, and the key stakeholders involved during this phase are all detailed in Table 2 below. The purpose of the information is to establish the foundation for the Full Demo Phase and to evaluate the operational readiness of the demo at the conclusion of the Pre-Demo Phase.

TABLE 2: DEMO 1 PRE-DEMO PHASE DEPLOYMENT STATUS

Section	Subsection	Description
Summary	Pre-Demo Phase Target	The focus of the pre-demo phase has been to prepare the demo infrastructure for later phases of the project, to start gathering data from the distribution network and to test data transfers between devices. In parallel with the pre-demo phase device installations to the actual pilot area, development and testing for the new algorithms and modules has been ongoing. The new algorithms will be deployed on the field only at later stages of the project.
	Status Summary	During the pre-demo phase, installations of equipment needed in the demonstration have been carried out as depicted in Figure 1. Intelligent electronic devices (IEDs) that provide the measurement data as IEC 61850 sampled values (SV) and status information as Generic Object-Oriented Substation Event (GOOSE) have been made available for the demonstration. Some of the IEDs were replaced by new devices and for some updating the configuration was adequate. The substation switches and some devices on the fiber network were replaced to support the 61850 data transfers. Network clocks were installed to enable remote time synchronisation. Research infrastructure including a switch and edge server was installed at the server room. The edge server will in future host also many of the new algorithms developed as a part of HEDGE-IoT. In parallel to device installations, algorithms and modules needed for the final HEDGE-IoT piloting are being developed and tested. The modules to be implemented realise the technology innovations of the Finnish pilot that include: • Digital platform capabilities for distribution grid automation • Congestion management solution and • Anomaly detection fault forecasting solution. During the pre-demo phase, the modules have been defined in detail and their development and testing has been ongoing. Testing both using simulations and in laboratory environment will continue and the functionalities will be integrated to the piloting area at later phases of the project.
	Services Used (from WP3)	During the pre-demo phase, the development of new services has concentrated mainly on the algorithms running on edge, i.e., service 3.5 Anomaly Detection and Fault Forecasting to Increase Distribution Network Resilience and service 3.6 Real-time Congestion

		Management. Service 4.4 Predictive Congestion Management will be discussed in more detail later. None of the services is fully operational at the actual distribution network piloting area yet. The current version of the edge server includes a version of the anomaly detection algorithm and a running environment for further data processing, which will be used to host one version of fault forecasting functionality.
	Stakeholders involved during Pre-Demo	• ABB is developing digital platform capabilities and has been partially responsible for device procurement and configuration. • Järvi-Suomen Energia is the Distribution System Operator (DSO) at whose network the demonstration takes place and has been the main responsible for pilot area installations. Enerva has also had an important role in the demo area preparations. • VTT is developing the functionality for anomaly detection and fault forecasting. • TAU is developing the congestion management functionality.

In Figure 1, the diagram illustrates the physical setup and functional layout of the first demonstration site of the Finnish pilot, highlighting the components installed and configured during the Pre-Demo Phase.

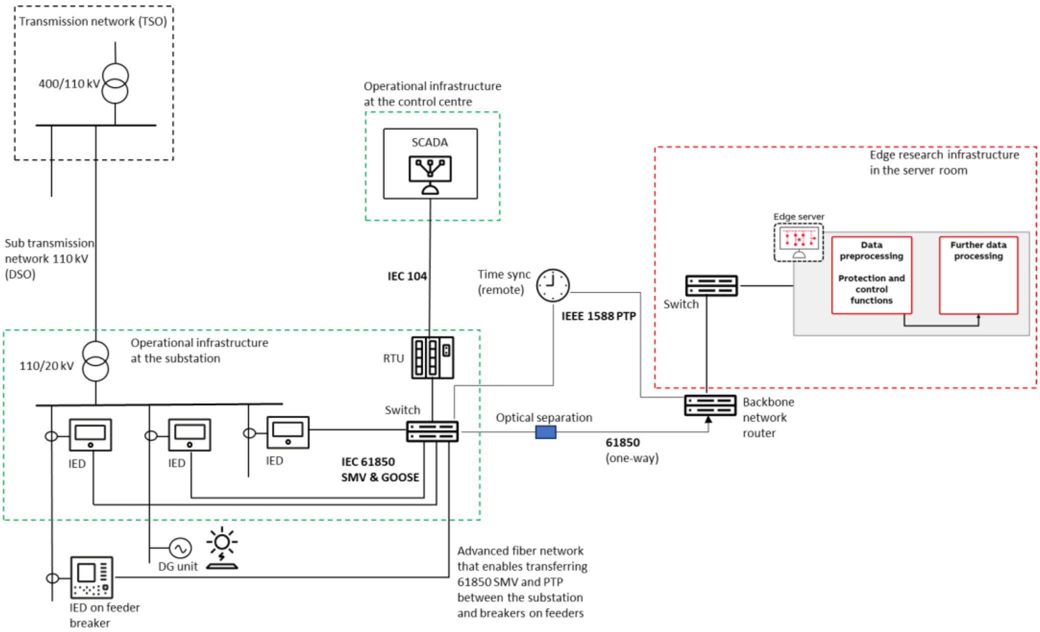

Figure 1. Installations at the first demonstration site during the pre-demo phase.

3.1.2 Infrastructure, Assets and Data Availability

Based, on the demo-deployment template that was introduced in chapter 2, a consolidated snapshot of the infrastructure and assets mobilised during the Pre-Demo Phase is provided in Table 3 for the Finnish demo. Each asset is accompanied by its technical description, deployment level, use status in months 16–18, and the WP 3 service to which it pertains.

TABLE 3: SUMMARY OF FINNISH DEMO INFRASTRUCTURE AND ASSETS DEPLOYED DURING THE PRE-DEMO PHASE

Asset	Description	Deployment Level	Used during Pre-demo	Under which WP3 service

Edge server	Server that runs all the HEDGE-IoT edge applications	Installed with limited functionality	**Yes**	Services 3.5 and 3.6 will eventually be deployed on the edge server
SSC600 SW	Virtualised centralised protection	Installed and configured	**Yes**	Includes a version of anomaly detection function and provides input data to the running environment for further data processing (disturbance recordings and events) which are related to service 3.5
Real-time data link (in D5.1 was called SSC600 SW with HEDGE-IoT extensions)	Platform capabilities for sharing pre-processed data to other applications	Under development	Partly, only on development environment	Services 3.5 and 3.6 will eventually utilise data provided through this
KVM	Virtualisation environment	Installed	**Yes**	Part of the edge server configuration
Docker	Containers for different HEDGE-IoT applications	Utilised as a part of the development environment	Partly, only on development environment	Part of the edge server configuration
Real-time congestion management solution	Application that includes real-time state estimation and congestion management functionalities	Under development	Partly, only on development environment	Service 3.6
Anomaly detector	SSC600 SW function that triggers disturbance recordings	Installed	**Yes**	Service 3.5
Anomaly detection and fault forecasting solution	Application that detects anomalies in measurement data, calculates indicators, triggers the disturbance recorder and provides early warnings	Under development	Partly, only on development environment	Service 3.5
Hirschmann RSP-30	Research infrastructure switch	Installed	**Yes**	Mandatory part of the demo setup, required by all services

Fiber diode	Fiber diode that allows traffic from the operational infra towards the research infra but not to the other direction	Installed	**Yes**	Mandatory part of the demo setup, required by all services
ABB CogniEN EDGE	Fault forecasting solution that operates based on disturbance recordings triggered by anomaly detection functionalities	Installed	Partly, collects data, fault forecasting functionality not verified yet in the real environment	Service 3.5
REX640 relays	Operational relays at Anttola and Hirvensalmi substations	Established, configurations updated	**Yes**	Used by all services related to Finnish pilot
REX615 relays	Operational relays at the breakers on feeders	Installed and configured	**Yes**	Used by all services related to Finnish pilot
Fiber converters	Fiber converters at the feeder breakers	Installed	**Yes**	Mandatory part of the demo setup, required by all services
Fiber communication network	Fiber communication network between control centre, substations and feeder breakers	Established	**Yes**	Used by all services related to Finnish pilot
Substation switches	Substation switches that support PTP and SV	Installed	**Yes**	Mandatory part of the demo setup, required by all services
Relay network switches	Relay network switches that support PTP and SV	Installed	**Yes**	Mandatory part of the demo setup, required by all services
Nokia 7705 SAR AX	Service aggregation routers	Installed (partly established)	**Yes**	Mandatory part of the demo setup, required by all services
GPS antenna	GPS antennas that enable the SARs to	Installed	**Yes**	Mandatory part of the demo setup, required by all services

	operate as PTP masters			
GPS overvoltage protection	GPS overvoltage protection	Installed	**Yes**	Mandatory part of the demo setup, required by all services
Smart meter	All grid customers have smart meters	Established	**Yes**	Services 3.6 and 4.4

Table 4 summarises the datasets relevant to the Pre-Demo Phase, indicating their availability, whether they were used during this period and their linkage to the corresponding WP3 technological enablers.

TABLE 4: OVERVIEW OF DATASETS RELEVANT TO THE PRE-DEMO PHASE OF THE FINNISH DEMO

Data Description	Used during Pre-Demo Phase	Under which WP3 service
Current measurements from all pilot area substation bays	Available from some pilot area substation bays but not all	Will be used by all services related to Finnish pilot
Voltage measurements from all pilot area substation bays	Available from some pilot area substation bays but not all	Will be used by all services related to Finnish pilot
Current measurements from breakers at feeders	Available from some breakers at feeders but not all	Will be used by all services related to Finnish pilot
Current measurements from breakers at feeders	Available from some breakers at feeders but not all	Will be used by all services related to Finnish pilot
Breaker statuses for devices at substations and on feeders	Available from some devices but not all	Will be used by all services related to Finnish pilot
Disturbance recordings triggered by anomaly detection algorithm(s)	Partly available	Service 3.5
Smart meter measurement data	Available for all customers connected on the piloting area	Services 3.6 and 4.4

3.1.3 Pre-Demo Results

This section captures the status and progress of System Use Case (SUC) implementation during the Pre-Demo Phase (M16–M18) for the Finnish Demo. For each SUC, key developments are outlined, including the specific actions undertaken, intermediate achievements, and alignment with the expected implementation steps and scenarios described in D2.2. In addition, the internal milestones defined in D5.1 are revisited and assessed in terms of progress and completion. This structured overview offers insight into the readiness and maturity of each SUC ahead of the upcoming demonstration cycles.

3.1.3.1 SUCs Implementation

This subsection presents the implementation progress of each System Use Case (SUC) as defined in D2.2 for the Finnish Demo, highlighting the actions carried out during the Pre-Demo Phase.

SUC-FL-01.01 & SUC-FL-01.02 ANOMALY DETECTION AND FAULT FORECASTING

Section	Subsection	Description
Overview	SUC Summary	The SUC-FI-01.1 and SUC-FI-01.2 represent anomaly detection and fault forecasting. UCs will result in detecting anomalies and forecast faults in the medium voltage electrical distribution networks, to enhance the resilience and reliability of the entire grid.
	Target(s)	Data analysis and validation
	Expected UC Milestones	First versions of new algorithm ready for lab testing
	Actions implemented	In the Hybrid Long Short-Term Memory (HLSTM) Algorithm, following new functions have been added. - Detect anomalies - Create sequences - Save_anomalies_to_csv - Build_and_train_model - Evaluate model
Requirements	Assumptions	- Hardware resources are maintained at a high utilisation level, ensuring that no crashes or significant slowdowns occur under a large dataset load. - Fault events in the dataset are precisely labeled (timestamped) and validated, ensuring that no mislabeled or ambiguous entries are present. - The operating systems running the HLSTM model have similar specifications as in the pilot systems.
	Dependencies	No dependencies
	Risks	- Difficulty in reproducing precise results when algorithms keep frequently changing on demand - Data versioning inconsistencies in training/validation biasing model outcomes - Unsupported libraries or dependencies in the operating system, e.g., missing tools, drivers, etc.
Readiness	Deployment diagram	The deployment diagrams for SUC-FL-01.01 & SUC-FL-01.02 are presented in Figure 2 and Figure 3 below for clarity.

	Deployment preparation	- Procuring server for VTT lab environment - Operating system installation - Software tools installation - Setup RTDS in the Lab
	Deployment assessment	Development of the algorithm has been ongoing. Data has been received from the pilot system for use in training the modules. More data sets are currently received and processed to support the work. Further work and preparation of the server environment are still required to proceed with the evaluation. One key risk is that development is currently based on offline datasets, and the online live data stream has not yet been tested. The mitigation involves using recorded datasets in a manner as similar as possible to the real-time stream.
Validation Activities Summary	Previous cycle	n/a
	Current cycle	Several functions have been designed and integrated in the algorithm to improve its latency and prediction performance on small scale datasets.
	Future cycle	- Installing simulation tools on server - System model for RTDS generating data streaming. - Pipelining server and RTDS. - Providing input to the HLSTM model for analysis.

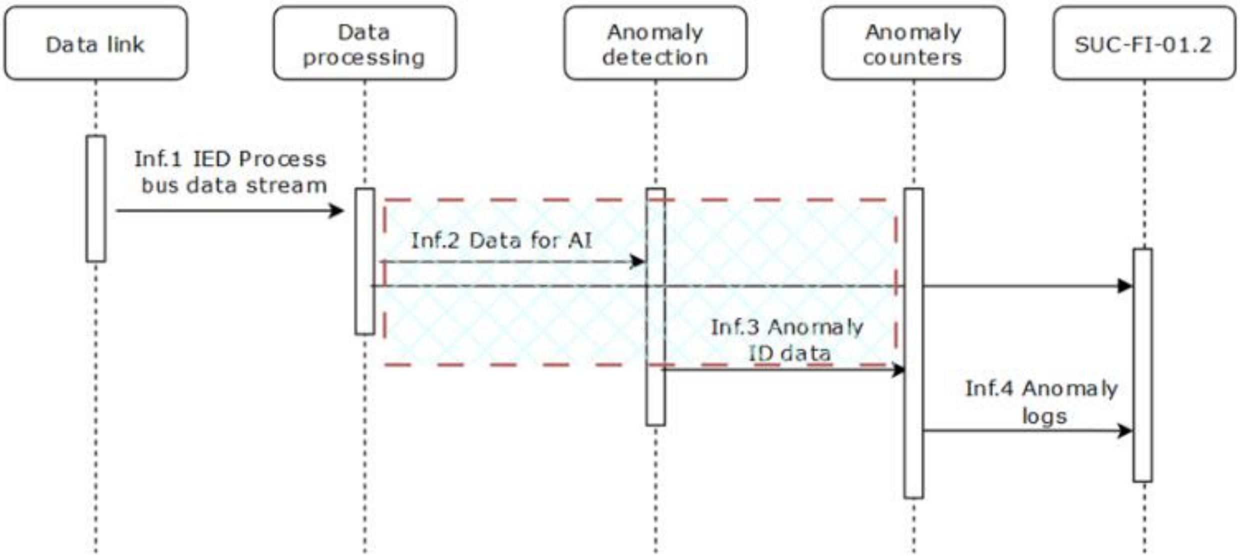

FIGURE 2: SEQUENCE DIAGRAM OF SUC-FI-01. 1(ONGOING PROGRESS)

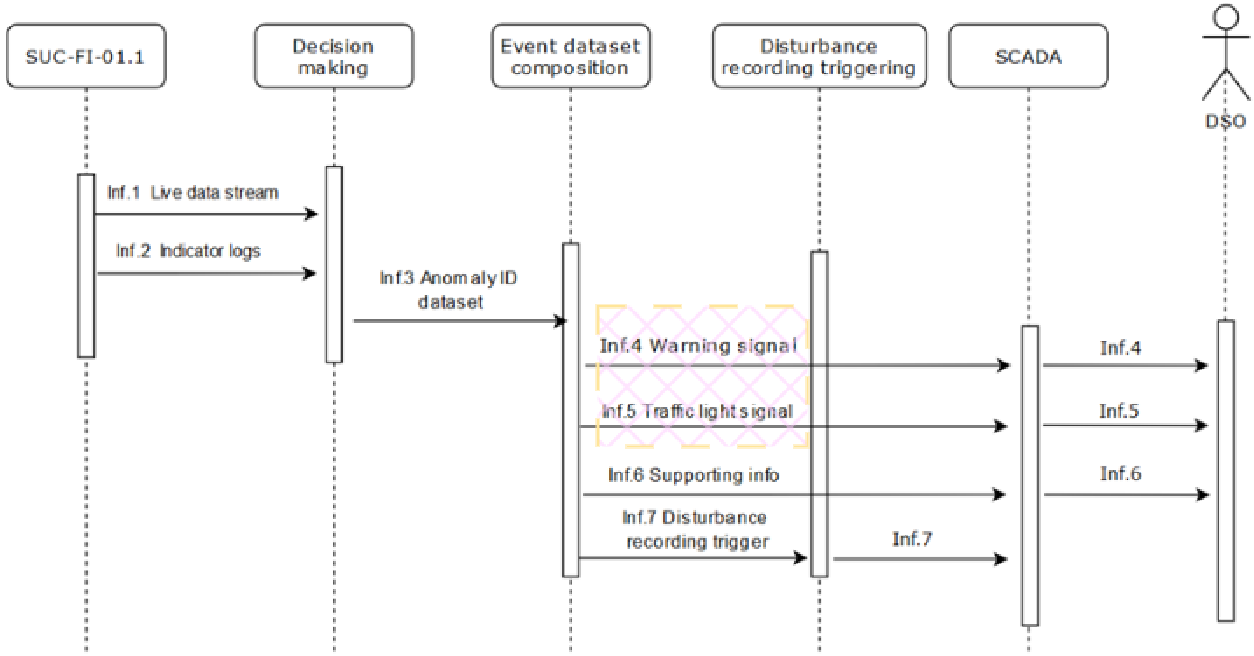

FIGURE 3: SEQUENCE DIAGRAM OF SUC-FI-01. 2 (ONGOING PROGRESS)

The activities undertaken for the above System Use Cases (SUCs) during the Pre-Demo Phase are supported by the deployment of the **Hybrid Long Short-Term Memory (HLSTM) algorithm**, which serves as the key enabling service for predictive anomaly detection.

The Finnish pilot created and tested the first version (v1) of a Hybrid Long Short-Term Memory (HLSTM) algorithm for predictive condition monitoring during the Pre-Demo Phase. The algorithm was developed to identify and classify patterns in electrical time-series data (such as current and voltage measurements) and forecast potential system issues based on historical patterns.

The key functionalities implemented include the anomaly detection across multiple measurement channels, visualisation of detected anomalies over time, and automated result storage.

To improve usability and operator awareness, a visual interface was also tested, utilising a color-coded "traffic light" system (green, yellow, and red) to indicate the severity of detected anomalies. While this prototype system was validated in a controlled environment, real-world deployment and large-scale testing will follow in the next project phase, during which the algorithm will be further optimised for handling real-time data streams and larger datasets.

SUC-FL-02.01 & SUC-FL-02.02 PREDICTIVE CM ON THE CLOUD

Section	Subsection	Input
Overview	SUC Summary	**SUC-FI-02.01** & **SUC-FI-02.02** Predictive CM on the cloud. UCs will result in predicting grid state variables, and in case of congestion expectation, perform CM decision making to remove congestion for example by procuring flexibility from local flexibility market (LFM).
	Target(s)	**Dataset harmonisation, validation, and analysis including:**

		• Finalisation of grid data harmonisation and validation. • Finalisation of load data validation. • Finalisation of load profiling (necessary for state estimation). • Performing grid analysis by putting together the validated load and grid data.
	Expected UC Milestones	• Dataset harmonisation, validation, and analysis. (completed) • Setting up the cloud server and run a message broker for exchanging data between components. (has not started yet) • Fetch electricity and weather data from Finnish meteorological institute (FMI) and ENTSOE transparency platform respectively. (has not started yet)
	Actions implemented	**Specific developments of the current cycle (common with SUC-FI-02.03 & SUC-FI-02.04) are:** • Demonstration grid's data has been migrated from the QGIS software (used by Järvi-suomen Energia) to MATLAB to model it based on state estimation needs (PTI format). • The missing data of grid components in QGIS (e.g., transformer impedances, cable impedances) has been found from component's documentations and added to the grid data model. • The grid data has been validated meaning that grid components are modelled correctly. • Historical load data (hourly resolution) has been collected and aggregated (secondary substation level) from smart meters in the demonstration area from 2022 to 2024. • Historical generation data (hourly resolution) has been collected from their measurement devices from 2022 to 2024. • Individual load profiles, which can be used for load estimation and forecasting, were calculated for secondary substations, taking into account the time of day, calendar data, and outdoor temperature. These profiles model hourly substation loads and their variance over the coming year. • Load and grid data have been associated with each other, and a grid analysis has been done to evaluate the state of the grid in previous years of grid operation (e.g., 2022, 2023, 2024).
Requirements	Assumptions	Procuring flexibility from the market is possible though simulated LFM (and maybe through real LFM through open call mechanism). Flexibility will be available from DER units to be procured and controlled. EDC allows for data exchange between CM on cloud and edge.

	Dependencies	The service will interact with CM on the edge (SUC-FI-02.01 & SUC-FI-02.02) through Eclipse data space connector (EDC).
	Risks	• Limited availability of DER flexibility to procure and activate. • As (SUC-FI-02.03 & SUC-FI-02.04) will be piloted and (SUC-FI-02.01 & SUC-FI-02.02) will be simulated, the piloting takes more time than expected affecting how much efforts can be allocated to simulated parts. The primary focus will be on piloting the solutions.
Readiness	Deployment diagram	*The deployment diagrams for SUC-FL-02.01 & SUC-FL-02.02 are presented in* Figure 4 *and* Figure 5 *below for clarity.*
	Deployment preparation	Requirements: • Server running a VM on the cloud. • Docker and message broker running on VM • Cloud and edge servers are communicating through EDC.
	Deployment assessment	Deployment of infrastructure for realization of **SUC-FI-02.01** & **SUC-FI-02.02** has been delayed. In terms of data set preparation, it has been completed. The designs of components and responsible partner to implement them in cloud to realise those use cases are still in progress that could introduce a risk. Another risk is that the primary focus of the pilot is to realise SUC-FI-02.03 & SUC-FI-02.04, first and that would mean a probable delay for cloud service implementations. One solution is to align the development of CM services on the edge such that those services can also be used on the cloud with some adjustments meaning that cloud services would not need to be developed from scratch.
Validation Activities Summary	Previous cycle	n/a
	Current cycle	The current cycle has progressed in the areas of data set preparation and cloud service architecture design, including subservices. Meetings have been held with Greek and Italian pilots to identify areas of common activity in order to enhance collaboration between pilots for cloud sub-services, such as load forecasting.
	Future cycle	• Setting up the test environment including a VM on the cloud, and message broker. • Publish the static data (grid and load data) to the message broker. • Perform load and generation forecast.

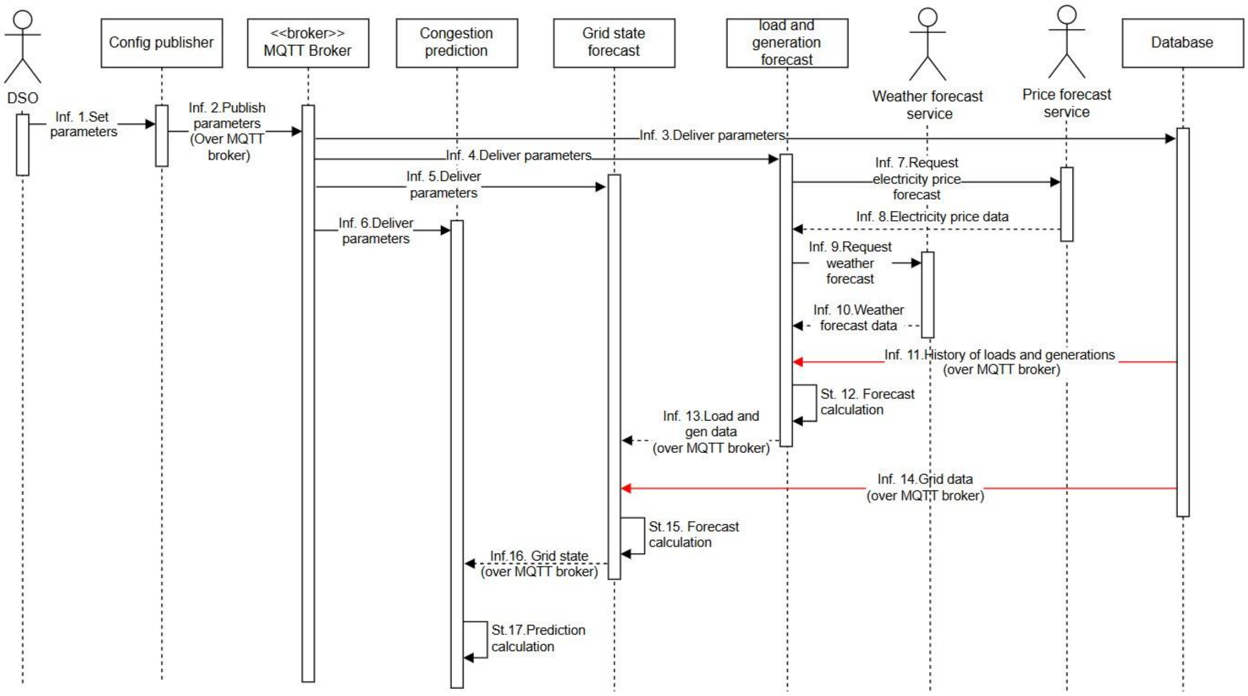

FIGURE 4: SEQUENCE DIAGRAM OF SUC-FI-02.01(ONGOING PROGRESS)

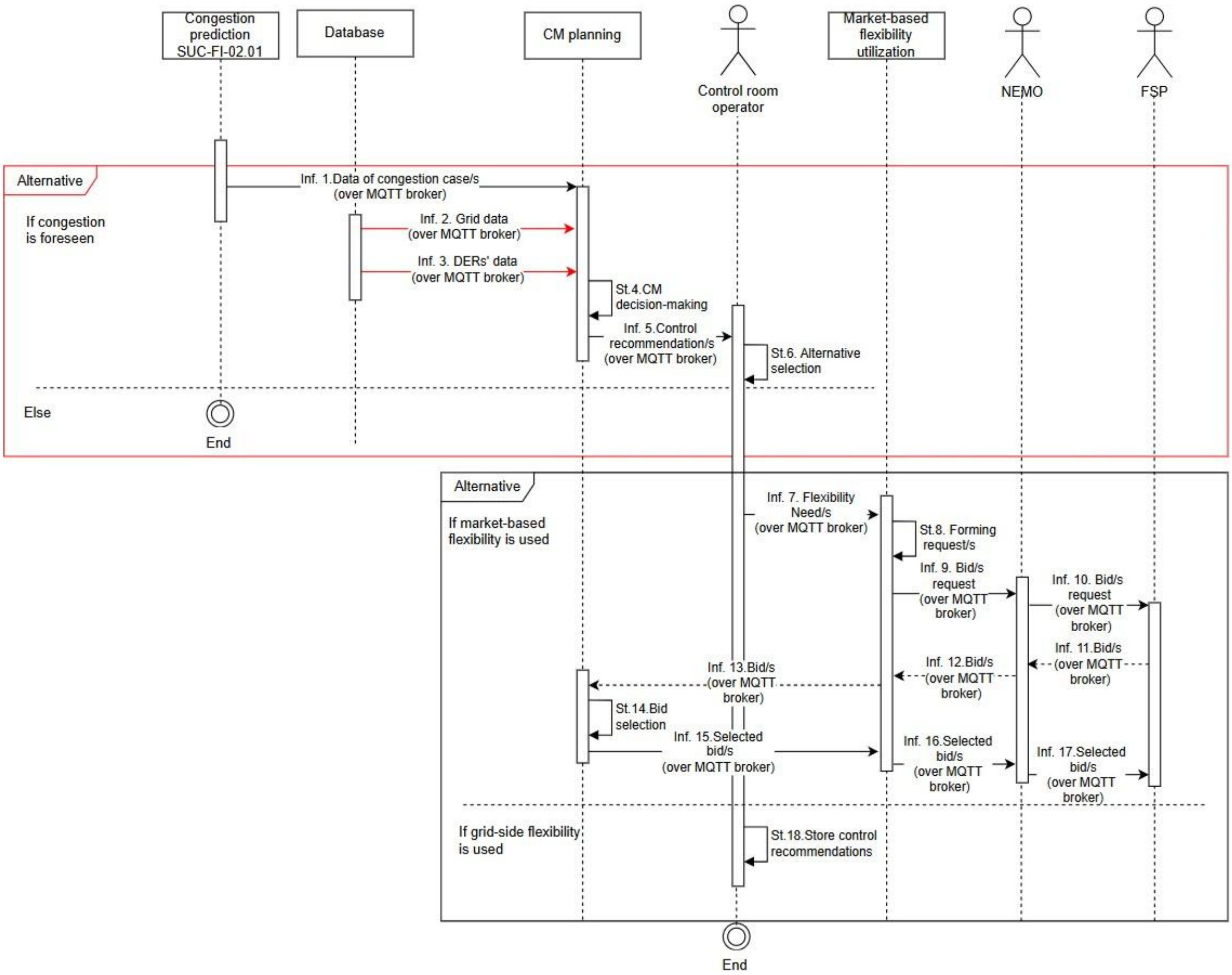

FIGURE 5: SEQUENCE DIAGRAM OF SUC-FI-02.02 (ONGOING PROGRESS)

The actions implemented in the context of **SUC-FI-02.01 and SUC-FI-02.02** have focused on preparing and validating the grid and load data as foundational inputs for congestion management services. As part of input data preparation, an analysis has been conducted to ensure that the grid data has been modelled correctly, while associating the aggregated load data at the secondary substation level with the grid data. The grid that hosts solar installations and hydro power plant shows signs of voltage rise in point of connection to the grid, as shown in the above figure. There is also seasonal voltage variations observed in the grid that are due to strong solar injections to the grid in summer and high heating demand in winter months. This has been an important step before developing algorithms for congestion management SUCs to assure that their input data are correct, paving the way for smother testing of the algorithms.

SUC-FL-02.03 & SUC-FL-02.04 REAL-TIME CONGESTION MANAGEMENT ON THE EDGE

Section	Subsection	Description
Overview	SUC Summary	SUC-FI-02.03 & SUC-FI-02.04 Real-time CM on the edge. The UCs result in estimating grid state variables, and in case of congestion, perform CM decision making to remove it.

	Target(s)	**Dataset harmonisation, validation, and analysis (common with SUC-FI-02.01 & SUC-FI-02.02) including:** • Finalisation of grid data harmonization and validation. • Finalisation of load data validation. • Finalisation of load profiling (necessary for state estimation). • Performing grid analysis by putting together the validated load and grid data. **In addition:** • Start developing the state estimation algorithm under SUC-FI-01.03. • Setting up the test environment at ABB and TAU for edge solutions.
	Expected UC Milestones	• Dataset harmonisation, validation, and analysis. (completed) • Setting up the edge server for testing at TAU and run a message broker for exchanging data between components. (mostly done) • Implement load and generation estimation. (has not started yet) • Agreement on the testing method, location and infrastructure between pilot partners. (done)
	Actions implemented	**Agreeing on a testing method**: The partners have agreed on the method of testing. Testing would have three phases of unit testing, integration testing and system testing. Unit testing and integration testing will be done in isolation by ABB and TAU, and after completion, system testing could be done so that ABB and TAU's systems are connected. The fully tested systems then will be finally migrated to the pilot site. **Agreeing on testing infrastructure and location**: Unit and integration testing could happen at ABB and TAU separately, but system testing will be conducted in ABB's premises. **Implementation of the testing environment:** Building the laboratory testing environments has started. **Algorithm development:** State estimation algorithm development has started. **Specific developments of the current cycle (common with SUC-FI-02.01 & SUC-FI-02.02) are:** • Demonstration grid's data has been migrated from the QGIS software (used by Järvi-Suomen Energia) to MATLAB to model it based on state estimation needs (PTI format). • The missing data of grid components in QGIS (e.g., transformer impedances, cable impedances) has been found from component's documentations and added to the grid data model.

<table>
<tr><td rowspan="4">Requirements</td><td></td><td>The grid data has been validated meaning that grid components are modelled correctly.
Historical load data (hourly resolution) has been collected and aggregated (secondary substation level) from smart meters in the demonstration area from 2022 to 2024.
Historical generation data (hourly resolution) has been collected from their measurement devices from 2022 to 2024.
Individual load profiles, which can be used for load estimation and forecasting, were calculated for secondary substations, taking into account the time of day, calendar data, and outdoor temperature. These profiles model hourly substation loads and their variance over the coming year.
Load and grid data have been associated with each other, and a grid analysis has been done to evaluate the state of the grid in previous years of grid operation (e.g., 2022, 2023, 2024).</td></tr>
<tr><td>Assumptions</td><td>On the edge, the congestion management functionality will be deployed on its own virtual machine or container structure.
Connection between virtual machines/container structures is through MQTT broker allowing TAU to receive real-time measurements from the real-time data link.</td></tr>
<tr><td>Dependencies</td><td>SUC-FI-02.04 is critically dependent on SUC-FI-02.03's results.

The partners developing services in separate virtual machines or container structures allow them to reduce the dependencies during the development stage. In the unit and integration testing, the behavior of functionality developed by other partners can be mocked to minimise its impact on the development and testing.</td></tr>
<tr><td>Risks</td><td>Developing and testing SUC-FI-02.03 is taking longer than expected, which is affecting the integration testing of SUC-FI-02.04. To mitigate that, SUC-FI-02.03's output can be mocked to prevent a delay in development of SUC-FI-02.04. Once both UCs are ready, they are connected in an integration test.

In system testing, different virtual machines (VMs) are not interoperable (e.g., syntax, semantics, and data availability). Exhaustive documentation regarding the interfaces will be created to ensure that all developers adhere to it, thereby mitigating interoperability risks.</td></tr>
<tr><td rowspan="2">Readiness</td><td>Deployment diagram</td><td>The deployment diagrams for SUC-FL-02.03 and SUC-FL-02.04 are presented in Figure 6 and Figure 7 below for clarity.</td></tr>
<tr><td>Deployment preparation</td><td>Server running the needed VMs on the edge.
Docker and message broker running on VMs
Cloud and edge servers communicate through EDC.</td></tr>
</table>

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	Deployment assessment	Deployment of infrastructure for realisation of **SUC-FI-02.03** & **SUC-FI-02.04** has been progressed by setting up a VM on a development environment. However, as the cloud server is not yet deployed, the edge and cloud communication is not yet functional. No risks is identified for the congestion management services on the edge at the moment.
Validation Activities Summary	Previous cycle	n/a
	Current cycle	The current cycle has progressed in the areas of data set preparation, edge service architecture design and subservice design, testing methods, infrastructure, and location. The development of edge services, namely state estimation under **SUC-FI-02.03**, has already begun. For CM decision making under **SUC-FI-02.04**, development is scheduled to start in August 2025.
	Future cycle	With the input data, testing plan, and infrastructure ready, the development of components can begin. The source code development for state estimation related to SUC-FI-02.03 has already begun, and the source code development for real-time CM related to SUC-FI-02.04 is scheduled to start in August 2025. In addition to source code development, documentation for the interfaces required for data exchange within VMs and between VMs must be developed. The documentation will serve as a blueprint for the implementation of the data exchange.

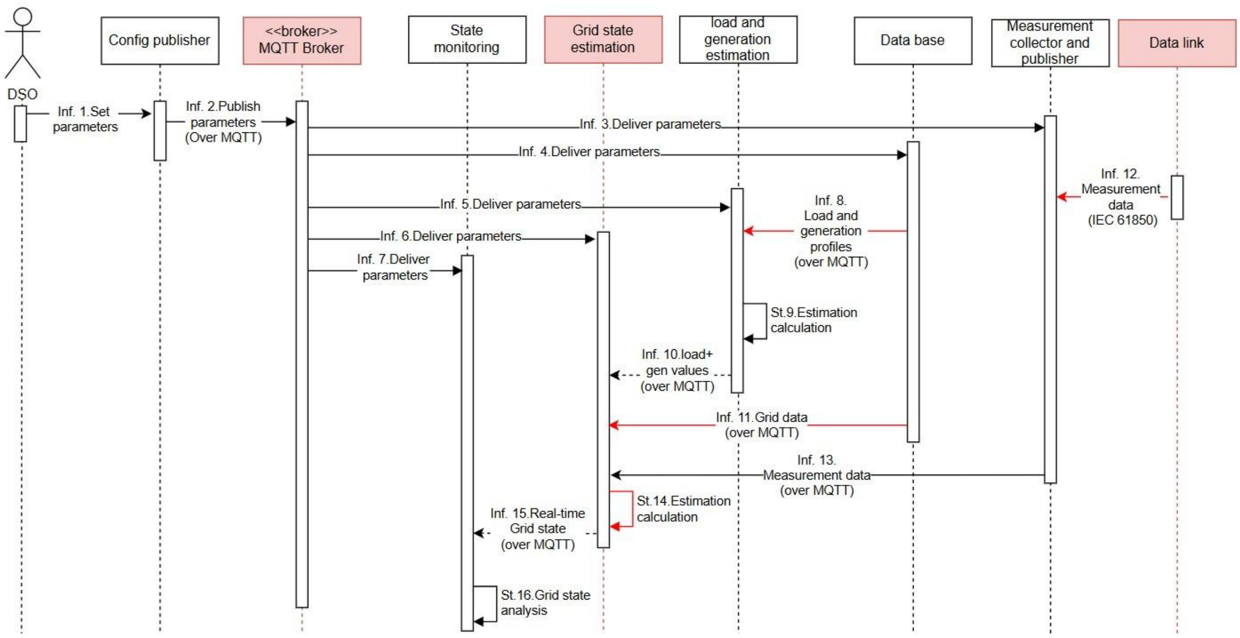

FIGURE 6: SEQUENCE DIAGRAM OF SUC-FI-02.03 (ONGOING PROGRESS)

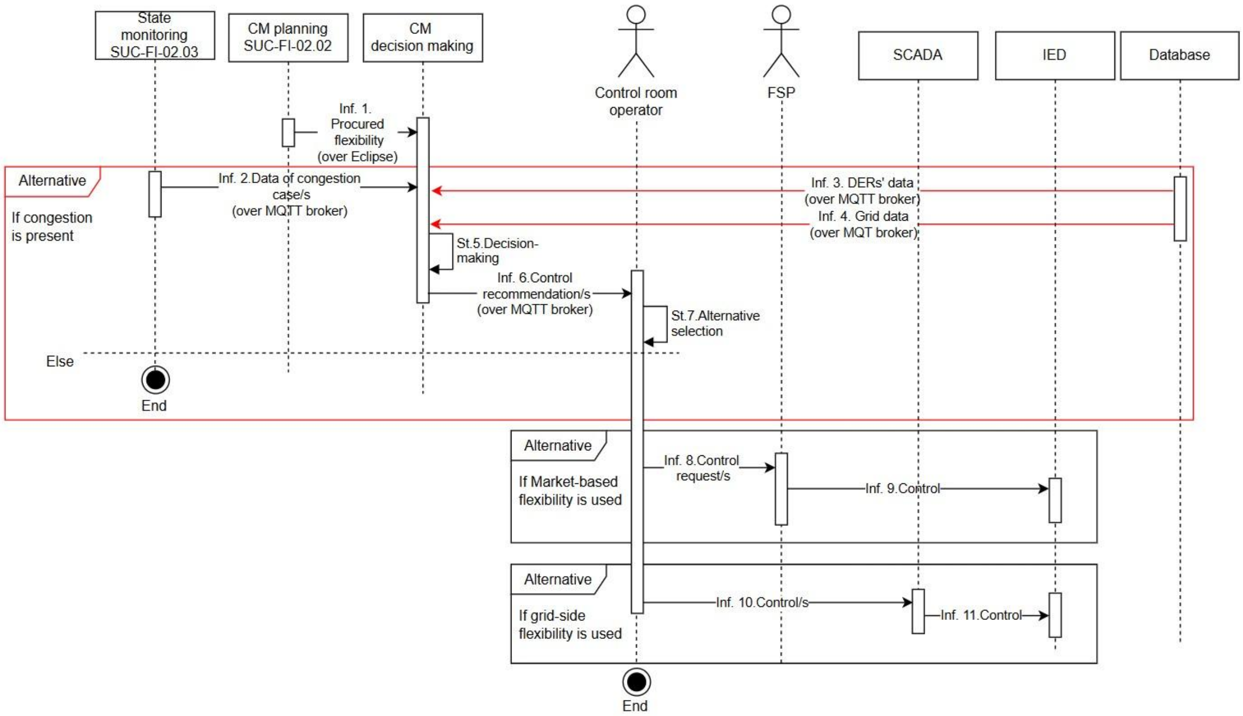

FIGURE 7: SEQUENCE DIAGRAM OF SUC-FI-02.04 (ONGOING PROGRESS)

For CM use cases on the cloud and on the edge, three main steps concerning the data sets have been completed including dataset harmonisation, validation, and analysis. For CM services at the edge, the testing method, infrastructure, and location has been agreed by the pilot partners followed by setting up the test environment at ABB and TAU accordingly. The development of state estimation sub-service within SUC-FI-02.03 has already started which will be followed by the development of real-time CM sub-service within SUC-FI-02.04 starting from August 2025.

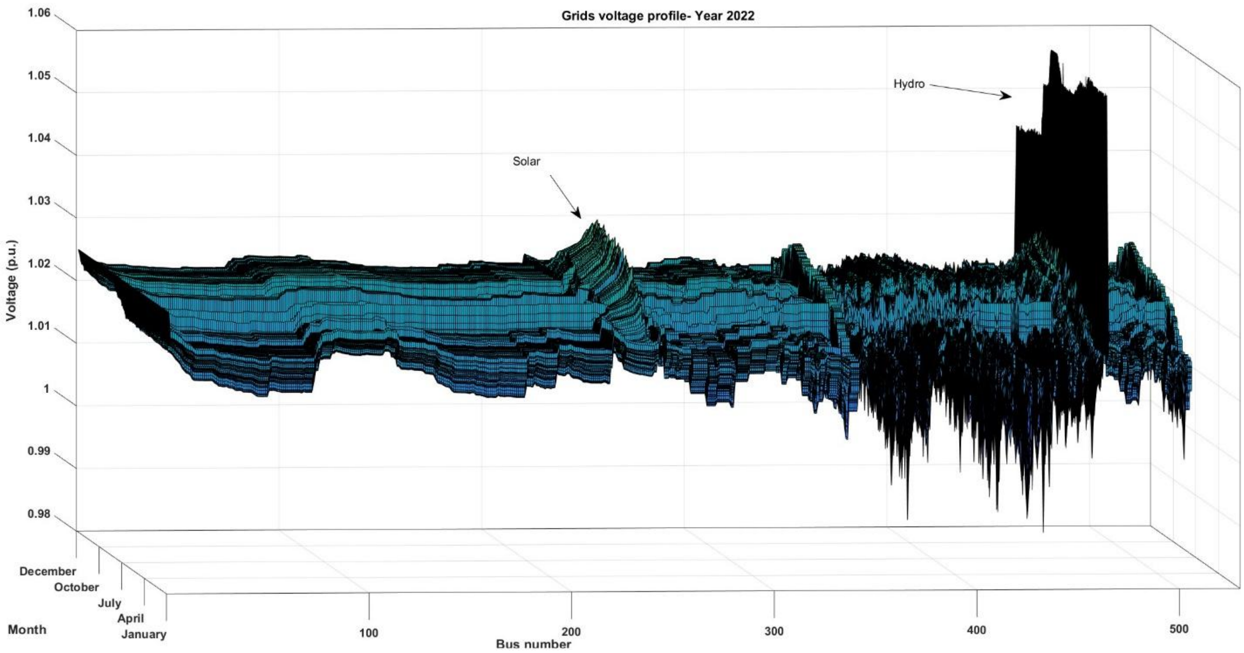

FIGURE 8: THE GRID'S VOLTAGE PROFILE IN 2022

During the Pre-Demo Phase, significant efforts were made to harmonise and validate input datasets for the CM-related use cases (SUC-FI-02.01 to SUC-FI-02.04). This included associating aggregated load and generation data to grid topology, which proved more complex than anticipated due to a change in the demonstration area. The new demo area includes medium- and low-voltage networks (20 kV, 1 kV, 400 V) across five feeders serving thousands of users. As manual modelling was unfeasible, the team developed a conversion tool to migrate grid data from QGIS into MATLAB PTI format, followed by a thorough validation process.

These preparatory steps caused delays in the CM algorithm development, particularly for SUC-FI-02.03 and SUC-FI-02.04. However, with foundational data work completed, development is now underway. The work also supports the scenario simulations for SUC-FI-02.01 and SUC-FI-02.02, which will follow.

3.1.3.2 Milestones and Progress

This subsection revisits the internal milestones identified in D5.1 and assesses their current status, noting any updates, delays, or partial completions observed during the Pre-Demo Phase. The information is presented in Table 5, which maps each milestone to the corresponding implementation steps and indicates the extent of progress achieved for the Finnish Demo.

TABLE 5: PROGRESS ON FINNISH DEMO INTERNAL MILESTONES LINKED TO THE IMPLEMENTATION OF SYSTEM USE CASES (SUCS) DURING THE PRE-DEMO PHASE

Internal Milestones	Month	SUC-FI-01.01	SUC-FI-01.02	SUC-FI-02.01	SUC-FI-02.02	SUC-FI-02.03	SUC-FI-02.04[1]
Installing first set of devices to start data gathering	M12	This milestone is related to building the piloting infrastructure that will be used for all SUCs/services. Most device installations were conducted in the planned milestone schedule, but some parts have been delayed until M18.					
Procuring and installing the second set of devices	M14	This milestone is also related to building the piloting infrastructure that will be used for all SUCs/services. At least most of the devices required also for the second substation area have been procured and installed. A need to procure additional devices may arise as the full-scale demonstration progresses, but this will be clarified later.					
Pre-demo up and running	M16	Anomaly detector deployed on the first piloting area (all steps), to be updated at later stages	Steps 1-2 partly implemented on the first piloting area (running environment exists and fault	Not yet on the piloting areas	Not yet on the piloting areas	Not yet on the piloting areas	Not yet on the piloting areas

[1] *Milestone progress was affected by a change in the pilot area and the need for grid model conversion and validation. See SUC Implementation (SUC-FI-02.03, 02.04) for details*

			forecasting will be added)				
First versions of new algorithms ready for lab testing	M16	Steps 1 and 2 partly implemented.	Steps 1 and 2 partly implemented.	Steps 11 and 14 partly implemented. Please, note that the numbering of steps has changed after D5.1.	Steps 2 and 3 partly implemented. Please, note that the numbering of steps has changed after D5.1.	Steps 8, 11, 12 and 14 partly implemented. Please, note that the numbering of steps has changed after D5.1.	Steps 3 and 4 partly implemented. Please, note that the numbering of steps has changed after D5.1.

CM use cases (SUC-FI-02. (01-04))

For CM use cases, the primary focus has been on harmonising and validating the input data—specifically grid, load and generation data. This process was initially expected to be straightforward and time-efficient; however, it has taken longer than anticipated, resulting in some delays to subsequent development tasks.

The main reason for the delay lies in the change of the pilot area. Originally, the demo area was based on a 110 kV grid, which is relatively simple to model and validate. In contrast, the new pilot area encompasses a much more complex network, including 20 kV, 1 kV, and 400 V levels. This grid feeds thousands of citizens across five feeders and contains hundreds of branches and components typical of medium- and low-voltage systems. Due to its scale and complexity, manual modelling of the new grid was not feasible. As a result, additional resources were allocated to develop source code that enables automatic migration of the grid model from QGIS to PTI in MATLAB. This includes a validation process to ensure the digital model accurately reflects the real grid and can be reliably used in later stages, particularly in state estimation and real-time CM.

The harmonisation, validation and analysis of input data are critical, as they directly impact the performance of algorithms used in both predictive and real-time CM use cases. With this foundational step now complete, algorithm development for SUC-FI-02.03 is underway. Development for SUC-FI-02.04 is planned to begin in August 2025. It's important to highlight that the work done on dataset preparation supports both cloud-based and edge-based CM use cases. Nevertheless, as outlined in previous documents, the immediate goal is to pilot SUC-FI-02.03 and SUC-FI-02.04. Scenario simulations for SUC-FI-02.01 and SUC-FI-02.02 will follow afterward.

3.1.4 Pre-Demo Evaluation

3.1.4.1 Requirements Evaluation

The following section presents the requirement for each SUC, which was initially introduced in D5.1 including the description, acceptance criteria, and assigned testing partner. An additional column now captures the progress status recorded during the Pre-Demo Phase, allowing a direct comparison between the targets set in D5.1 and the results achieved to date.

SUC-FL-01.01 & SUC-FL-01.02 ANOMALY DETECTION AND FAULT FORECASTING

Req	Description	Acceptance Criteria	Progress
QoS.1	Accuracy of data requirements	Data is available with proper measurement accuracy and resolution	Cannot be evaluated yet (requires real-time data link being up and running)
QoS.2	Frequency of data exchanges	Data is available with the resolution of IEC61850-9-2 Sampled value or at equivalent rate depending on the format	Cannot be evaluated yet (requires real-time data link being up and running)
Sec. 1	Information integrity	Missing data or frozen data stream must be noted as a function of the data link	Cannot be evaluated yet (requires real-time data link being up and running)
D.1	Quality of data	Data timestamped and of proper quality, with indication of missing datapoints.	Cannot be evaluated yet (requires real-time data link being up and running)
D.2	Correctness of source data	Data source indicated as part of the dataset	Cannot be evaluated yet (requires real-time data link being up and running)
D.3	Format for AI algorithm input	Input data format defined and implemented	Initial definition available, to be modified when implementation work progresses
D.4	Format for anomaly log defined	Anomaly log format is available.	Initial definition available, to be modified when implementation work progresses
Conf.1	Commonly used communication protocol	In principle IEC61580 is applied. In addition, data link format as specified.	Cannot be evaluated yet (requires real-time data link being up and running)
O.1	Adequate computational power	Implemented analytics can be run on the EDGE server.	Cannot be evaluated before the algorithm has been deployed in the running environment to be used in the piloting

SUC-FL-02.01, SUC-FL-02.02 SUC-FL-02.03 SUC-FL-02.04 CONGESTION MANAGEMENT USE CASES

Req.	Description	Acceptance Criteria	Progress
Conf.1	The operation mode of the information producer/receiver	Manual	Cannot be evaluated yet. The evaluation can be done after parameter scheduler is implemented.
Conf.2	The operation mode of the information producer/receiver	Automatic	Cannot be evaluated yet.
QoS.1	Elapsed time response requirements for exchanging data	Less than 1 second	Cannot be evaluated yet.
QoS.2	Availability of information flows	99.9% + availability - Allowed outage: a few times per year, max 1 hour each.	Partly evaluated. For example, for grid data, load data, and generation data.
QoS.3	Frequency of data exchange	Periodicity greater than a few minutes,	Partly evaluated for primary substation measurements.

		OR upon event OR every few seconds.	
Sec.1	Eavesdropping	Ensuring confidentiality, avoiding illegitimate use of data, and preventing unauthorised reading of data.	Partly evaluated in terms of grid, load and generation data being only accessed/used by authorised parties.
Sec.2	Information integrity violation	Ensuring that data is not changed or destroyed.	Not yet evaluated. Evaluation after implementing the data exchange interfaces.
Sec.3	Authentication	Ensuring that data comes from the stated source or goes to the authenticated receiver.	Not yet evaluated. Evaluation after implementing the data exchange interfaces.
Sec.4	Information theft	Ensuring that data cannot be stolen or deleted by an unauthorised entity.	Not yet evaluated. Evaluation after implementing the data exchange interfaces.
D.1	Logging	Logging of all information exchanged during this interaction is required, OR Logging of the source, destination, requesting application, and requesting user of information exchanges is required, but not the data itself.	Not yet evaluated. Initial designs of logging systems have been already started.
D.2	Up-to-data management	Received data must be up-to-date within seconds of source data changing.	Not yet evaluated.
D.3	Data consistency and synchronisation management across systems	Second-by-second synchronisation OR Day-by-day synchronisation.	Not yet evaluated.
D.4	Management of data across organisational boundaries	Data exchanges go across boundaries between system developed by different vendors OR data exchanges go across organisational boundaries.	Initial designs have been done including the protocol. Evaluations have not started yet and will be after implementing the data exchange interfaces between organisations.
D.5	Naming of data items	Matching of names is handled by a	Not yet evaluated. Evaluation after implementing the data exchange interfaces.

		"converter" at the Information Receiver.	

3.1.4.2 KPIs Progress

The KPIs to be measured by the Finnish demo, their corresponding baseline and target values, are presented in Table 6 below. A new "Progress" column has been included to document developments during the Pre-Demo Phase (M16–M18). A "0" value under the progress column indicates that no measurable data has been collected during the pre-demo phase for the respective KPI. This does not reflect underperformance but rather the fact that measurement is scheduled to begin in the Full Demo Phase.

TABLE 6: KEY PERFORMANCE INDICATORS (KPIS) DEFINED FOR THE FINNISH DEMO, INCLUDING SUC RELEVANCE, BASELINE AND TARGET VALUES, AND REPORTED PROGRESS DURING THE PRE-DEMO PHASE

ID	KPI	Baseline	Target	Progress
OB1	Different types of IoT/edge devices to be exploited in Demo Areas e.g., Smart Meter, HEMS, Sensors, inverter	0	>5	IEDs on substations and on breakers at feeders, edge server, smart meters
KPI4	Real-time data sharing among stakeholders	0	10% Y1, 40% Y2, 60% Y3, 100% Y4	Functionality under development
KPI8	IoT/Edge/Fog sites uptime and availability	n/a	99,9%	Data not available yet
KPI9	Flexibility unlocked and transacted in markets	0	30% increase	n/a
KPI11	Increased grid operational performance	n/a	> 20% in CAIDI	n/a
KPI17	Increased flexibility incorporation enabled by IoT/Edge technologies for grid security	0	5% Y1, 10% Y2, 15% Y3, 30% Y4, 45% Y5+	n/a
KPI22	Increase DERs participation in flexibility provision	0	5% Y1, 10% Y2, 15% Y3, 20% Y4, 25% Y5+	n/a

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3.2 DEMO 2 – LEVERAGING IOT AND EDGE COMPUTING TO FOSTER LOCAL FLEXIBILITY MARKETS [GREECE]

3.2.1 Pre – Demo Phase Activities Summary

This section presents a structured summary of the activities that the Greek Demo conducted during the Pre-Demo Phase (M16-M18). It expands upon the demo deployment template introduced in Chapter 2, which functions as a reference for monitoring the development of each demonstrator. The status of the pre-demo targets, the WP3 services utilised, and the key stakeholders involved during this phase are all detailed in Table 7 below. The purpose of the information is to establish the foundation for the Full Demo Phase and to evaluate the operational readiness of the demo at the conclusion of the Pre-Demo Phase.

TABLE 7: DEMO 2 PRE-DEMO PHASE DEPLOYMENT STATUS

Section	Subsection	Input
Summary	Pre-Demo Phase Target	The main target on the Pre-Demo Phase for the Greek demo is to test the initial software applications for the edge and cloud components to be installed. To do this, a campaign to attract residential users to install the submetering IoT devices was launched and as of M18, with more than 50 users been onboarded as part of the pilot (compared to the 100 residential users as per the GA). This allowed to test the components and proceed with initial testing of the main hardware and software stack, to ensure that the devices are working as expected and securely.
	Status Summary	• Successful installation of 55 IoT sensors in residential houses and billing energy meters (installations are ongoing to reach the GA amount). • Secure data transmission of residential data. • Testing of edge and cloud data operations. • Development of initial optimisation algorithms for flexibility services and DR schemes. • Development of forecasting modules for energy demand, production and disaggregation (federated and online learning) • Development of User Interfaces (mobile app and website) for residential end-users and the aggregator. • Initial design and testing of the Local Flexibility Platform. • All SUCs are operational (see section 3.2.3.1 for further details)
	Services Used (from WP3)	1. Federated Learning for Energy Forecasting & Disaggregation 2. Flexibility Optimisation Service 3. Demand Forecasting Service
	Stakeholders involved during Pre-Demo	1. Residential end-users 2. Aggregator (PPC) 3. DSO (HEDNO) 4. TSO (IPTO) 5. NEMO (HENEX)

3.2.2 Infrastructure, Assets and Data Availability

Based, on the demo-deployment template that was introduced in chapter 2, a consolidated snapshot of the infrastructure and assets mobilised during the Pre-Demo Phase is provided in Table 8 for the Greek demo. Each asset is accompanied by its technical description, deployment level, use status in months 16-18, and the WP3 service to which it pertains.

TABLE 8: SUMMARY OF DEMO INFRASTRUCTURE AND ASSETS DEPLOYED DURING THE PRE-DEMO PHASE

Asset	Description	Deployment Level	Used during Pre-demo	Under which WP3 service
Submetering IoT devices	IoT devices in residential switchboards with edge processing capabilities	Deploying and testing period	**Yes**	Flexibility Optimisation Service, Demand Forecasting Service, Disaggregation Service, FL, Aggregator and Mobile App Platforms
Databases for data exchange	Cloud storage	Operational	**Yes**	Flexibility Optimisation Service, Demand Forecasting Service, Disaggregation Service, FL, Aggregator and Mobile App Platforms
Smart Building and Flexibility Modelling AI-based Tools	A set of AI tools and algorithms for residential consumers running on the edge and cloud	Under development	**Yes**	Flexibility Optimisation Service, Demand Forecasting Service, Disaggregation Service, FL, Aggregator and Mobile App Platforms
User Interfaces	Mobile app and web interface for residential consumers and aggregators	Under development and testing	**Yes**	Residential mobile app and web interface, aggregator web interface
Local Flexibility Platform	Flexibility trading platform	Under development and testing	Partly	n/a
LV nodes	Metering devices at network nodes to procure flexibility	Under testing	Partly	n/a

Table 9 summarises the datasets relevant to the Pre-Demo Phase, indicating their availability, whether they were used during this period and their linkage to the corresponding WP3 technological enablers.

TABLE 9: OVERVIEW OF DATASETS RELEVANT TO THE PRE-DEMO PHASE OF THE GREEK DEMO

Data Description	Used during Pre-Demo Phase	Under which WP3 service
Residential current measurements	Full data	Flexibility Optimisation Service, Demand – Production Forecast Service, Disaggregation Service, FL, Aggregator and Mobile App Platforms

Residential voltage measurements	Full data	Flexibility Optimisation Service, Demand – Production Forecast Service, Disaggregation Service, FL, Aggregator and Mobile App Platforms
Residential active and reactive power measurements	Full data	Flexibility Optimisation Service, Demand – Production Forecast Service, Disaggregation Service, FL, Aggregator and Mobile App Platforms
Residential power factor measurements	Full data	Flexibility Optimisation Service, Demand – Production Forecast Service, Disaggregation Service, FL, Aggregator and Mobile App Platforms
Network frequency measurements	Full data	Flexibility Optimisation Service, Demand – Production Forecast Service, Disaggregation Service, FL, Aggregator and Mobile App Platforms
1-phase/3-phase residential active energy measurements	Full data	Flexibility Optimisation Service, Demand – Production Forecast Service, Disaggregation Service, FL, Aggregator and Mobile App Platforms
MV Power-Bus Voltage data	Yes, as a data sample	-
HV/MV Transformer Power data	Yes, as a data sample	-
DSO smart metering data	Yes, as a data sample	-
Company Data	Yes	Flexibility Optimisation Service
Asset Data	Yes	Flexibility Optimisation Service
BID Data	Yes	Flexibility Optimisation Service
Results Data	Yes	Flexibility Optimisation Service

3.2.3 Pre-Demo Results

This section captures the status and progress of System Use Case (SUC) implementation during the Pre-Demo Phase (M16-M18) for the Greek Demo. For each SUC, key developments are outlined, including the specific actions undertaken, intermediate achievements, and alignment with the expected implementation steps and scenarios described in D2.2. In addition, the internal milestones defined in D5.1 are revisited and assessed in terms of progress and completion. This structured overview offers insight into the readiness and maturity of each SUC ahead of the upcoming demonstration cycles.

3.2.3.1 SUCs Implementation

This subsection presents the implementation progress of each System Use Case (SUC) as defined in D2.2 for the Greek Demo, highlighting the actions carried out during the Pre-Demo Phase.

SUC-GR-01.01 OPTIMISATION OF FLEXIBILITY DISTRIBUTION

Section	Subsection	Input
Overview	SUC Summary	In this SUC the Aggregator aggregates the available flexibility assets of consumers, models their behaviour, and identifies feasible flexibility actions to submit optimised bids to the Local Flexibility Market (LFM), using near real-time monitoring, forecasting, and optimisation algorithms to determine the appropriate incentives for consumers.
	Target(s)	Design and implement an optimisation model that leverages the forecasts of residential demand and prosumer production, computes optimal demand-response strategies and consumer incentives, and produces an optimal bid (quantity, price) for the aggregator to bid to the LFM.
	Expected UC Milestones	For the demo phase, we will first showcase the aggregator's ability to ingest and harmonise all relevant production and consumption data from the energy supplier to assess the flexibility potential of the prosumers and thus feed the optimisation models. With those insights in hand, the optimisation engine will be run live to compute optimal incentives and allocate flexibility across participants. Finally, we'll reveal the tailored offers generated by the aggregator, ready for submission to the Local Flexibility Market.
	Actions implemented	In this cycle, we developed and integrated the RL-based dispatch optimisation engine end-to-end. We formalised the aggregator's decision process as a reinforcement-learning problem, defining state and action spaces, crafting reward functions that balance market revenues with consumer comfort, and simulating the market environment using real consumption and PV production forecasts. We then trained the agent on historical and near-real-time data, validated its policy through back-testing across our four flexibility scenarios, and finally embedded the trained model into the aggregator's pipeline to automatically generate and adjust optimised bids for the Local Flexibility Market.
Requirements	Assumptions	We assumed reliable, hourly-resolution consumption and PV data aggregated from 10 prosumers; a simulated Local Flexibility Market that faithfully mirrors price signals, bid rules, and settlements; stable consumer responsiveness; secure, low-latency communications; linear battery behaviour without degradation or nonlinear losses; and that the RL model was trained on data spanning all expected operational conditions (weather, load, and market fluctuations).
	Dependencies	This module relies on the Demand Forecasting SUC (SUC-GR-01.02) and the Production Forecasting SUC (SUC-GR-01.03) to ingest hourly consumption and PV generation forecasts, the User Interaction Interface SUC (SUC-GR-01.05) to present flexibility offers and collect prosumer responses, and the Local Flexibility Market (LFM) service to notify the aggregator whenever a new market time unit (MTU) opens.
	Risks	Algorithmic uncertainties arise if forecasting errors or the RL optimiser fail to generalise. Another risk is also the large complexity of the algorithm when the number of prosumers increase.

Readiness	Deployment diagram	The deployment diagram for SUC-GR-01.01 is presented in Figure 9 below for clarity.
	Deployment preparation	Deployment requires a network of edge-IoT devices and smart meters in pilot homes, all streaming hourly consumption and PV data; a GDPR-compliant data management framework with encrypted storage and API gateway; the User Interaction Interface (SUC-GR-01.05) hosted on a web server to deliver offers and collect responses;
	Deployment assessment	The Demand and Production Forecasting modules, the RL dispatch optimiser, and the smart-meter infrastructure are implemented and tested.
Validation Activities Summary	Previous cycle	n/a
	Current cycle	We've deployed and validated the Demand and Production Forecasting modules, activated the smart-meter network for reliable hourly data streams, and integrated and back-tested the RL Dispatch Optimisation engine on real prosumer datasets. These actions directly address last cycle's recommendations to secure end-to-end data acquisition, improve forecast accuracy, and operationalise advanced optimisation within the aggregator pipeline.
	Future cycle	In the next cycle, we'll extend the optimiser to support multiple customer portfolios and calibrate tiered incentive levels for each group, integrating a probabilistic model of prosumer acceptance or rejection into the decision logic. We'll also refine the RL reward to reflect these acceptance probabilities and ensure the engine can output bids formatted as supply-demand curves.

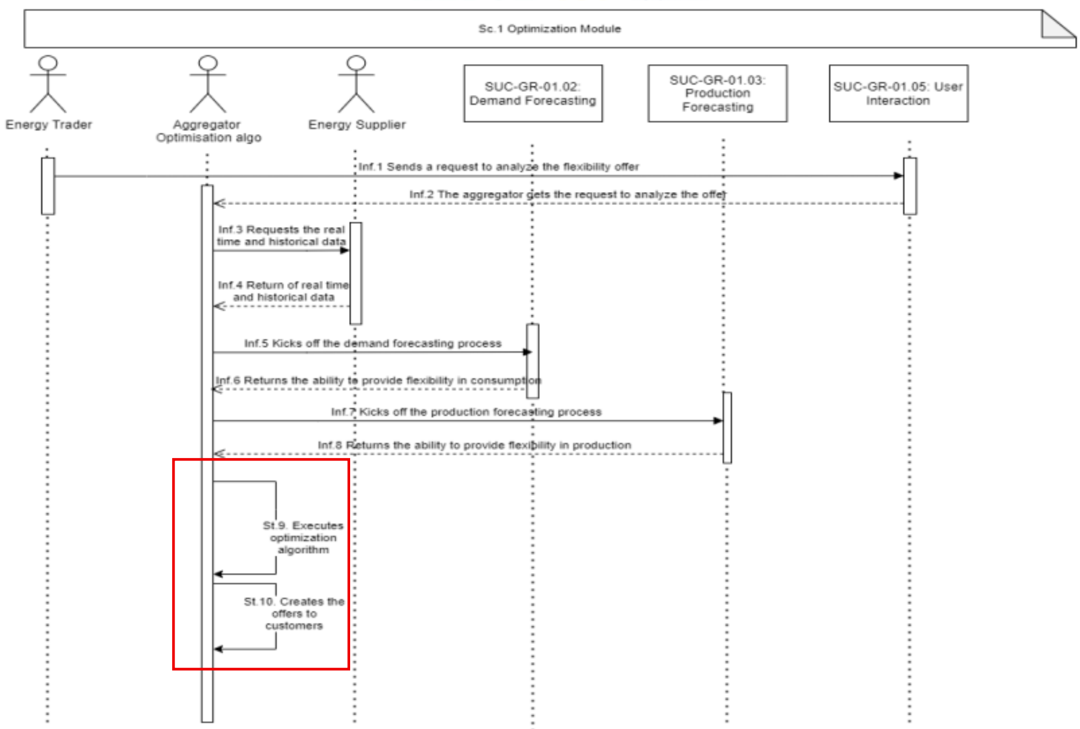


FIGURE 9: DEPLOYMENT DIAGRAM FOR SUC-GR-01.01 (ONGOING PROCESS)

During the pre-demo cycle, the Flexibility Optimisation Service that underpins SUC-GR-01.01 was exercised end-to-end in a sandbox environment that mimics the forthcoming Local Flexibility Market (LFM). A lightweight mock-LFM API and companion web UI allowed to push synthetic bids—quantity, price and Market-Time-Unit (MTU)—and pull them back for status checks. The service consistently cleared each submission round-trip in ≈ 1.2 s, well inside the performance envelope set. Every bid is retrievable by its unique ID, with the API streaming live state transitions (pending → approved/rejected). Role-based access control blocks unauthorised calls, and each write action lands in an immutable audit log that records timestamp, user ID and bid metadata, giving operators a complete forensic trail.

On top of this stable transaction layer, the reinforcement-learning optimiser was trained on one year of data from ten residential prosumers, aggregated to hourly MTUs. When replayed against the 24 February 2025 evening peak (18:00–19:00), the engine produced a bid stack that cuts demand precisely at price spikes, as you can see from Figure 10.

```
=== DR info for 2025-02-24 18:00:00 ===
1) Incentive paid            : 0.08 €
2) Energy reduction (kWh)     : 8.00 kWh
3) Bid details:
   • Price at hour            : 0.39 €/kWh
   • Quantity offered (kWh) : 8.00 kWh
```

FIGURE 10: SAMPLE OUTPUT FROM THE RL-BASED FLEXIBILITY OPTIMISATION SERVICE

The resulting heat-map confirms flexibility actions clustering at midday and again after sunset—see Figure 11 below.

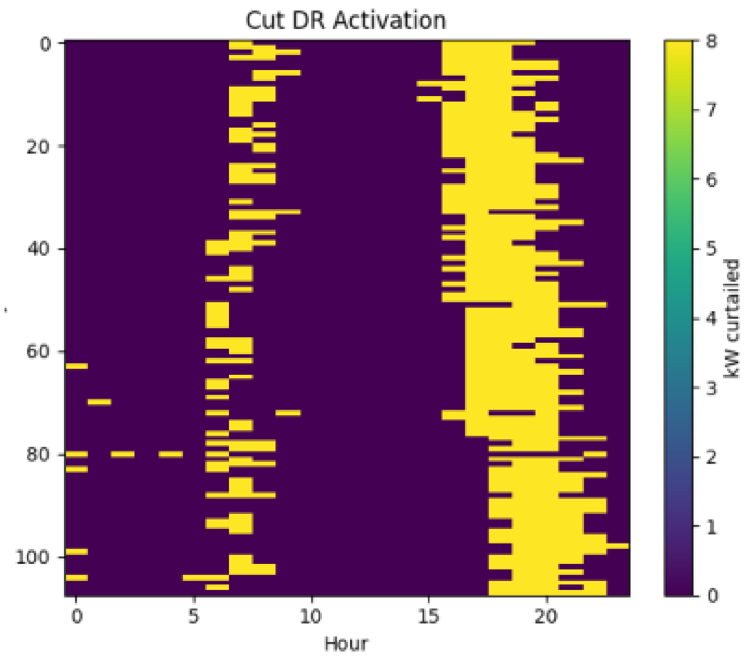


FIGURE 11: HEAT-MAP OF DEMAND-RESPONSE "CUT" ACTIVATIONS GENERATED BY THE OPTIMISER

Co-funded by the European Union

In back-tests across the same dataset the optimiser generated revenue-positive bids in more than 90 % of MTUs, providing early evidence that the service can monetise household flexibility once real meters come online. These outcomes show that the core bidding workflow, incentive logic and security safeguards are already production-grade; the next evaluation cycle will replace synthetic inputs with live smart-meter streams and connect the optimiser to the production LFM gateway, bringing the Greek pilot another step closer to real-world flexibility trading.

Furthermore, the **Non-Intrusive Load Monitoring (NILM) service**, which supports **SUC-GR-01.01**, has progressed through multiple development stages to enhance its accuracy and real-world applicability. Initial foundational work involved testing baseline Denoising Autoencoder (DAE) models on open-source datasets, such as UK-DALE and REDD. While these early tests established a proof of concept, they also revealed limitations in generalising to the specific appliances and usage patterns found in the Greek pilot households. To overcome this, the service was upgraded to a Clustering-enhanced Denoising Autoencoder (C-DAE) framework. This advanced version integrates unsupervised pre-clustering of appliance load signatures with supervised DAE training, a method that significantly improves performance, especially for low-duty-cycle appliances.

The C-DAE system was retrained using real consumption data collected from Greek pilot households, with a focus on identifying dishwashers, washing machines, and washer-dryers. A key part of this process was using the silhouette score and elbow method to identify the optimal number of clusters for each appliance type, resulting in k = 4 for dishwashers and k = 2 for both washing machines and washer-dryers. This clustering enabled the models to specialise, resulting in a significant improvement in disaggregation performance. For instance, the F1-score for the dishwasher surged from 0.21 to 0.97, while the washing machine's F1-score increased from 0.25 to 0.97. This was accompanied by a significant reduction in power estimation error, with the RMSE for the washing machine decreasing by 45% (from 484W to 264W). As detailed in Figure 12, Figure 13 and Figure 14 below,

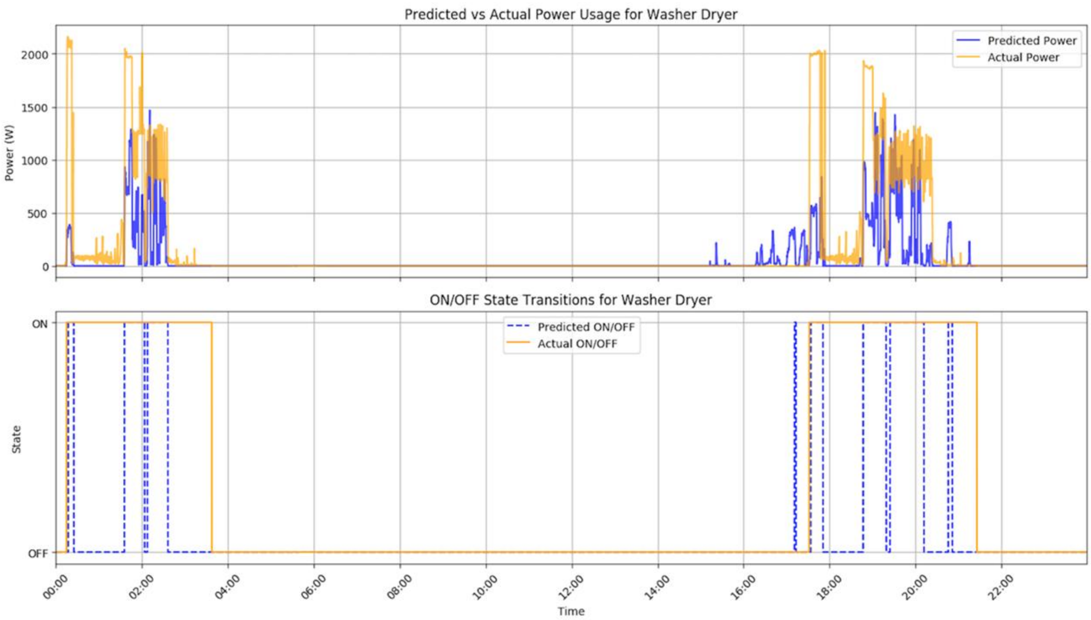


FIGURE 12: NILM PERFORMANCE FOR A WASHER-DRYER: TOP—PREDICTED VS. ACTUAL POWER; BOTTOM—PREDICTED VS. ACTUAL ON/OFF STATES.

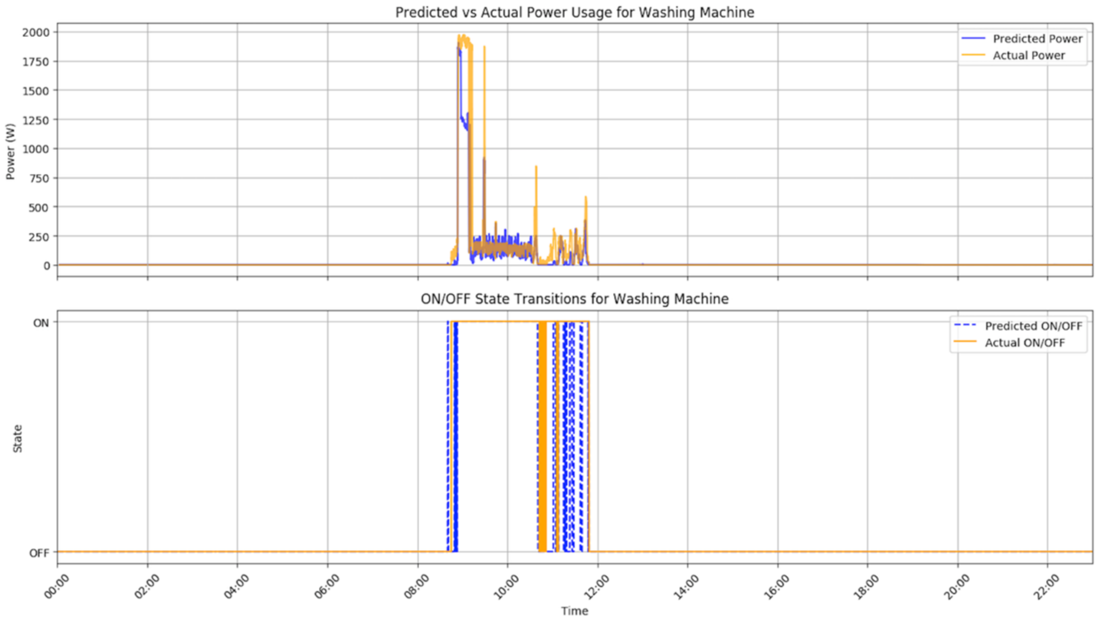


FIGURE 13 : NILM PERFORMANCE FOR A WASHING MACHINE: TOP—PREDICTED VS. ACTUAL POWER; BOTTOM—PREDICTED VS. ACTUAL ON/OFF STATES.

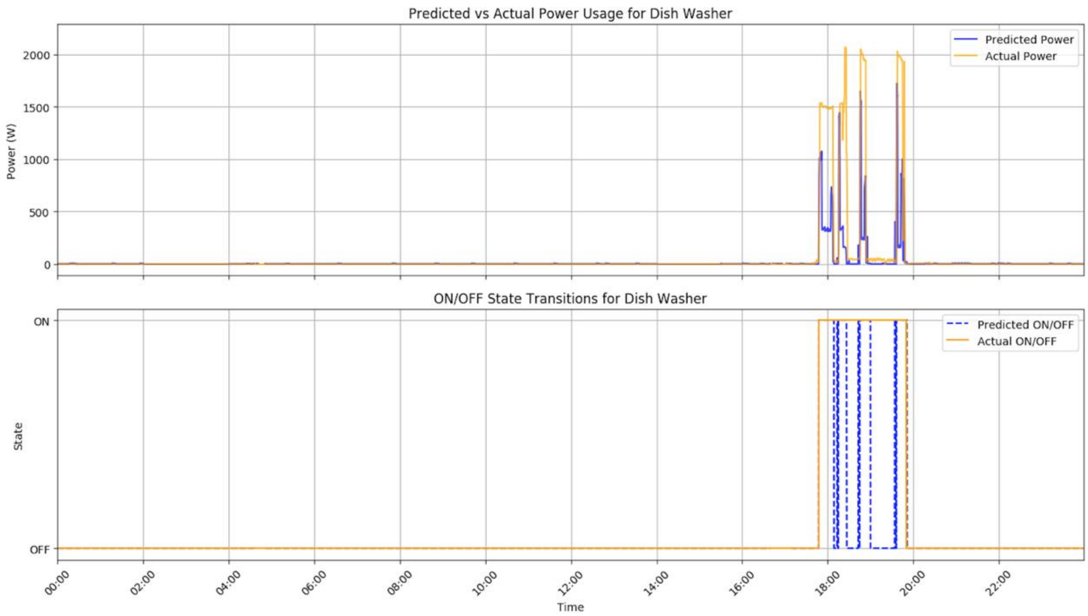
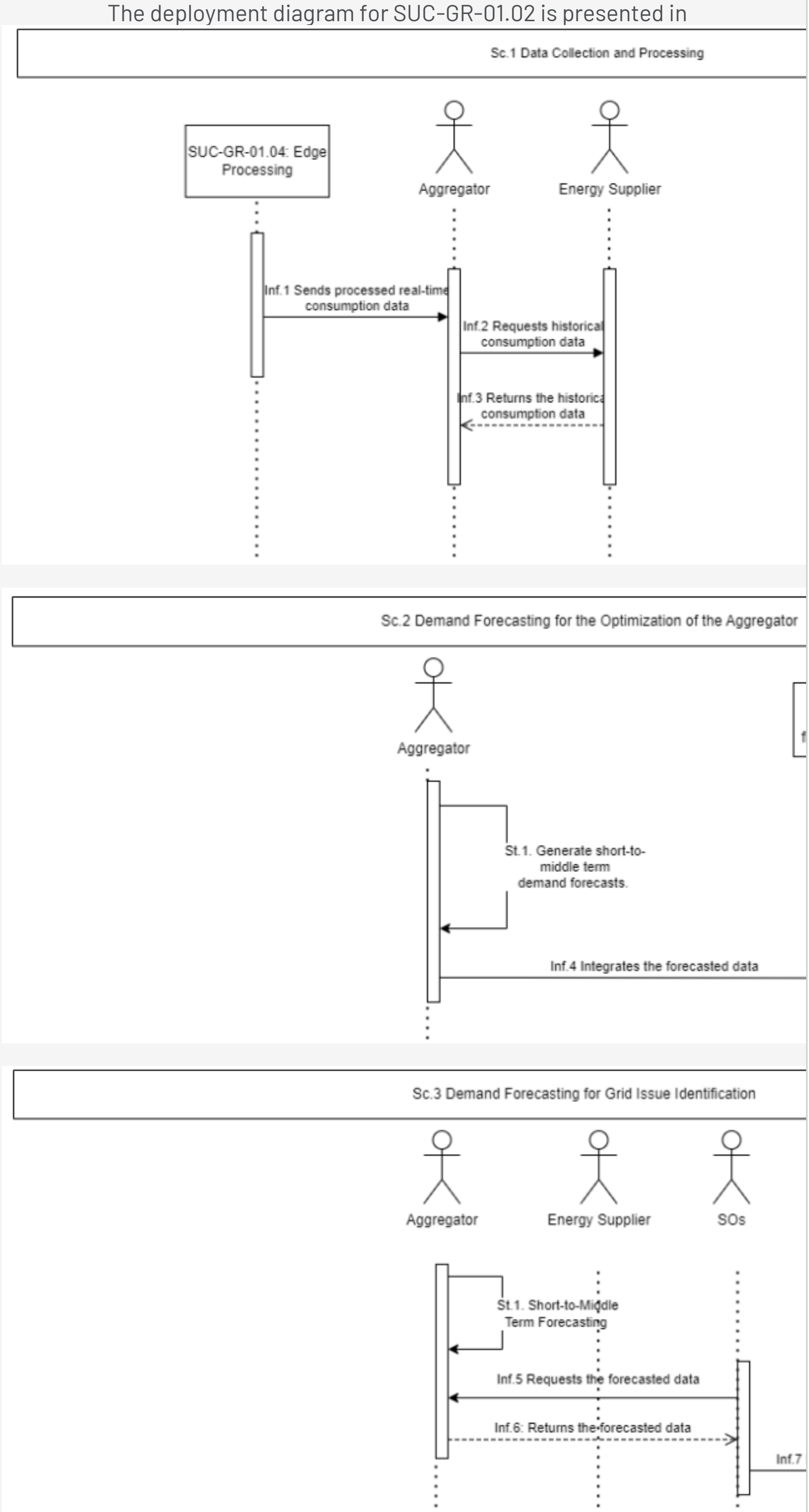


FIGURE 14: NILM PERFORMANCE FOR A DISHWASHER: TOP—PREDICTED VS. ACTUAL POWER; BOTTOM—PREDICTED VS. ACTUAL ON/OFF STATES.

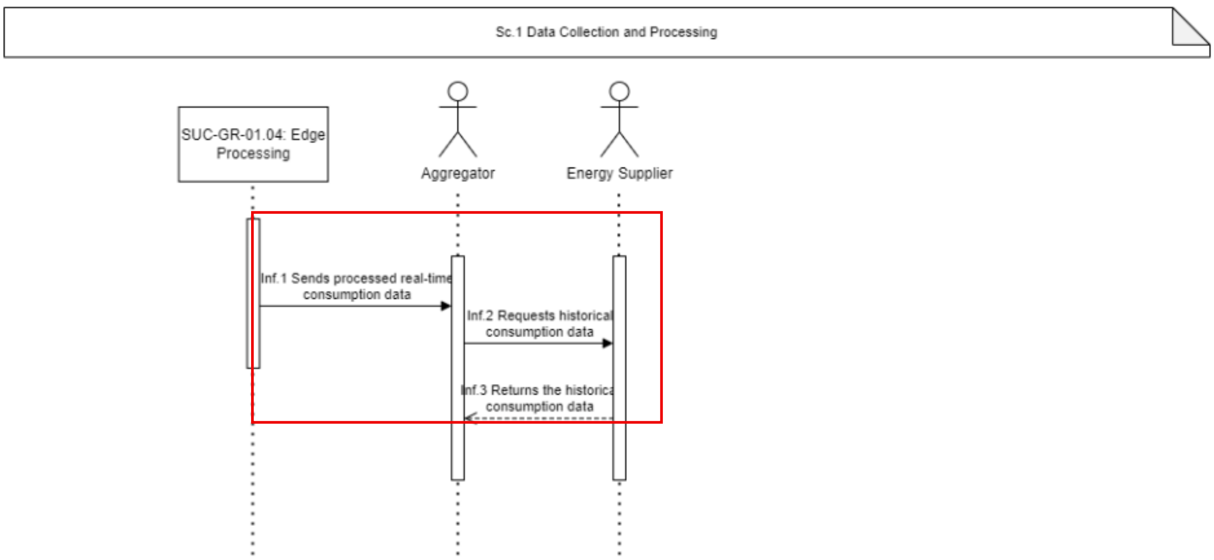
The model now demonstrates enhanced temporal precision and noise resilience, with recall and precision metrics exceeding 0.95 for every tested appliance. The upgraded NILM engine is now partially integrated into the backend. It is undergoing live pilot testing, enabling the real-time detection of controllable loads and providing accurate, disaggregated profiles to the Flexibility Optimisation module. This improvement also enhances the accuracy of bidding and dispatch planning.

SUC-GR-01.02 DEMAND FORECASTING

Section	Subsection	Description
Overview	SUC Summary	Demand forecasting for residential customers using real-time and historical data from smart meters and IoT devices. It supports aggregators in flexibility market decisions and grid operators in identifying grid issues.
	Target(s)	Accurate forecasts of residential energy demand consumers with installed smart meters and edge devices
	Expected UC Milestones	• Accurate demand forecasts integrated into aggregator bidding tools. • Real-time data processing. • Support for grid issue detection by SOs. • Compliance with GDPR. • Use of HEDGE-IoT assets.
	Actions implemented	• Installation of edge IoT devices in households. • Real-time and historical data collection. • Pre-processing and forecasting implemented. • Forecasting module run by aggregator. • Forecasts exportable to enable sharing with SOs for grid analysis.
Requirements	Assumptions	• Availability of historical and real-time data. • Participation and consent from consumers. • Installed edge IoT infrastructure. • Availability of flexibility offers from LFM.
	Dependencies	Integration with SUC-GR-01.04 (Edge Processing / Data Capture) for data retrieval and handling, SUC-GR-01.01 (flexibility optimisation) and the User Interaction Interface (SUC-GR-01.05) for visualisation of the forecasts.
	Risks	• Incomplete data from IoT devices. • Latency or accuracy issues in forecasting.

Readiness	Deployment diagram	The deployment diagram for SUC-GR-01.02 is presented in  Figure 15 below for clarity.

	Deployment preparation	• Smart meters and IoT sensors installed. • Preprocessing and ML models pipelines development. • Access to HEDGE-IoT data services. • GDPR-compliant data flow infrastructure.
	Deployment assessment	• Most technical components deployed and operational. • Data flows validated for accuracy and frequency. • Mitigations in place for data quality and privacy concerns.
Validation Activities Summary	Previous cycle	n/a
	Current cycle	• Successfully collected and processed real-time data. • Forecasts generated and integrated into aggregator platform. • Forecasting data ready to be provided to Aggregator Platform. • Edge infrastructure tested for performance.
	Future cycle	• Optimise ML forecasting models. • Improve integration with HEDGE-IoT analytics tools. • Validate scalability and latency performance under full load. • Forecasting data to be provided to SOs for grid issue detection.



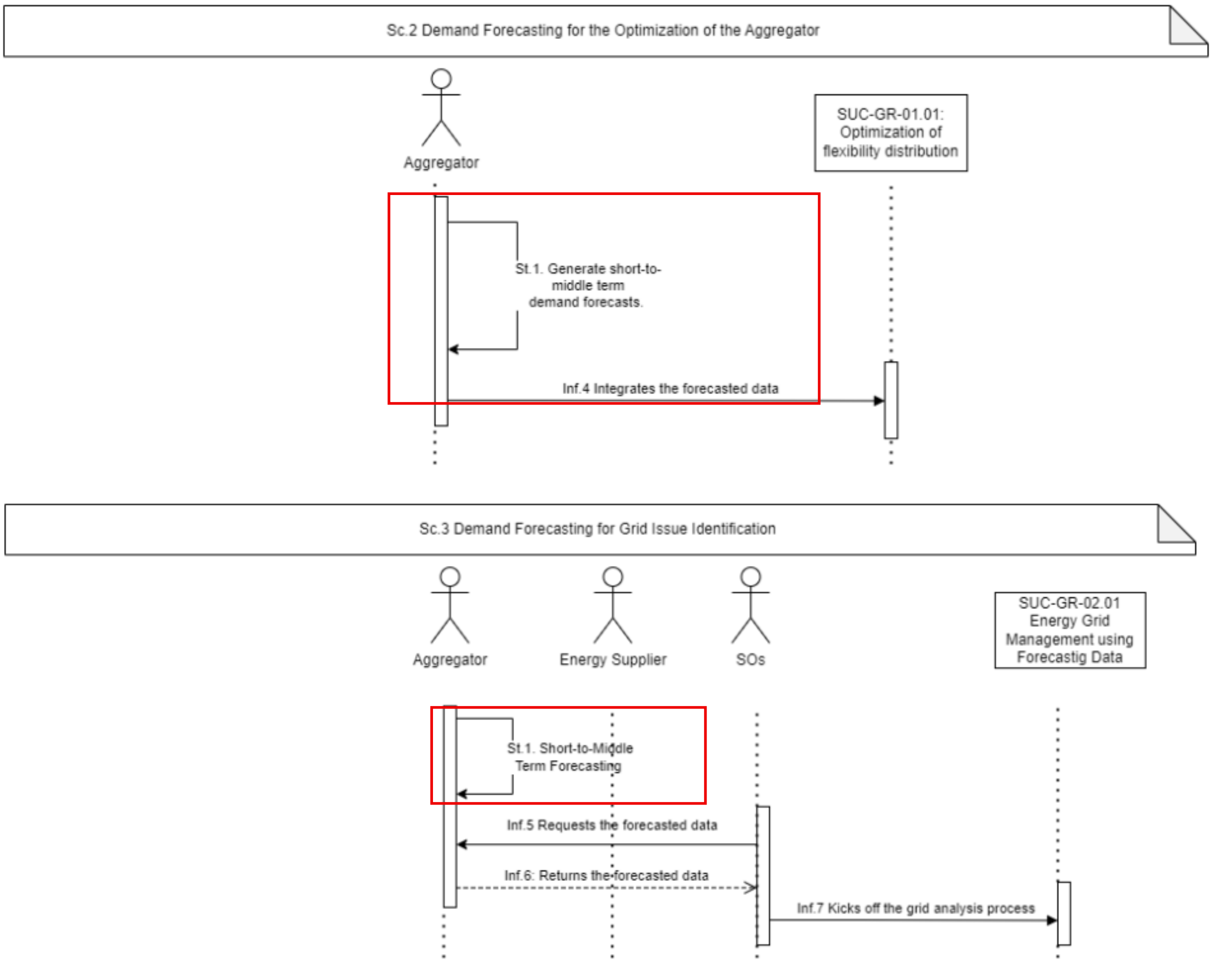


FIGURE 15: DEPLOYMENT DIAGRAM FOR SUC-GR-01.02 (ONGOING PROCESS)

During the Pre-Demo phase a demand-forecasting pipeline that ingests 15-minute and hourly smart-meter data, auto-generates rolling statistics, lags and calendar flags, normalises them with version-controlled scalers, and serves predictions through a low-latency API has been deployed. For grid-level decisions a three-layer bi-GRU network outputs the next 24-hourly points in a single pass, currently achieving MAE = 0.17 kWh and R^2 = 0.77 on aggregated load—see Figure 16 below.

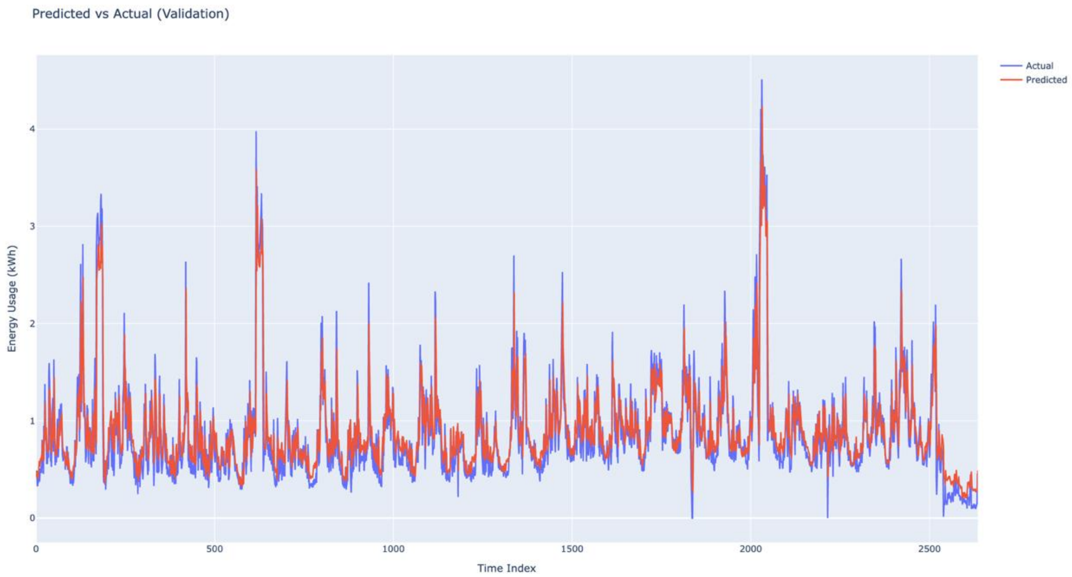


FIGURE 16: PREDICTED VS. ACTUAL ENERGY DEMAND — AGGREGATED SHORT-TERM MODEL (15-MINUTE RESOLUTION, VALIDATION SET).

At household level a recursive bi-LSTM forecasts 15-minute steps up to two hours ahead with MAE = 0.028 kWh and R^2 = 0.64 (see Figure 17 below). All artefacts—model weights, scalers, feature lists and validation metrics—are versioned in MinIO, ensuring reproducibility and auditability; inference latency remains below 200 ms, satisfying the real-time requirements of SUC-GR-01.02 and SUC-GR-01.03.

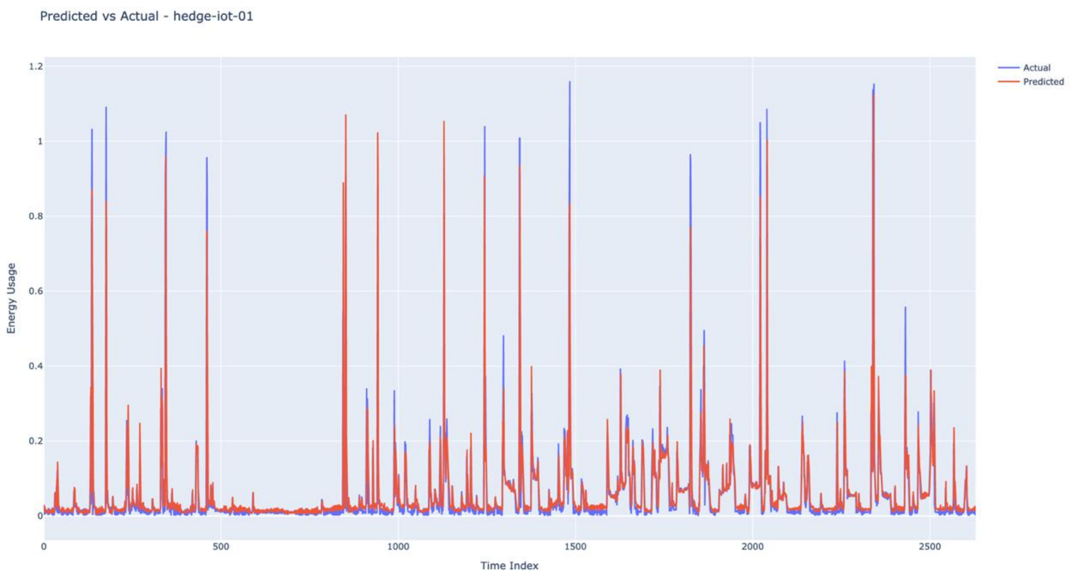
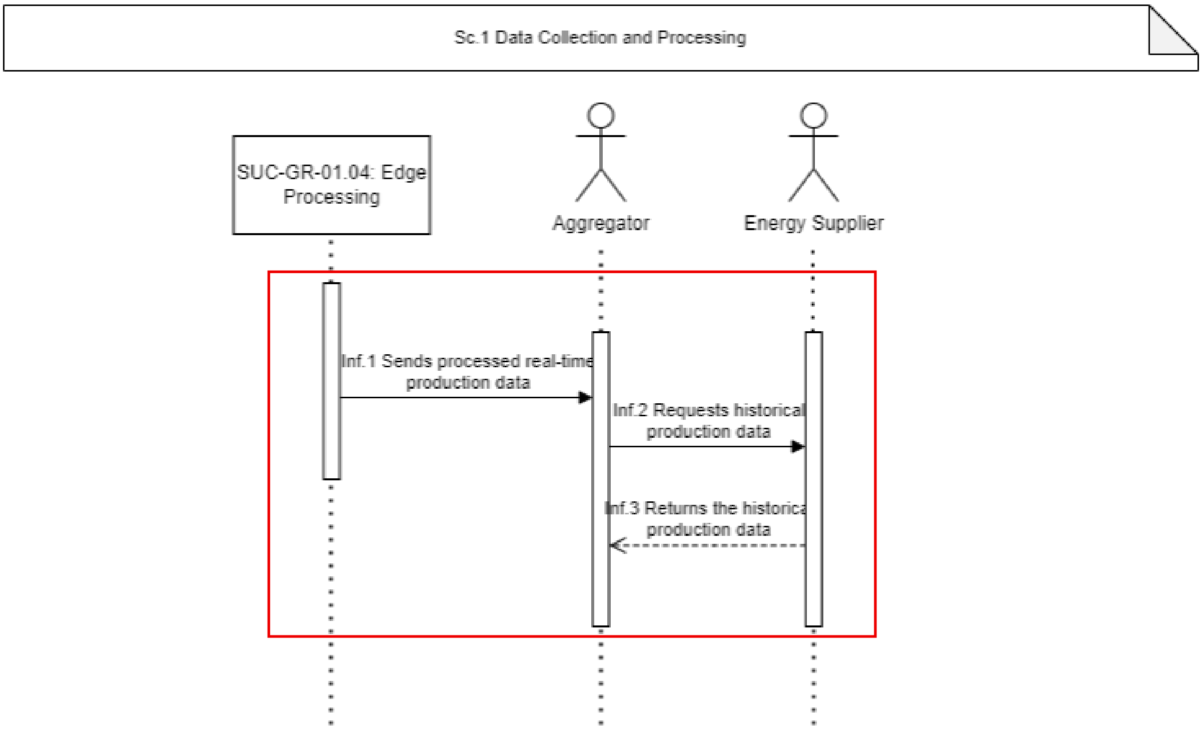


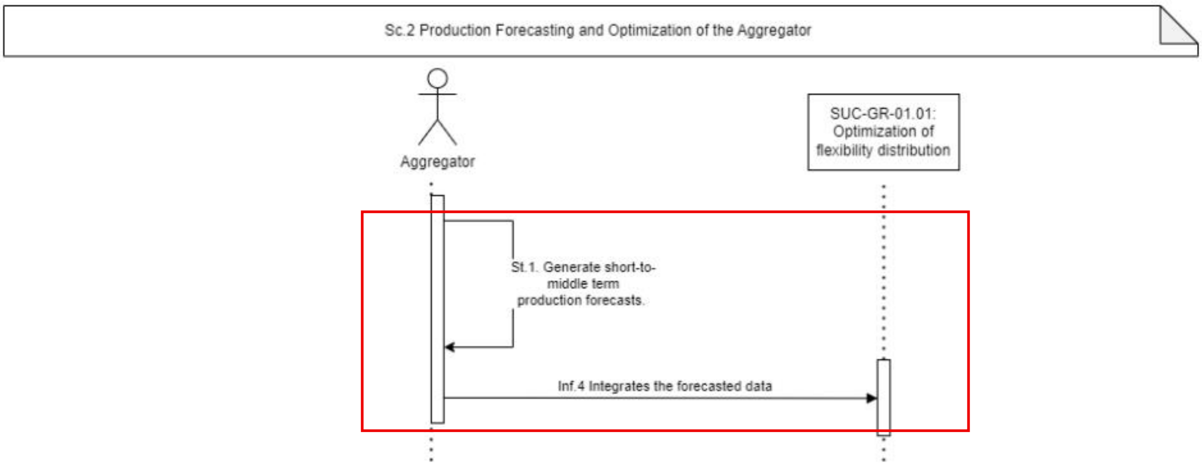
FIGURE 17: PREDICTED VS. ACTUAL ENERGY DEMAND — INDIVIDUAL HOUSEHOLD SHORT-TERM MODEL (15-MINUTE RESOLUTION).

SUC-GR-01.03 PRODUCTION FORECASTING

Section	Subsection	Input
Overview	SUC Summary	Forecasting energy production from prosumer households (with PV systems) to assess their flexibility potential. The system integrates real-time, historical, and weather data to support aggregators in optimisation and market bidding, and to assist system operators in identifying grid issues.
	Target(s)	Residential prosumers with PV systems, Aggregators (e.g. PPC), System Operators (HEDNO/IPTO), Energy Suppliers.
	Expected UC Milestones	• Accurate production forecasts using ML and weather data • Integration with aggregator optimisation tools • Grid support via forecasted flexibility • HEDGE-IoT tools and edge device integration • GDPR-compliant data processing
	Actions implemented	• Edge and smart meter installations in residential sites • Data ingestion from PV systems • ML model training (Bi-LSTM) • Forecasts integrated into aggregator platform
Requirements	Assumptions	• Availability of IoT/Edge devices • Historical production data from suppliers • Consumer participation and data consent • Weather data availability • Existence of LFM offers for flexibility
	Dependencies	• Integration with SUC-GR-01.01 (Optimisation) • Edge data from SUC-GR-01.04 • Weather APIs • HEDGE-IoT platform for real-time processing
	Risks	• Low quality or missing data • Forecasting errors (esp. during low-light conditions) • Interoperability with legacy systems • Insufficient participation or inadequate edge infrastructure
Readiness	Deployment diagram	The deployment diagram for SUC-GR-01.03 is presented in Figure 18 below for clarity.

	Deployment preparation	• Edge and cloud integration with HEDGE-IoT • Smart meters for PV production, (battery systems) installed • Forecasting APIs implemented • Secure infrastructure (TLS 1.2, AES-256) • User interfaces embedded in aggregator platform
	Deployment assessment	• Model training completed. Results demonstrate high evaluation metrics. • Real-time forecasting validated on Dingle dataset (an open dataset due to low data availability from pilot) • Logging, backups, GDPR controls in place • Scalable and exception-safe architecture ready for WP5 pilots
Validation Activities Summary	Previous cycle	n/a
	Current cycle	• Real-time production forecasting tested • Integration with optimisation and aggregator dashboards validated • Grid issue detection capability demonstrated • Model versioning, audit logging, and security tested
	Future cycle	• Extend to additional households • Integrate with live market platforms (HENEX) • Improve recursive forecasting accuracy • Enable App Store/Data Space interoperability • Enhance dashboard usability and control options • Forecasting data to be provided to SOs for grid issue detection.


Sc.1 Data Collection and Processing
SUC-GR-01.04: Edge Processing
Aggregator
Energy Supplier
Inf.1 Sends processed real-time production data
Inf.2 Requests historical production data
Inf.3 Returns the historica production data


Sc.2 Production Forecasting and Optimization of the Aggregator
Aggregator
SUC-GR-01.01: Optimization of flexibility distribution
St.1. Generate short-to-middle term production forecasts.
Inf.4 Integrates the forecasted data

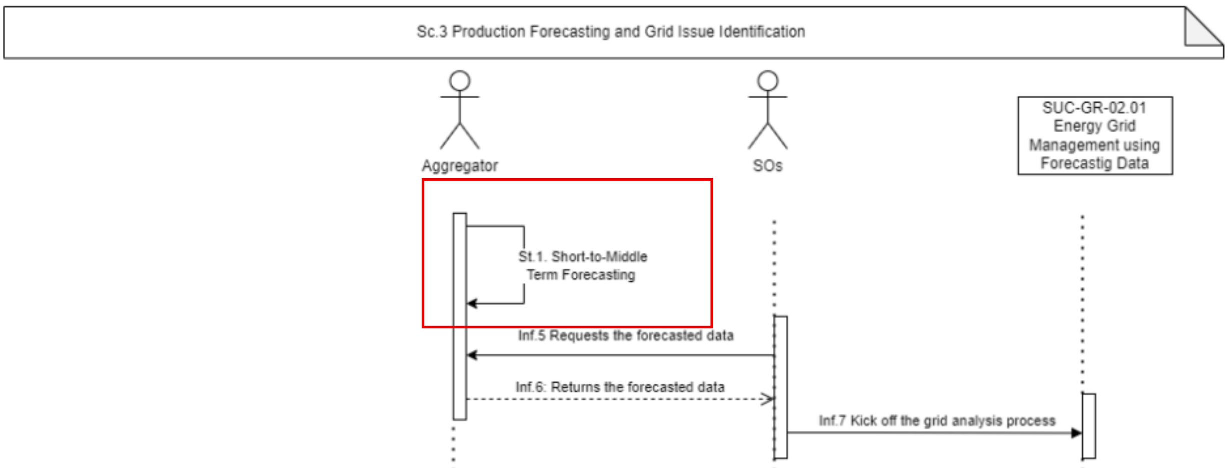

Sc.3 Production Forecasting and Grid Issue Identification
Aggregator
SOs
SUC-GR-02.01 Energy Grid Management using Forecastig Data
St.1. Short-to-Middle Term Forecasting
Inf.5 Requests the forecasted data
Inf.6: Returns the forecasted data
Inf.7 Kick off the grid analysis process

FIGURE 18: DEPLOYMENT DIAGRAM FOR SUC-GR-01.03 (ONGOING PROCESS)

In the context of the production side forecasting a dedicated pipeline was established to generate 15-minute PV forecasts, satisfying the data-quality requirements of SUC-GR-01.02 and SUC-GR-01.03. Because on-site irradiance sensors were not yet online, development and validation relied on the open-source StoreNet Dingle data set (20 dwellings, 15-minute resolution, ~approximately 50% PV-equipped).

The workflow is production-grade. A time-aligned ingestion layer merges PV output with high-resolution weather variables; feature engineering then adds historical lags, rolling statistics, and calendar cues. All inputs are normalised via a version-controlled MinMaxScaler before being fed into a three-layer bidirectional LSTM (100 → 60 → 10 units) that predicts the next 15-minute value recursively. The training utilises MSE loss with the Adam optimiser and dropout regularisation; every model artifact, scaler, and log is versioned in MinIO for full traceability.

The final model achieves an MAE of 0.059 kWh, an RMSE of 0.116 kWh, and an R^2 of 0.89. The elevated MAPE is attributable to near-zero night-time output and does not affect operational usefulness. As illustrated in Figure 19, the predicted curve closely tracks the actual profile, confirming that the service is ready for integration into live dashboards and the RL optimiser in the forthcoming Full-Demo Phase.

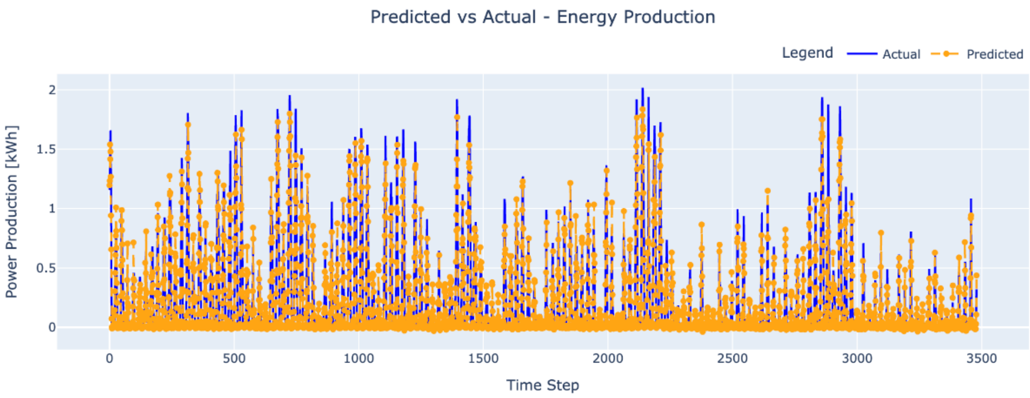


FIGURE 19: PREDICTED VS. ACTUAL PV PRODUCTION — 15-MINUTE BI-LSTM FORECAST (STORENET "DINGLE" CASE STUDY).

SUC-GR-01.04 EDGE PROCESSING

Section	Subsection	Input
Overview	SUC Summary	Real-time monitoring and analysis of residential energy consumption and production using edge IoT devices. It supports flexibility participation in the Local Flexibility Market (LFM) by generating validated, aggregated data and insights for consumers and aggregators.
	Target(s)	Residential consumers and prosumers with IoT edge devices, Aggregators, System Operators, Meter Operators (ICCS).

	Expected UC Milestones	Deployment of edge processing systems in pilot households. Successful real-time data capture and validation. Anomaly detection and trend analysis implemented. Data sharing with Aggregator, UI, and forecasting services (edge & cloud). Integration with SUC-GR-01.02, 01.03, 01.05.
	Actions implemented	Edge IoT devices are installed in demo sites. Data capture APIs operational. Real-time processing pipeline in place. Validated data flows to Aggregator UI and forecasting modules. Statistical metrics implemented. Federated Learning for energy forecasting initial tested completed.
Requirements	Assumptions	IoT edge devices are available and installed. Stable connectivity for real-time data. User participation and data consent. Data is of high quality and accessible.
	Dependencies	Integration with SUC-GR-01.02 (Demand Forecasting), 01.03 (Production), and 01.05 (UI). Data infrastructure for real-time ingestion and analysis.
	Risks	Incomplete or inaccurate data due to sensor/connection faults. Latency in data transmission. System overload or downtime at edge level.
Readiness	Deployment diagram	The deployment diagram for SUC-GR-01.04 is presented in Figure 20 below for clarity.
	Deployment preparation	IoT devices (smart meters) deployed in homes. Edge infrastructure installed and connected. MQTT protocol used for data submission. APIs for data retrieval tested. UI and backend integrated with data pipelines.
	Deployment assessment	System captures, validates, and processes data within seconds. The feedback loop tested with consumers. Forecasting interfaces operational. Data privacy and audit logs established. The system achieves 99.9% uptime with backups.
Validation Activities Summary	Previous cycle	n/a
	Current cycle	Real-time edge data collection and validation tested. Aggregator UI integration was completed. Data forwarded to production/demand forecast systems.
	Future cycle	Extending installation to more households. Implement anomaly detection.

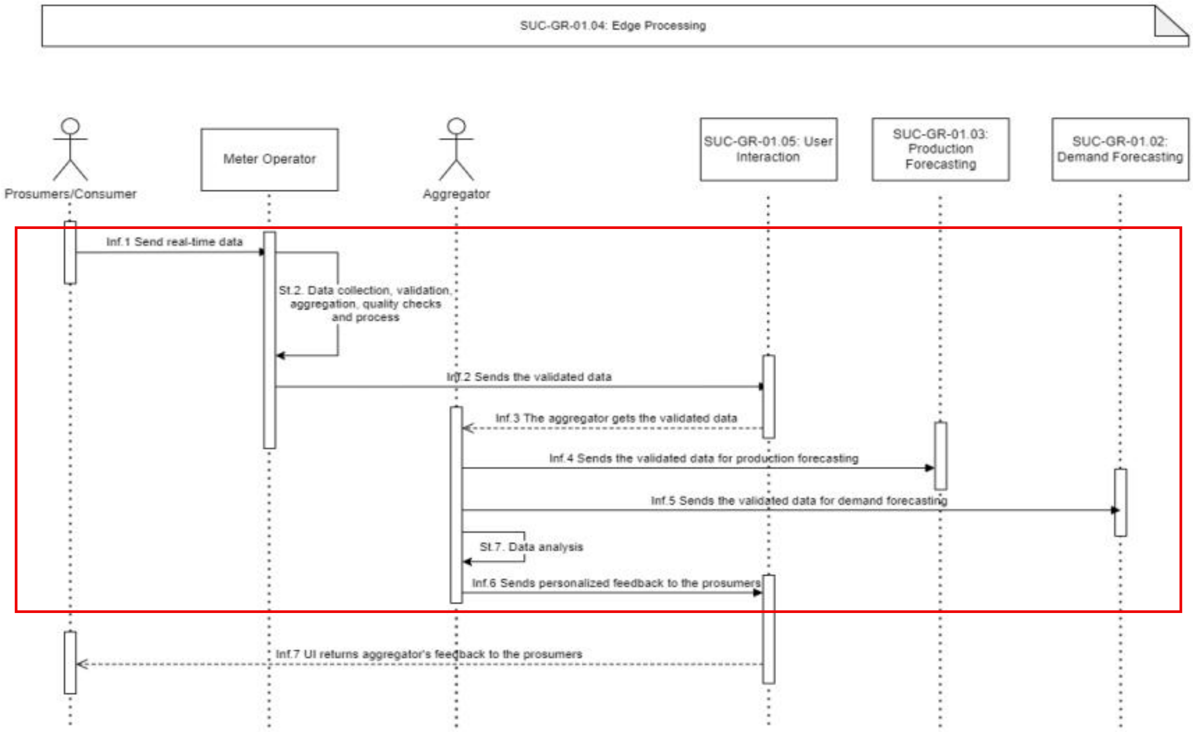


FIGURE 20: DEPLOYMENT DIAGRAM FOR SUC-GR-01.04 (ONGOING PROCESS)

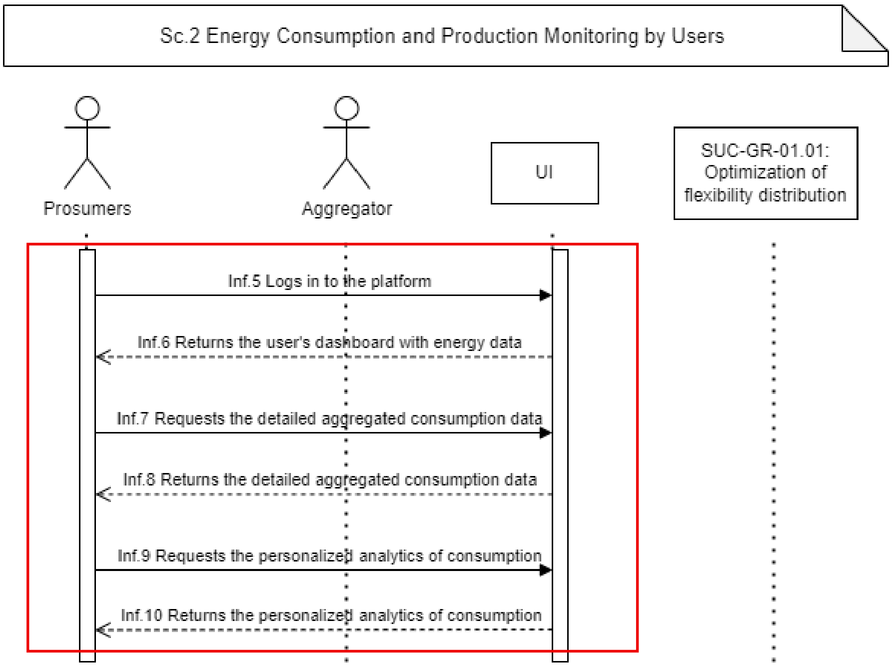
For this SUC, the Federated Learning (FL) service is designed to provide privacy-preserving demand and PV forecasting for the households of the Greek demo. The objective is for each gateway to train a small local model and share only encrypted weight updates with a central coordinator, rather than transmitting raw smart-meter values to the cloud. The central training on actual pilot data is 70% complete; however, the device CPU found the cloud-trained Bi-LSTM models to be too heavy. Plans for the Full-Demo phase include cloud model training and edge-side inference. Once fully deployed, the FL forecasts will be directly incorporated into the NILM and RL-optimisation pipelines.

SUC-GR-01.05 USER INTERACTION

Section	Subsection	Input
Overview	SUC Summary	This SUC delivers an intuitive web/mobile interface through which residential consumers and prosumers can receive, review and answer flexibility requests issued by the aggregator. Besides two-way signalling, the UI visualises 5-min-granular consumption/production data, personalised analytics and the monetary incentives earned for accepted actions, thereby turning end-users into active players in the Local Flexibility Market (LFM).
	Target(s)	During the pre-demo phase (M16), the end-to-end delivery of every SUC-GR-01.05 message between the user interface and the aggregator back-end is to be demonstrated without data loss. Authenticated, encrypted channels shall be used, and the agreed latency and availability thresholds are to be met.

	Expected UC Milestones	**SC.1**: All steps of SC.1 are expected to be deployed by M20. **SC.2**: All steps accomplished, via access to a personalised dashboard that displays all available energy consumption information and provides data access, download and preview capabilities, upon authentication. **SC.3**: The aggregator accesses a dedicated dashboard displaying key metrics such as total energy demand, PV production, net energy balance, and user distribution within the network. The dashboard features live line charts of recent consumption and production data at 5-minute intervals, along with detailed bar charts presenting average and peak values over the past 24 hours. Additionally, short-term forecasts for electricity consumption and production are visualised with confidence bands, enabling the aggregator to monitor real-time and near-future energy trends effectively. PV management and energy price monitoring functionalities are not currently visible in the interface.
	Actions implemented	The dashboards for all scenarios were developed using React to ensure a responsive and user-friendly interface. User authentication and authorisation are managed securely through Keycloak. Dynamic charts were created to visualise consumption, production, and forecast data, leveraging real-time queries to the connected database that stores granular energy data. This architecture enables seamless retrieval and presentation of up-to-date metrics, supporting the monitoring and decision-making processes required by each scenario.
Requirements	Assumptions	• Data are recorded in 1s frequency and are aggregated into multiple time resolutions (ex. 5min, 15min) • Data can be lost if the infrastructure is down
	Dependencies	• API endpoints to interact with the different devices asynchronously • Backup & Monitoring services for the database and cluster status • Authentication service for the verification and access control of users (aggregator & user mode)
	Risks	• Equipment & installation failures can result in bad energy readings and invalid data • Server hardware failure and power outage can result in data gaps • Consumers/Prosumers not familiarised with digital interfaces can result in reduced real-time engagement
Readiness	Deployment diagram	The deployment diagram for SUC-GR-01.05 is presented in Figure 21 below for clarity.
	Deployment preparation	Custom mobile app designed and developed for communicating with the devices and displaying analytics. Custom scripts for setting up the IoT devices developed. User stories created for user navigation.
	Deployment assessment	Updated and redeployed the mobile ui based on initial user feedback. Collected of user screenshots, written and verbal feedback for bug fixes and features prioritisation. Stabilised beta version for proof of concept.
	Previous cycle	n/a

Validation Activities Summary	Current cycle	During the current cycle, the mobile and web UI were deployed and tested with real-time data and actual users. Integration with the cloud services was successful as well as the device control through the app. Feedback was taken to fix issues in the user experience report bugs in API. Emphasis was given in the ease of the user navigation and aesthetics of the visual interface. Further feedback is being collected both for the improvement of the visual components and bugs in the display of real-time data, such as gaps in the data or unexpected values.
	Future cycle	Integration of live notifications for flexibility requests, billing data, energy and production live data and forecasts to the aggregator, connection with Greek spot market prices, integration with flexibility optimisation service for automated requests.



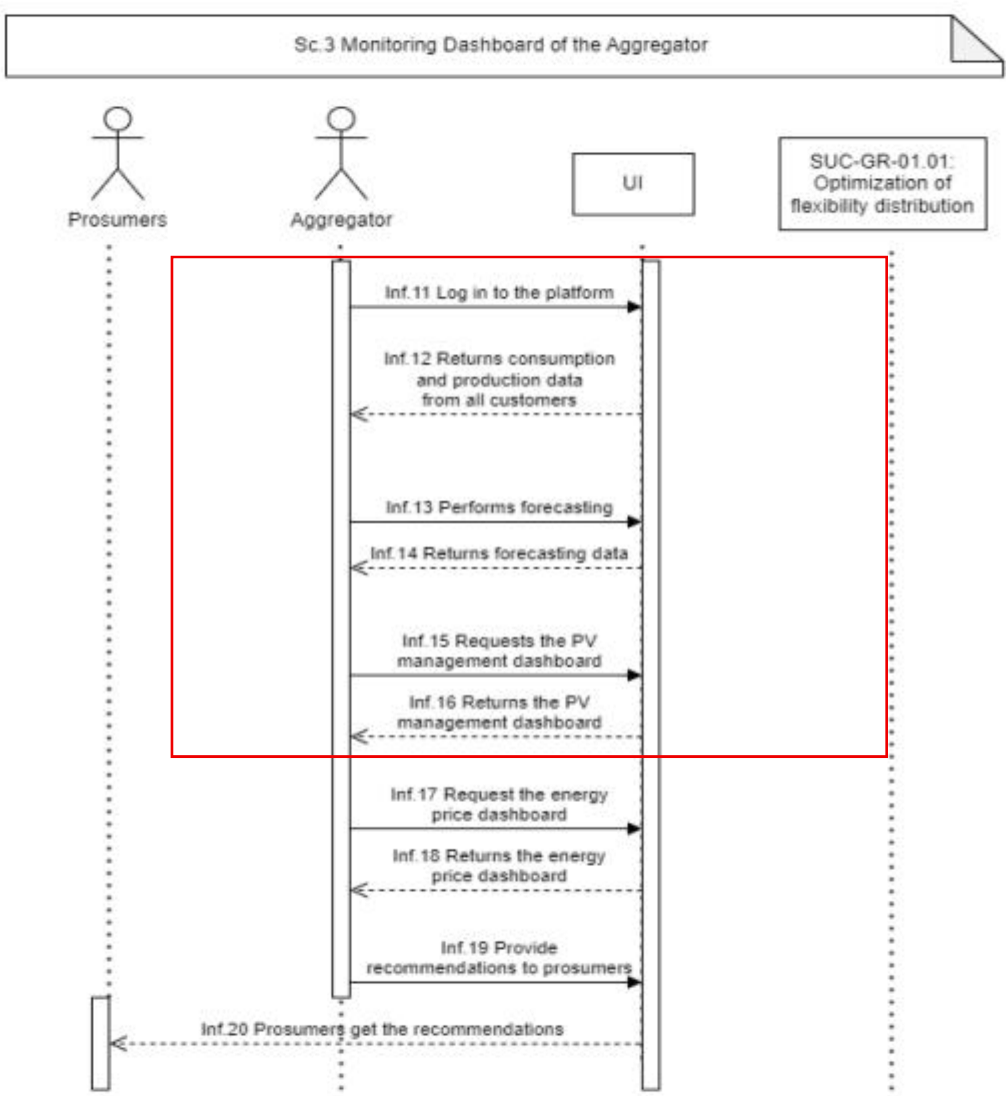


FIGURE 21: DEPLOYMENT DIAGRAM FOR SUC-GR-01.05

The user-interaction service defined in SUC-GR-01.05 is operational, offering two complementary front-ends: one for the mobile app, for the users providing an overview of household electricity consumption as depicted in Figure 22 and one for the aggregator as depicted in Figure 23. Regarding the mobile application, a native Android/iOS app streams one-second readings from household meters and organises them across three screens:

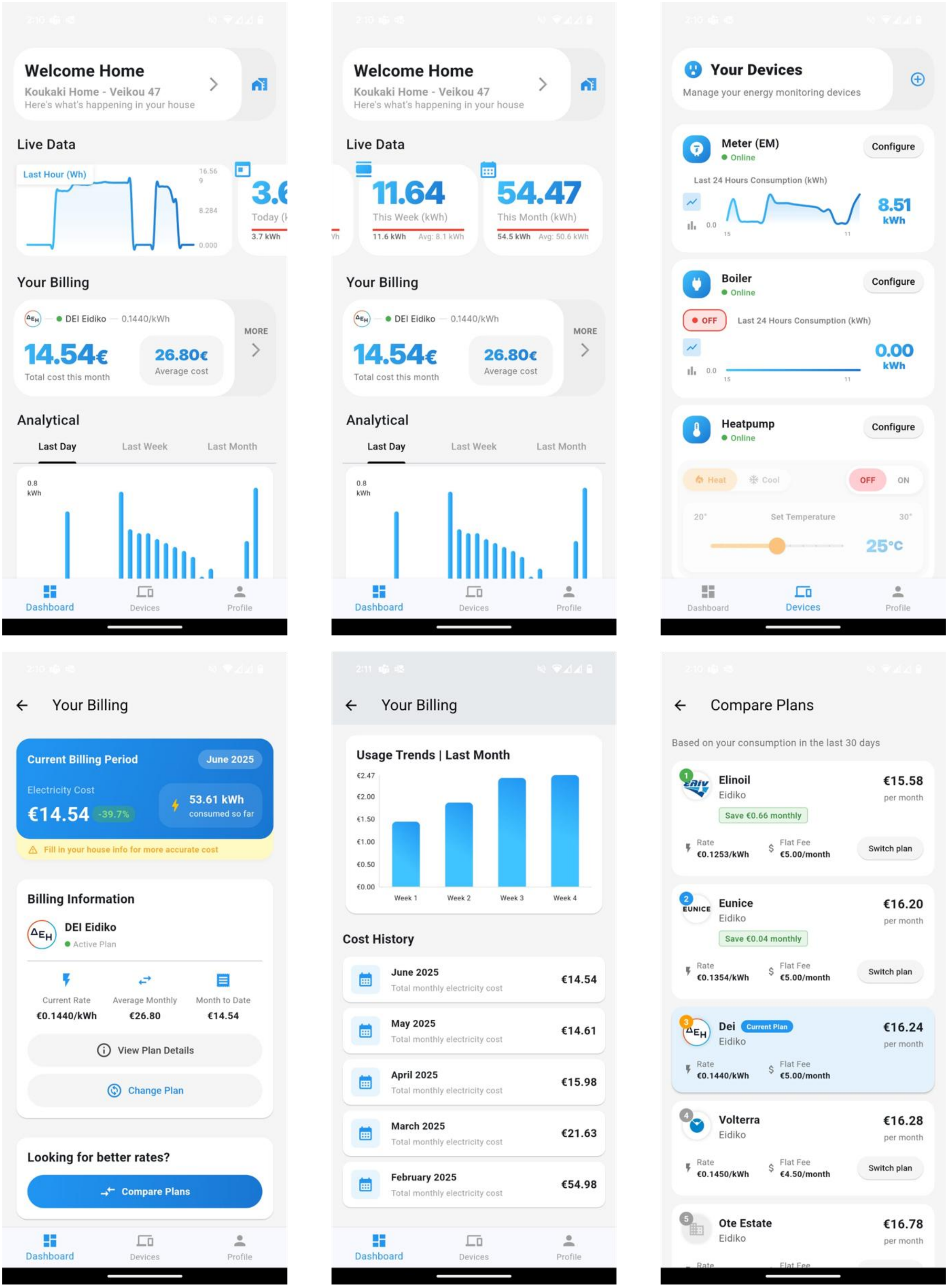


FIGURE 22: SCREENSHOTS OF THE DASHBOARD, DEVICES AND BILLING TABS

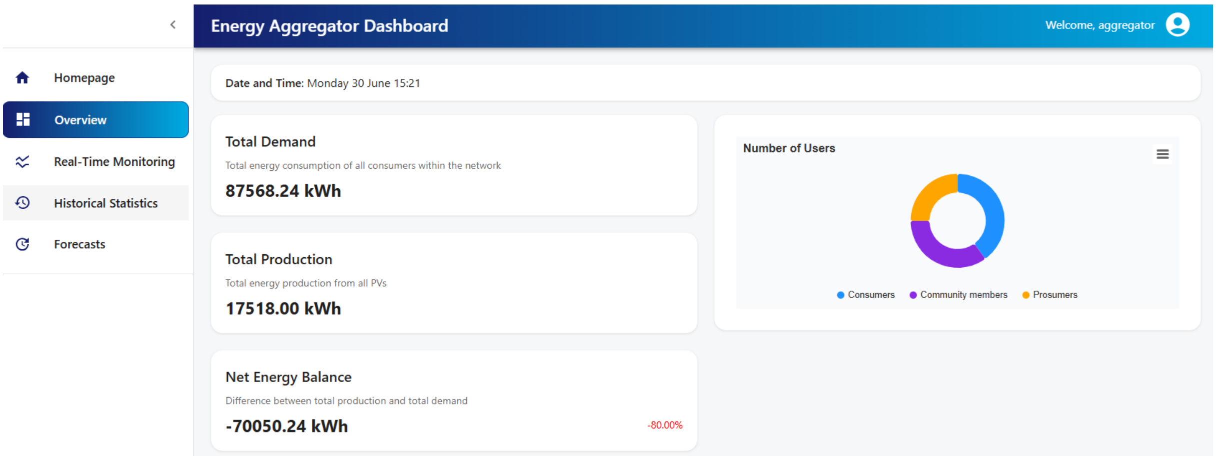


FIGURE 23: ENERGY AGGREGATOR DASHBOARD - OVERVIEW SCREEN

- **Dashboard** with live, daily, weekly and monthly kWh with line- and bar-chart views plus average monthly electricity costs.
- **Devices** indicating 24-hour consumption trend and ON/OFF or temperature status for each appliance, boiler or heat-pump;
- **Billing** for current-month spend, historical cost history and a dynamic tariff comparison that recommends cheaper suppliers based on recent usage.

About the aggregator dashboard, a cloud dashboard aggregates live feeds from the pilot homes. The Overview panel displays total demand, total production, and net energy balance, along with a pie chart showing the breakdown of consumers, community members, and prosumers. **Real-Time Monitoring** refreshes load and generation curves every 60 seconds; **Historical Statistics** provides 24-hour and 7-day bar charts with average and peak call-outs; and **Forecasts** overlay short-term load and PV predictions (blue = measured, red = forecast, orange band = confidence interval). These front-ends depicted collectively in Figure 24 close the user-interaction loop for the Greek demo, feeding live data to residents and decision support to the aggregator while drawing on the forecasting and optimisation services described in SUC-GR-01.02/03 and SUC-GR-01.01.

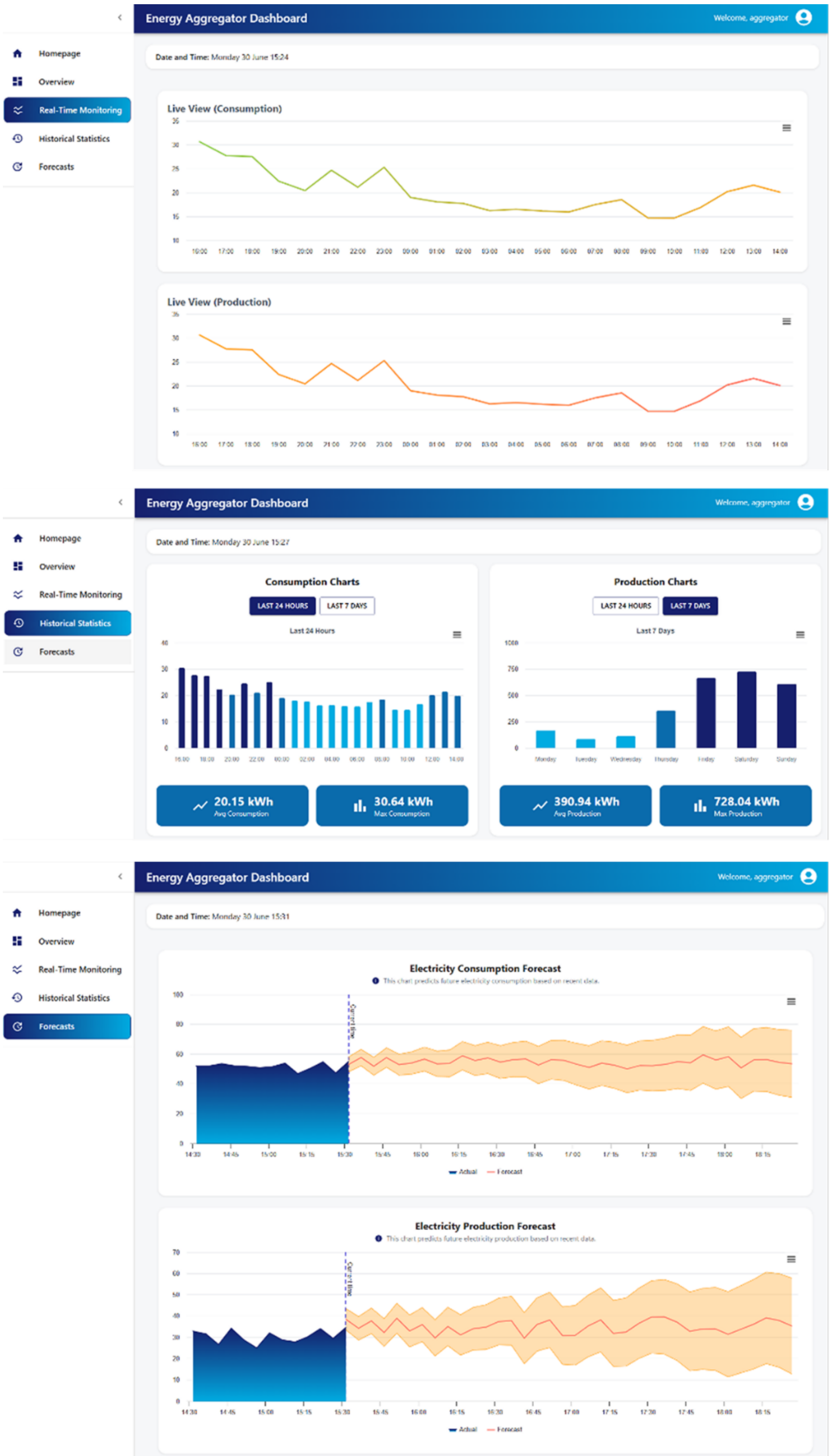


FIGURE 24: ENERGY AGGREGATOR DASHBOARD - REAL TIME MONITORING, HISTORICAL STATISTICS AND FORECAST MODULES

SUC-GR-02.01 ENERGY GRID MANAGEMENT USING FORECASTING DATA

Section	Subsection	Description
Overview	SUC Summary	This SUC enables the integration of forecasted demand and production data into the DSO's grid analysis and decision support tools to optimise local grid operation
	Target(s)	Integrate forecasting services (SUC-GR-01.02 and GR-01.03) with the DSO's grid model and perform grid analysis using parametrised input data.
	Expected UC Milestones	• Integration of production and demand forecast APIs into grid analysis tool • First functional validation of the grid-analysis workflow - tool
	Actions implemented	• Developed internal tool to automate grid analysis using forecast data • Validated sample input cases within the grid analysis tool
Requirements	Assumptions	• Forecast data is available with sufficient accuracy and timeliness • Grid topology and parameters are known and static for initial tests
	Dependencies	• Depends on output from SUC-GR-01.02 (demand forecast) and SUC-GR-01.03 (PV production forecast) • Uses internal grid-model tool and pre-existing network models
	Risks	Delays during the recruitment of consumers
Readiness	Deployment diagram	The deployment diagram for SUC-GR-02.01 is presented in Figure 25 below this table for clarity.
	Deployment preparation	• To complete installation of the IoT submetering devices • To develop the rest API for data exchange between Aggregator and DSO
	Deployment assessment	• Testing for connectivity with the smart meter and the IoT submetering devices. • Testing of data sharing through the rest API.
Validation Activities Summary	Previous cycle	n/a
	Current cycle	Receiving data from smart meters and IoT submetering devices on MQTT broker.
	Future cycle	Successful data sharing through the rest API.

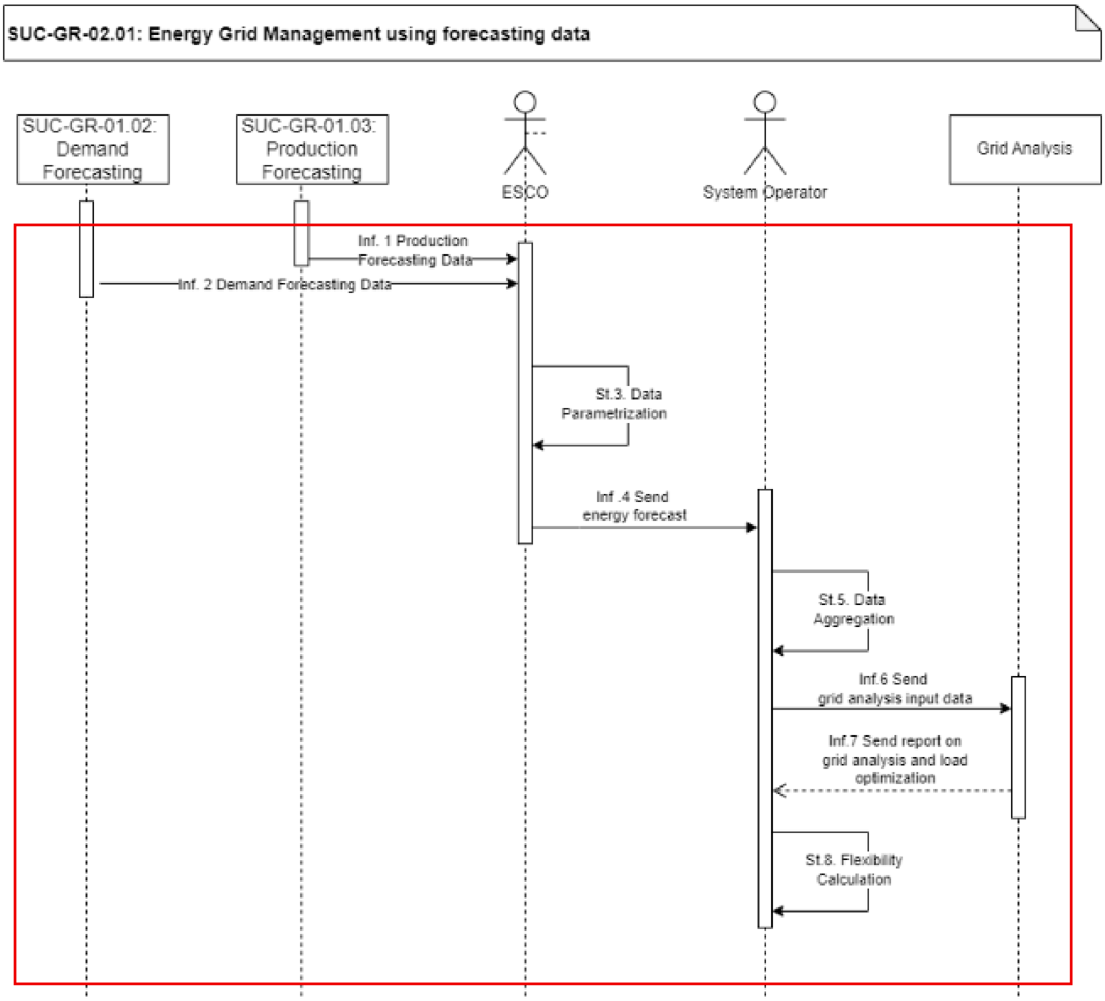


FIGURE 25: DEPLOYMENT DIAGRAM FOR SUC-GR-02.01

SUC-GR-03.01 REGISTRATION & PREQUALIFICATION ON LOCAL FLEXIBILITY MARKET

Section	Subsection	Input
Overview	SUC Summary	The scope of the SUC is to describe the authorisation process for users, in the Local Flexibility Market (LFM) Platform. The LFM Platform offers distinct registration and prequalification procedures tailored to each user's role, ensuring a personalised and efficient process for accessing the platform's features and opportunities.
	Target(s)	Successful execution of the user registration and prequalification processes on the LFM Platform. Additionally, this cycle aims to evaluate the overall usability and effectiveness of the user interface to ensure a smooth and intuitive experience for all user roles.
	Expected UC Milestones	The goal is for a user to be able to successfully register on the LFM Platform, submit assets based on their assigned role, create portfolios, and utilise those portfolios within the platform's environment. These capabilities will demonstrate

		the integration and functional readiness of the authorisation and asset management workflow
	Actions implemented	During this evaluation cycle, key development activities were carried out, including the implementation of core application logic (code development), both API and user interface, and the design and deployment of the supporting database. The application was successfully deployed in a cloud environment, ensuring accessibility and scalability for further testing and user onboarding.
Requirements	Assumptions	Users have assets that can offer flexibility
	Dependencies	The implementation and evaluation cycle depends on the availability and proper configuration of AWS cloud services, which host the application and ensure access to backend infrastructure. These services form the backbone of the platform's deployment, testing, and scalability capabilities.
	Risks	AWS cloud unavailability, very low risk based on AWS service provision agreement (<1%)
Readiness	Deployment diagram	The deployment diagram for SUC-GR.03.01 is presented in Figure 26 below for clarity.
	Deployment preparation	Preparation efforts included the implementation of the backend services and the development of the user interface (frontend), alongside the creation and configuration of the supporting database. To ensure streamlined deployment and scalability, the application was containerised using Docker. The final deployment was successfully carried out in the AWS cloud environment, enabling the infrastructure required for testing and evaluation.
	Deployment assessment	The development & deployment has been successfully completed, and the service is currently in the testing phase. No significant issues have emerged so far, indicating a solid level of readiness for evaluation. The infrastructure appears stable and functional, supporting ongoing validation activities.
Validation Activities Summary	Previous cycle	n/a
	Current cycle	During the current evaluation phase, several key milestones were achieved. These include the completion of the user registration and authorisation processes, enabling role-based access to the platform (FSPs, SOs & Market Operators). Additionally, users were able to register their assets, complete the qualification process for those assets, and proceed with the creation of portfolios. These actions align directly with the intended goals of the cycle, demonstrating that the fundamental user flows of the LFM Platform are functional and ready for further testing or enhancements. Furthermore, the platform's current features were presented to relevant stakeholders during a dedicated session, where its main functionalities were showcased. This session provided an opportunity to gather preliminary feedback from potential users and domain experts, contributing to the iterative improvement of the system ahead of the Full Demo Phase.
	Future cycle	The upcoming cycle will focus on extended testing and debugging activities to ensure system robustness and user satisfaction. Additionally, notification functionalities will be developed and integrated to enhance communication between the platform and its users, supporting a more responsive and interactive user experience. Further enhancement of security on the service will be developed.

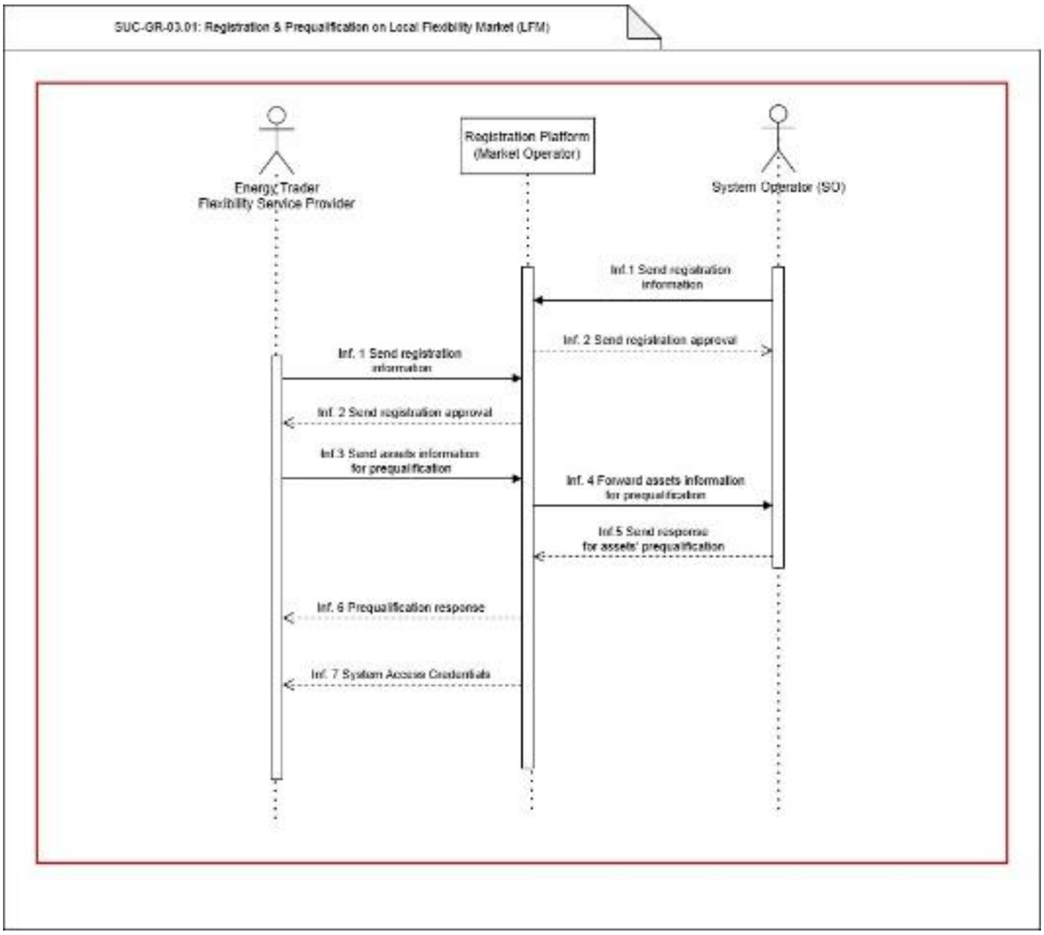


FIGURE 26: DEPLOYMENT DIAGRAM FOR SUC-GR-03.01

SUC-GR-03.02 FLEXIBILITY TRADING

Section	Subsection	Input
Overview	SUC Summary	This use case involves the trading of flexibility services to support grid stability and enhance market efficiency. It focuses on the coordination and interactions among System Operators (SOs), Market Operators (MOs), and Flexibility Service Providers (FSPs) within a structured flexibility market framework. The core processes include the submission of flexibility requests and offers, feasibility assessment of potential trades, market clearing, and settlement procedures. These processes are supported by robust information exchange and coordination mechanisms between the involved actors, ensuring transparency and responsiveness in market operations.
	Target(s)	In this evaluation cycle, the main milestone is the demonstration of a functional and operational energy flexibility trading algorithm. The use case aims to prove that users (FSPs & SOs) can successfully submit flexibility bids and receive corresponding results through the platform.
	Expected UC Milestones	During this evaluation cycle, the following milestones are expected to be achieved: • Activation of a functional bidding mechanism that enables users (FSPs & SOs) to submit valid flexibility offers.

		• Daily generation and proper configuration of Market Time Units (MTUs) and corresponding Trading Windows. • Accurate operation of trading gates, ensuring that they open and close according to the defined schedule. • Execution of the flexibility trading resolution algorithm with validated and correct outcomes reflecting market conditions and user inputs
	Actions implemented	During this evaluation cycle, several key actions were implemented to reach the defined targets and expected milestones: • Development of the core platform functionalities supporting the flexibility trading process. • Dockerisation of the platform to enable modular deployment and portability. • Deployment of the platform on cloud infrastructure (AWS) for scalability and remote accessibility. • Creation and integration of the underlying database structures necessary for storing bids, trades, and temporal parameters. • Automation of Market Time Unit (MTU) and Trading Window generation through scheduled cron jobs. • Real-time management of trading windows, including automated opening and closure based on predefined rules. • Activation of the Flexibility Trading Optimisation Algorithm, ensuring successful execution and return of valid trade results.
Requirements	Assumptions	It is assumed that the participating users have successfully registered on the platform, in alignment with the user onboarding and registration process described in SUC-GR-03.01. This ensures that all functionalities related to bid submission, trading interactions, and result retrieval can be properly validated within an active and authenticated user environment. The DSO has visibility on the network state, can perform network forecast and can submit bids based on them The FSP own assets that can offer flexibility, have visibility on their consumption and submit bids based on their biding strategy. Also, the TSO has to check the effects that the trades have on the network and confirm whether the trades are possible or not.
	Dependencies	The successful execution of the current evaluation cycle relies on the following dependencies: • **AWS Cloud infrastructure**, which hosts the deployment of the flexibility trading platform, providing scalability, availability, and compute resources for algorithm execution and data storage. • **User registration and prequalification**, as defined in SUC-GR-03.01, ensuring that users—whether acting as Flexibility Service Providers (FSPs) or System Operators (SOs)—have completed the onboarding process and are authorised to participate in trading activities according to their roles.

		• The Distribution System Operator (DSO) has visibility over the network state, is capable of performing **network forecasts**, and can submit bids based on anticipated grid conditions and operational requirements. • Flexibility Service Providers (FSPs) own or manage flexible assets, have insight into their **consumption and generation patterns**, and submit bids aligned with their individual bidding strategies and asset capabilities. • The Transmission System Operator (TSO) confirms the feasibility of the trades agreed via the LFM.
	Risks	AWS cloud unavailability, very low risk based on AWS service provision agreement (<1%) The SUC-based procedure fails primarily because the DSO does not provide realistic network data, which in turn prevents the submission of accurate flexibility bids.
Readiness	Deployment diagram	THE DEPLOYMENT DIAGRAM FOR SUC-GR.03.02 IS PRESENTED IN FIGURE 27 BELOW FOR CLARITY.
	Deployment preparation	The preparation phase for deployment included the full-stack implementation of the platform components and their integration with cloud infrastructure. Key steps involved: • **API development** to support user actions, market processes, and bid management. • **Frontend UI creation** for intuitive interaction with platform functionalities. • **PostgreSQL database setup** to manage user information, trades, time units, and flexibility offers. • **Infrastructure provisioning** using AWS EC2 instances with Docker-based containerisation to ensure scalable and portable deployment. • **Scheduled automation** via cron jobs for the generation of Market Time Units (MTUs), Trading Windows (TDs), gate management (open/closure), and triggering of the Flexibility Trading Algorithm. • Use of **registered users**, onboarded during the SUC-GR-03.01 registration process, to simulate and validate trading scenarios.
	Deployment assessment	An assessment was conducted to verify the readiness of the platform components and underlying infrastructure for the upcoming evaluation cycle. Key elements considered included the functional completeness of each module, successful integration of services, and system performance under simulated scenarios. Risk mitigation measures focused on: • Validation of API endpoints and market logic to ensure alignment with defined trading processes. • Load testing of the platform under multiple user and bid submission events to assess stability and responsiveness. • Contingency mechanisms for key operations (e.g. bid submission failures, MTU/TD generation errors) to maintain continuity.

		• Verification of cron-based automations and cloud infrastructure uptime guarantees. • Review of user registration workflows and correct role-based permissions, following SUC-GR-03.01 standards. The assessment confirmed that the deployment meets the technical and functional requirements for launching the evaluation cycle, with identified risks either mitigated or addressed via fallback processes.
Validation Activities Summary	Previous cycle	n/a
	Current cycle	During the current evaluation cycle, the core platform functionalities were implemented and tested. Key achievements include: • Successful deployment of the flexibility trading optimisation algorithm and its integration with the bidding process. • Automation of MTU and Trading Window generation, along with real-time gate management. • Execution of real trades by registered users through the platform, validating the end-to-end trading process. • Identification of remaining gaps in **notifications**, **settlement**, and **result clearing** components, which are scheduled for upcoming implementation.
	Future cycle	In the upcoming evaluation cycle, focus will be placed on completing the remaining components and enhancing the platform's robustness and usability. Planned activities include: • Implementation of the **notification system** to inform users about bid status, trading results, and gate timings. • Deployment and validation of the **settlement and clearing mechanisms**, finalising the trading lifecycle and enabling financial reconciliation. • **Security hardening** of exposed API endpoints, including authentication layers and permission management. • User feedback collection and functional refinements based on usage patterns observed during the current cycle. • Performance optimisation and potential scalability testing to ensure system responsiveness under realistic user load scenarios.

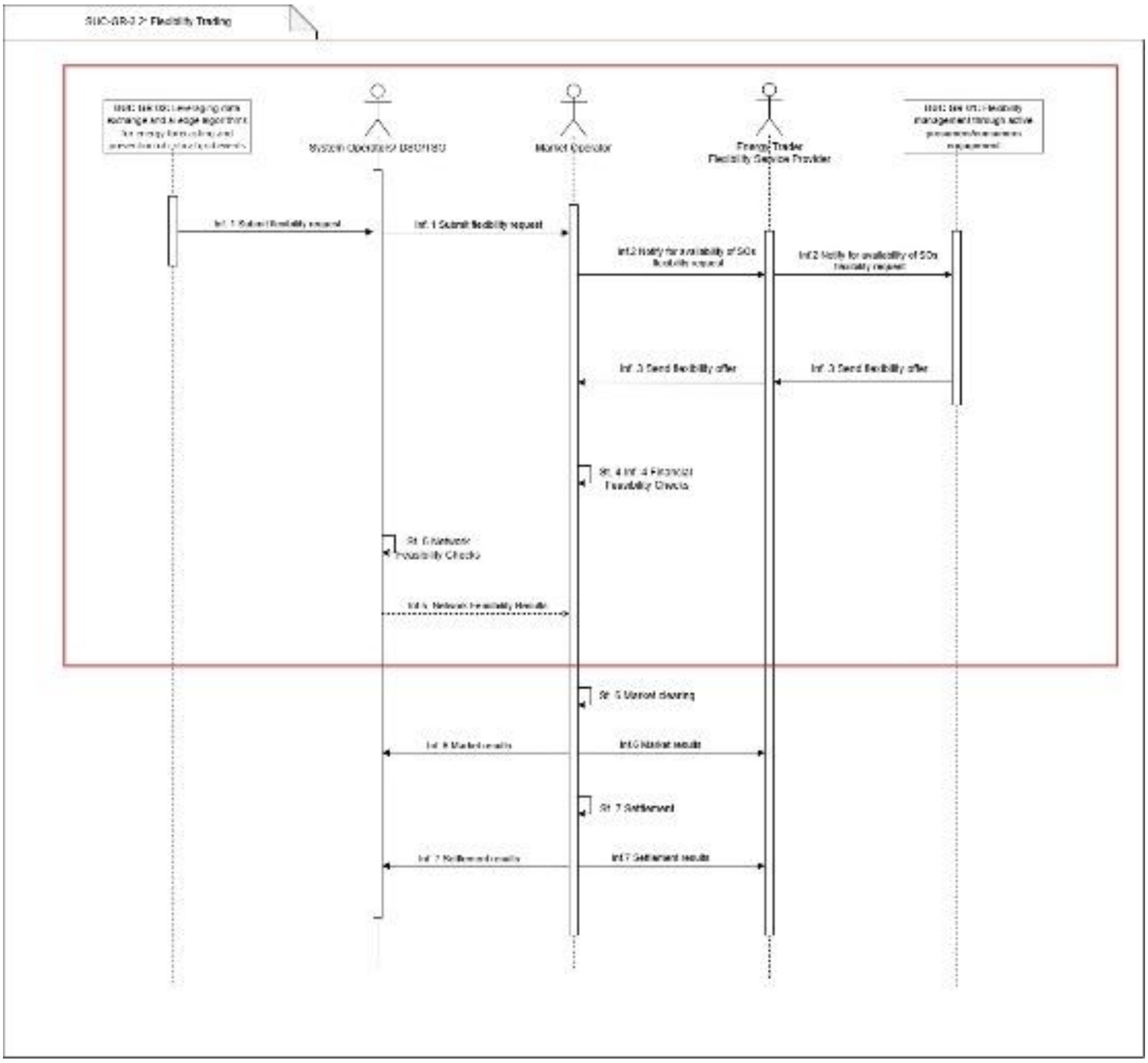


FIGURE 27: DEPLOYMENT DIAGRAM FOR SUC-GR-03.02

HENEX has successfully deployed a secure pilot instance of the Local Flexibility Market (LFM) on its AWS infrastructure, enabling user registration pages (see Figure 28 below for reference), asset onboarding forms, and role profiles for System Operator, Market Operator, and Flexibility Service Provider.

FIGURE 28: LOCAL FLEXIBILITY MARKET: LOGIN AND REGISTRATION PORTAL

The registration workflow was tested with internal test users, and the platform was used to register a sample flexibility portfolio, submit trial bids, and manage market-time-unit scheduling to ensure bid windows opened and closed accurately, as depicted in Figure 29 and Figure 30 below. In Figure 29, the "Assets" view shows test resources already onboarded, their status within market-time units and quick-access actions for evaluation or editing. Please note that in Figure 30 , each row represents a 15-minute trading window with color-coded status indicators showing whether the window is open (green) or closed (red) and whether bids have been successfully cleared.

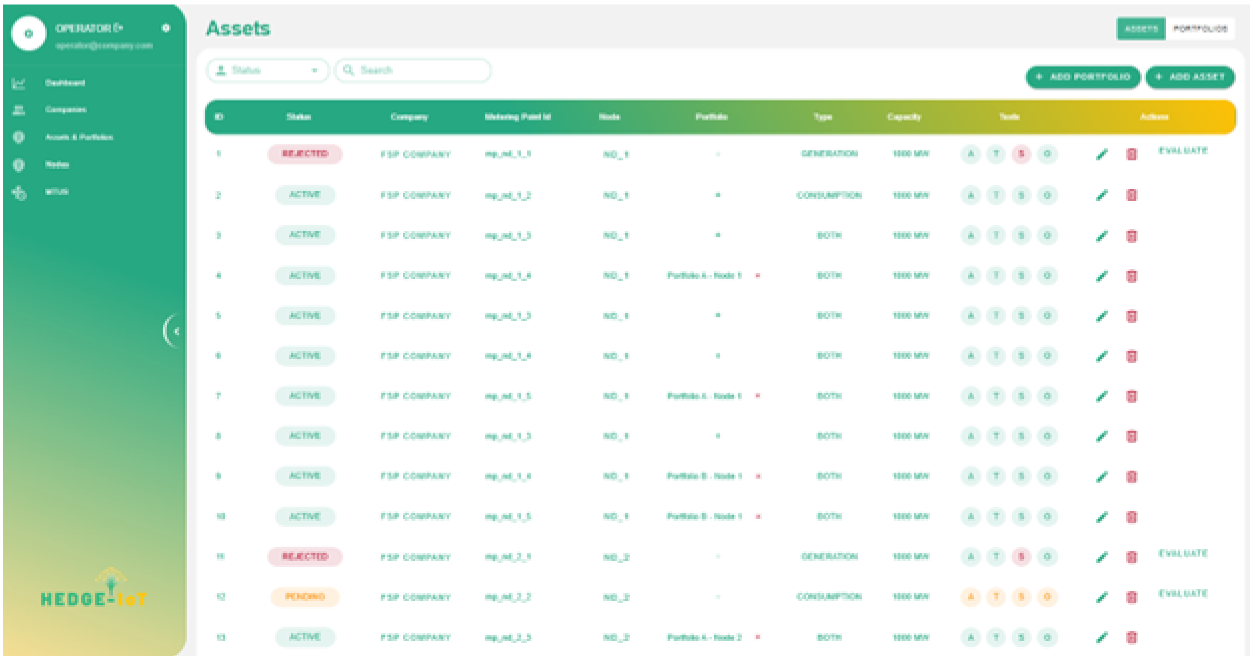


FIGURE 29: LOCAL FLEXIBILITY MARKET - ASSET DASHBOARD

FIGURE 30: LFM PLATFORM MTU SCHEDULER

3.2.3.2 Milestones and Progress

This subsection revisits the internal milestones identified in D5.1 and assesses their current status, noting any updates, delays, or partial completions observed during the Pre-Demo Phase. The information is presented in Table 10, which maps each milestone to the corresponding implementation steps and indicates the extent of progress achieved for the Greek Demo.

TABLE 10: PROGRESS ON GREEK DEMO INTERNAL MILESTONES LINKED TO THE IMPLEMENTATION OF SYSTEM USE CASES (SUCS) DURING THE PRE-DEMO PHASE

Internal Milestones	Month	SUC-GR-01.01	SUC-GR-01.02	SUC-GR-01.03	SUC-GR-01.04	SUC-GR-01.05	SUC-GR-02.01	SUC-GR-03.01	SUC-GR-03.02
Finalisation of required data sources	M9	-	-	-	-	-	-	n/a	n/a
Initial data sample testing	M11	SC1 Steps4-10	SC1 All Steps	SC1 All Steps	SC1 Steps 1-7	SC2 All Steps SC3 Steps 1-6	SC1 Steps 1,2,5-8	n/a	n/a
Alpha version	M12	SC1 Steps4-10	SC1,2,3 All Steps	SC1,2,3 All Steps	SC1 Steps 1-7	SC2,3 Steps	SC1 Steps 1,2,5-8	SC1 All Steps	SC1,2 All Steps
Complete connection	M15	Ongoing	Ongoing	Ongoing	Ongoing	Ongoing	Not tested yet	n/a	n/a

points with data sources									
Beta version	M20	-	-	-	-	-	-	-	-
Final version	M26	-	-	-	-	-	-	-	-
Fully Validated in the demo	M36	-	-	-	-	-	-	-	-

3.2.4 Pre Demo Evaluation

3.2.4.1 Requirements Evaluation

The following section presents the requirement for each SUC, which was initially introduced in D5.1 including the description, acceptance criteria, and assigned testing partner. An additional column now captures the progress status recorded during the Pre-Demo Phase, allowing a direct comparison between the targets set in D5.1 and the results achieved to date.

SUC-GR-01.01 OPTIMISATION OF FLEXIBILITY DISTRIBUTION

Req.	Description	Acceptance Criteria	Progress
QoS.1	Contractual timelines for data exchange	Checks that contractual timelines for exchanging data exist and are followed	To be tested later
QoS. 2	Frequency of data exchanges	Data frequency tests	To be tested later
Sec. 1	Information theft	Consent of users. Data are secured in storage facilities (edge & cloud). Performance tests.	To be tested later
Sec. 2	Information integrity violation	Data are secured in storage facilities (edge & cloud). Periodic sample testing and backups.	To be tested later
Sec. 3	Replay	Databases security. Use of HEDGE-IoT connector	To be implemented later
D.1	Management of data across organisational boundaries	Available data pipelines. Use of HEDGE IoT connector	To be implemented later
D.2	Correctness of source data	Performance tests in IoT devices. Random checks and sample validations	To be tested later
D.3	Data consistency and synchronisation management across systems	System monitoring of edge and cloud components. System uptime.	To be tested later

O.1	Personal data processing	User consent if personal data is required. Data anonymisation techniques where needed.	Implemented
O.2	Right to access, rectify, erasure, restriction	Data be available in end users	Implemented
O.3	Data transfer consent	User consent	Implemented
Conf.1	Operation mode of Information Producer	Tests to check the automation of information production	To be tested later
Conf.2	Operation mode of Information Receiver	Tests to check the automation of information receipt	To be tested later
Conf.3	Relative maturity of current implementation	Checks that the implementation is mature and well implemented	To be implemented later
Conf.4	Distance between entities	Check the topology of the entities	To be implemented later

SUC-GR-01.02 DEMAND FORECASTING & SUC-GR-01.03 PRODUCTION FORECASTING

Req.	Description	Acceptance Criteria	Progress
QoS.1	Elapsed time response requirements for exchanging data	Check the forecast horizons and the availability of the forecast	Implemented
QoS. 2	Availability of information flows	Data pipelines availability	Implemented
QoS. 3	Accuracy of data requirements	Accuracy is accepted through consensual agreements and periodic sample testing	Implemented
QoS. 4	Frequency of data exchanges	Every data exchange request is performed	Implemented
Sec. 1	Information theft	Consent of users. Data are secured in storage facilities (edge & cloud). Performance tests.	Implemented
Sec. 2	Information integrity violation	Data are secured in storage facilities (edge & cloud). Periodic sample testing and backups.	Implemented
Sec. 3	Replay	Databases security. Use of HEDGE-IoT connector	To be implemented later
Sec. 4	Denial of service	Database security and user roles based security. Use of HEDGE-IoT connector	To be implemented later

Sec. 5	Authentication	Database security and user roles based security. Use of HEDGE-IoT connector	To be implemented later
D.1	Type of source data	Comparisons and validity checks between edge sensors	To be implemented later
D.2	Correctness of source data	Performance tests in IoT devices. Random checks and sample validations	To be implemented later
D.3	Up-to-date management	Data are updated per agreed intervals (minute, 5-mins, 15-mins, 1-h)	Implemented
D.4	Management of large volumes of data that are being exchanged	Amount of data exchanged between edge and cloud components	Implemented
D.5	Data consistency and synchronisation management across systems	System monitoring of edge and cloud components. System uptime.	Implemented
D.6	Management of accessing different types of data to be exchanged	Establishment of specific data models	Implemented
D.7	Transaction integrity required (backup and rollback capability)	Standard security tests are performed periodically	Implemented
D.8	Management of data formats in data exchanges	Use of common data models and interoperability standards	To be implemented later
O.1	Personal data processing	User consent if personal data is required. Data anonymisation techniques where needed.	Implemented
O.2	Right to access, rectify, erasure, restriction	Data be available in end users	Implemented
O.3	Data transfer consent	User consent	Implemented
Conf.3	Distance between entities	Check the topology of the entities	To be implemented later
Conf.4	Data exchange methods	Use of agreed edge and cloud communication protocols	Implemented
Conf.7	Operation mode of Information Producer	Tests to check the automation of information production	To be implemented later
Conf.8	Operation mode of Information Receiver	Tests to check the automation of information receipt	To be implemented later

SUC-GR-01.04 EDGE PROCESSING

Req.	Description	Acceptance Criteria	Progress
QoS.1	Elapsed time response requirements for exchanging data	Data exchange is less than 1 minute	Implemented
QoS. 2	Availability of information flows	Data pipelines availability	Implemented
QoS. 3	Accuracy of data requirements	Accuracy is accepted through consensual agreements and periodic sample testing	Implemented
QoS. 4	Frequency of data exchanges	Every data exchange request is performed	Implemented
Sec. 1	Eavesdropping	Standards security measures	Implemented
Sec. 2	Information integrity violation	Data are secured in storage facilities (edge & cloud). Periodic sample testing and backups.	Implemented
Sec. 3	Authentication	Database security and user roles based security. Use of HEDGE-IoT connector	To be implemented later
Sec. 4	Repudiation	Data are always available to be sent	Implemented
Sec. 5	Information theft	Consent of users. Data are secured in storage facilities (edge & cloud). Performance tests.	Implemented
D.1	Type of source data	Comparisons and validity checks between edge sensors	Implemented
D.2	Correctness of source data	Performance tests in IoT devices. Random checks and sample validations	Implemented
D.3	Up-to-date management	Data are updated per agreed intervals (minute, 5-mins, 15-mins, 1-h)	Implemented
D.4	Management of large volumes of data that are being exchanged	Amount of data exchanged between edge and cloud components	Implemented
D.5	Data consistency and synchronisation management across systems	System monitoring of edge and cloud components. System uptime.	Implemented
D.6	Validation of data exchanges	Periodic accuracy tests with edge meters	Implemented
D.7	Management of data formats in data exchanges	Use of common data models and interoperability standards	Implemented

O.1	Personal data processing	User consent if personal data is required. Data anonymisation techniques where needed.	Implemented
O.2	Right to access, rectify, erasure, restriction	Data be available in end users	Implemented
O.3	Data transfer consent	User consent	Implemented
Conf.7	Operation mode of Information Producer	Tests to check the automation of information production	To be implemented later
Conf.8	Operation mode of Information Receiver	Tests to check the automation of information receipt	To be implemented later

SUC-GR-01.05 USER INTERACTION

Req.	Description	Acceptance Criteria	Progress
QoS.1	Elapsed time response requirements for exchanging data	Data exchange is less than 1 minute	Implemented (~100ms)
QoS. 2	Availability of information flows	Data pipelines availability	Implemented Data are preprocessed on the cloud asynchronously and provided back to the user through APIs
QoS. 3	Accuracy of data requirements	Accuracy is accepted through consensual agreements and periodic sample testing	Partly Implemented Accuracy of measurements are tested for some houses by comparing to the energy bill measurement
QoS. 4	Frequency of data exchanges	Every data exchange request is performed	Data are transmitted every second from the house meter
Sec. 1	Eavesdropping	Standard security measures	Implemented Data are encrypted over TLS for the MQTT protocol
Sec. 2	Authentication	Database security and user roles based security. Use of HEDGE-IoT connector	Implemented MQTT connection is protected by role based security and API access is protected by access token auth
Sec. 3	Information theft	Consent of users. Data are secured in storage facilities (edge & cloud). Performance tests.	Implemented Data are secured in proprietary database which cannot be accessed from a public url.

Sec. 4	Denial of Service	Data are always available to be sent	System is not secured against Denial of Service attacks
Sec. 5	Information theft	Database security and user roles based security. Use of HEDGE-IoT connector	Database can only be accessed internally from another api service.
D.1	Type of source data	Comparisons and validity checks between edge sensors	All sensors transmit the same payload structure. Any structure that is different is ignored from the preprocessing
D.2	Correctness of source data	Performance tests in IoT devices. Random checks and sample validations	Not implemented
D.3	Management of large volumes of data that are being exchanged	Amount of data exchanged between edge and cloud components	There is no large data exchanged, the exchange happens frequently with small data chunks
D.4	Data consistency and synchronisation management across systems	System monitoring of edge and cloud components. System uptime.	Implemented Monitoring dashboard is configured for the cloud component status
O.1	Personal data processing	User consent if personal data is required. Data anonymisation techniques where needed.	Data anonymisation is not implemented. User signs a form for handling and processing of data.
O.2	Right to access, rectify, erasure, restriction	Data be available in end users	To be implemented later
O.3	Data transfer consent	User consent	Not Implemented
Conf.1	Operation mode of Information Producer	Tests to check the automation of information production	Implemented Proprietary script to control the frequency of data and connectivity of sensor
Conf.2	Operation mode of Information Receiver	Tests to check the automation of information receipt	Implemented MQTT broker connected to a proprietary connector for real-time data reception.

SUC-GR-02.01 ENERGY GRID MANAGEMENT USING FORECASTING DATA

Req	Description	Acceptance Criteria	Progress
QoS.1	Frequency of data exchanges: Upon request	Data exchanges occur upon request and meet required frequencies for the system's performance.	To be tested later
Sec.1	Authentication and Access Control mechanisms commonly used with this data exchange: Private (secret) key encryption	Authentication and encryption validated.	To be implemented later

D.1	Correctness of source data: Source data is usually correct	Random checks and sample validations	To be tested later
D.2	Up-to-date management: Received data must be up-to-date within hours of source data changing	Random checks and sample validations to verify that received data is up to date within hours of changes in source data.	To be tested later
Conf.1	Data exchange methods: Client-server Through database	Client-server or database exchange methods validated through performance tests.	To be tested later
O.1	Data transfer consent: The data subject shall have the right to obtain from the controller without undue delay the access, rectification, erasure, restriction of inaccurate personal data concerning him or her.	GDPR compliance verified through consent management and system monitoring.	To be tested later

SUC-GR-03.01 REGISTRATION & PREQUALIFICATION ON LOCAL FLEXIBILITY MARKET & SUC-GR-03.02 FLEXIBILITY TRADING

Requirement	Description	Acceptance Criteria	Progress
QoS.1	Availability of information flows	Information flows must be available at all times, with no disruption to data transmission.	To be tested later
QoS.2	Accuracy of data requirements	Data requirements must be precise and verified to ensure correctness.	To be tested later
QoS.3	Frequency of data exchanges	Data exchanges should occur at defined intervals, adhering to the required frequency.	To be tested later
Sec. 1	Ensuring confidentiality, avoiding illegitimate use of data, and preventing unauthorised reading of data, is:	Data must be encrypted, access control implemented, and unauthorised access prevented.	To be tested later
Sec. 2	Information integrity violation: Ensuring that data is not changed or destroyed is:	Mechanisms should be in place to prevent unauthorised data modification or destruction.	To be tested later
Sec. 3	Authentication and Access Control mechanisms commonly used with this data exchange	Secure access via API keys or tokens must be verified and managed appropriately.	To be tested later

D.1	Correctness of source data	Source data must be verified to ensure it is accurate and reliable.	To be tested later
D.2	Up-to-date management	Data must be continuously managed to ensure its timeliness and relevance	To be tested later
O.1	Personal data processing	Personal data must be processed in compliance with relevant regulations.	To be tested later
O.2	Right to access, rectify, erasure, restriction	Mechanisms should be in place to allow individuals to access, correct, erase, or restrict their data.	To be tested later
O.3	Data transfer consent	Users must provide explicit consent for the transfer of their personal data.	To be tested later
O.4	Data Retention Policy	There should be a clear policy on how long data is retained, with provisions for secure deletion.	To be tested later
Conf.1	Number of Information Producers	Identify and maintain a count of all data producers.	To be tested later
Conf.2	Number of Information Receivers	Identify and maintain a count of all data receivers.	To be tested later
Conf.3	Data exchange methods	Document and verify all methods used for data exchange.	To be tested later
Conf.4	Communication access services requirements	Ensure communication services used for data exchange meet specified requirements.	To be tested later
Conf.5	Commonly used communication protocol	Ensure communication services used for data exchange meet specified requirements.	To be tested later

3.2.4.2 KPIs Progress

The KPIs to be measured by the Greek demo, their corresponding baseline and target values, are presented in Table 11 below. A new "Progress" column has been included to document developments during the Pre-Demo Phase (M16–M18). A "0" value under the progress column indicates that no measurable data has been collected during the pre-demo phase for the respective KPI. This does not reflect underperformance but rather the fact that measurement is scheduled to begin in the Full Demo Phase.

TABLE 11: KEY PERFORMANCE INDICATORS (KPIS) DEFINED FOR THE GREEK DEMO, INCLUDING SUC RELEVANCE, BASELINE AND TARGET VALUES, AND REPORTED PROGRESS DURING THE PRE-DEMO PHASE

ID	KPIs	Baseline	Target	Progress

OB1	Different types of IoT/edge devices to be exploited in Demo Areas e.g., Smart Meter, HEMS, Sensors, inverter	0	>5	Submetering IoT devices, billing devices, smart plugs
OB4	Users involved in the piloting	100	20% at M18, 60% at M32, 100% at M42	55 devices have been installed so far, actively transmitting
KPI3	% Of planned usage of HEDGE-IoT tools/data services (e.g., transactions, periodicity) in field demos	0	10% Y1, 40% Y2, 60% Y3, 100% Y4	0
KPI4	Real-time data sharing among stakeholders	0	10% Y1, 40% Y2, 60% Y3, 100% Y4	55 devices transmitting in real-time (per second)
KPI6	End-users' bill reduction by offering flexibility services	n/a	10% Y1, 40% Y2, 60% Y3, 100% Y4	0
KPI7	Increased RES and IoT deployment for providing flexibility services	0	10% Y1, 20% Y2, 25% Y3, 30% Y4	0
KPI8	IoT/Edge/Fog sites uptime and availability	n/a	99,9%	Availability of cloud components ~96%
KPI9	Flexibility unlocked and transacted in markets	0	30% increase	n/a
KPI10	Number of consumers engaged with flexibility services	0	>1000 end users	55 users
KP12	Faster application response times	n/a	20% improvement	All interactions with the user are performed through the cloud. Response times are between 100-200ms
KPI13	Savings in network bandwidth and lower latency	n/a	20%	Savings in network bandwidth come from the standardised and minimised payload from the devices. The rate of transmission is fixed. 1 measurement per second.
KPI17	Increased flexibility incorporation enabled by IoT/Edge technologies for grid security	0	5% Y1, 10% Y2, 15% Y3, 30% Y4, 45% Y5+	0
KPI21	Cross-energy flexibility enabled by HEDGE-IoT solution	0	15% at the end of the project	0

KPI22	Increase DERs participation in flexibility provision	0	5% Y1, 10% Y2, 15% Y3, 20% Y4, 25% Y5+	0

3.3 DEMO 3 – DIGITALIZE ENERGY COMMUNITIES AND EV STATION BY IOT AND EDGE CLOUD TO ENHANCE GRID RESILIENCE AND RES HOSTING [ITALY]

3.3.1 Pre – Demo Phase Activities Summary

This section presents a structured summary of the activities that the Italian Demo conducted during the Pre-Demo Phase (M16–M18). It expands upon the demo deployment template introduced in Chapter 2, which functions as a reference for monitoring the development of each demonstrator. The status of the pre-demo targets, the WP3 services utilised, and the key stakeholders involved during this phase are all detailed in Table 12 below. The purpose of the information is to establish the foundation for the Full Demo Phase and to evaluate the operational readiness of the demo at the conclusion of the Pre-Demo Phase.

TABLE 12: DEMO 3 PRE-DEMO PHASE DEPLOYMENT STATUS

Section	Subsection	Input
Summary	Pre-Demo Phase Target	Connecting the platforms. Prepare the engagement campaign. Procure field devices and storage. Design network algorithms.
	Status Summary	Objectives completed
	Services Used (from WP3)	• Apio IoT Platform • Energy Community Platform • Market Interface Platform • Flexibility Register • PGUI
	Stakeholders involved during Pre-Demo	All stakeholders envisaged by the BUCs have been engaged

3.3.2 Infrastructure, Assets and Data Availability

Based, on the demo-deployment template that was introduced in chapter 2, a consolidated snapshot of the infrastructure and assets mobilised during the Pre-Demo Phase is provided in Table 13 for the Italian demo. Each asset is accompanied by its technical description, deployment level, use status in months 16–18, and the WP 3 service to which it pertains.

TABLE 13: SUMMARY OF ITALIAN DEMO INFRASTRUCTURE AND ASSETS DEPLOYED DURING THE PRE-DEMO PHASE

Asset	Description	Deployment Level	Used during Pre-demo	Under which WP3 service
Blockchain Access Layer	IoT Devices Management and measurement notarisation algorithms.	To be integrated with the demo's assets	Yes	N/A

Energy Community management web app	Web interface for enabling energy community management by FSP and for setpoint computation	To be developed	Yes	ECP Platform (Apio Balance, D3.4)
Report Generator	Backend Software for generating Energy Community performance report	To be developed	No	N/A
PV Performance Forecasting Tool	ML Based tool for photovoltaic performance forecasting	To be developed	Yes	ECP Platform (Apio Balance, D3.4)
PV Performance Benchmarking Tool	Real-Time photovoltaic performance benchmarking algorithms	To be Deployed	Partly	N/A
Behind The Meter Assets	EMS / BMS and other field equipment	To be Deployed	No	N/A
Anomaly Detection Tool	Real-Time and Batch anomaly detection algorithms	To be Developed	Partly	N/A
Flexibility Register	Archives flexible assets, market result and settlements	To be Integrated with the demo's assets	Yes	N/A
IoT Platform	Handles connection to IoT-enabled resources and make data available to other systems	To be Integrated with the demo's assets	Yes	ECP Platform (Apio Balance, D3.4)
Asset Management	A DSO's system handling the physical and constructive characteristics of grid elements	To be Integrated with the demo's assets	Partly	N/A
Topology Processor	A DSO's system containing the current and expected grid topology	To be Integrated with the demo's assets	Partly	N/A
IoT Weather stations	IoT-enabled weather stations; temperature, humidity, wind, irradiation	To be deployed	Yes	N/A
Dynamic line rating tool	Conductor thermal ratings in a dynamic evolution for LV and MV cable	To be developed	Partly	N/A
Load and Production Forecast tool	Tool to foreseen loads and productions in Short Terms.	To be developed	Partly	N/A

Weather service	Contains data from both IoT Weather stations and remote weather service(s)	To be developed	No	N/A
Grid Measurement Assets	IoT-enabled sensors and IED installed on lines and/or substations	Deployed	Partly	N/A

Table 14 summarises the datasets relevant to the Pre-Demo Phase, indicating their availability, whether they were used during this period and their linkage to the corresponding WP3 technological enablers.

TABLE 14: OVERVIEW OF DATASETS RELEVANT TO THE PRE-DEMO PHASE OF THE ITALIAN DEMO

Data Description	Used during Pre-Demo Phase	Under which WP3 service
Residential active power measurements	Data Sample	ECP Platform
Forecasted Photovoltaic Performances	Data Sample	ECP Platform
Computed Photovoltaic Performances	Data Sample	ECP Platform
Customer Information	Data Sample	ECP Platform
Market Data	Data Sample	ECP Platform
Grid Topology	Data Sample	N/A
DSO smart metering data (LV, MV, consumers/prosumers/PV plants)	Data Sample	N/A

3.3.3 Pre-Demo Results

This section captures the status and progress of System Use Case (SUC) implementation during the Pre-Demo Phase (M16-M18) for the Italian demo. For each SUC, key developments are outlined, including the specific actions undertaken, intermediate achievements, and alignment with the expected implementation steps and scenarios described in D2.2. In addition, the internal milestones defined in D5.1 are revisited and assessed in terms of progress and completion. This structured overview offers insight into the readiness and maturity of each SUC ahead of the upcoming demonstration cycles.

3.3.3.1 SUCs Implementation

This subsection presents the implementation progress of each System Use Case (SUC) as defined in D2.2 for the Greek Demo, highlighting the actions carried out during the Pre-Demo Phase.

SUC-IT-01.01 ENERGY COMMUNITY POWER MANAGEMENT

Section	Subsection	Input
Overview	SUC Summary	The SUC-IT-01.1 implements a centralised power management solution for energy communities, replacing the classical local BTM approach. By leveraging data from DERs, EMS, baselines, and market sources, it enables smarter power management policies
	Target(s)	The current evaluation cycle targets involve the engagement of at least one Energy Community—including six consumers and one vulnerable member, the open-source release of data connector implementations, and increased participation in flexibility markets through the proposed solution. These targets support Use Case Objective 1.
	Expected UC Milestones	The internal milestones to be achieved are the functional and technical requirements milestones. Those will be achieved fully, since all the specifications are laid out. Platform prototype Available & Data Models will be achieved fully also. The Use case will implement the first 4 steps of the scenario.
	Actions implemented	The identification and registration of Behind-The-Meter (BTM) resources in the Energy Community Platform, interfacing these resources via field data or manufacturer channels, and initiating data normalisation using the appropriate ontology. External data such as baselines were integrated into the platform. Initial versions of optimisation algorithms were developed to generate activation setpoints, and setpoint dispatch mechanisms were established. In parallel, containerised microservices were implemented for local and cloud deployment, exposing REST JSON APIs.
Requirements	Assumptions	The key assumptions regard that enough energy community members (producers and prosumers) are instrumented, allowing consistent data acquisition.
	Dependencies	The execution of this activity depends on interactions with other developed services and components, ensuring several key prerequisites are met. This includes engaging enough energy community members, to provide comprehensive and representative data. Additionally, it is necessary to identify at least one vulnerable user within the community. These dependencies are essential to ensure the reliability and relevance of the implementation and testing.
	Risks	Delays in the enrolment of energy communities.
Readiness	Deployment diagram	The deployment diagram for SUC-IT-01.01 is presented Figure 31 below for clarity.
	Deployment preparation	The implementation of the SUC requires a reliable infrastructure and components that can ensure high availability of information flows (90%+), frequent and event-driven data exchanges, and efficient handling of large and diverse data types. Data must be accessible across organisational boundaries, validated, accurate, and updated within minutes of changes. These requirements support robust data management and quality of service, ensuring the proper functioning of the HEDGE-IoT ecosystem in the context of the SUC.

	Deployment assessment	Two components are not yet deployed: the integration with the flexibility register (waiting for credentials and topics on Flexibility Register's end) and the forecasting service, which will be deployed by the end of the pre-demo phase.
Validation Activities Summary	Previous cycle	n/a
	Current cycle	The stage implements the "Flexibility Offers" scenario, where the FSP Operator responds to DSO requests by computing optimal setpoints for DERs. Key actions include normalising DER measurements, notarising them on blockchain, collecting market and baseline data, identifying vulnerable resources, computing and dispatching optimal setpoints, and generating KPI reports. These actions ensure technical, economic, and social parameters are effectively used to enable flexibility services.
	Future cycle	It is possible that an improvement of power management could be required. Likely, the required implementations for Transversal Use Cases.

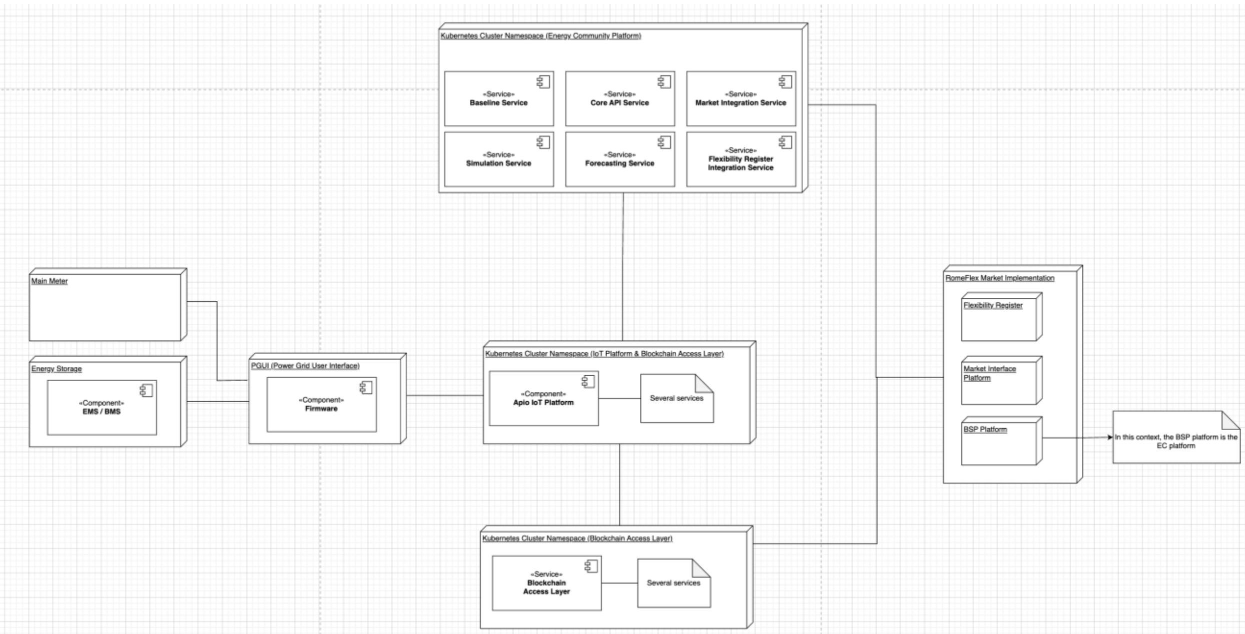


FIGURE 31: DEPLOYMENT DIAGRAM FOR SUC-IT-01.1

Service "ECP Platform – PLATFORM FOR DERS AND ENERGY COMMUNITIES" (which is described as technological enabler in D3.4) has been tested in the context of SUC-IT-01.01. The main areas of testing were

- The integration with the **Market Interface Platform** and the **Flexibility Register**, to obtain market data, baselines and measurements.
- **The Power Management Algorithm**, to compute the best flexibility offers and setpoint to maximise economic in presence of REC incentives and flexibility compensation.

In this phase, since RECs are still in the process of being involved in the project, all tests were conducted with synthetic data sources (simulators).

SUC-IT-01.02 ENERGY COMMUNITY PERFORMANCE FORECASTING

Section	Subsection	Input
Overview	SUC Summary	SUC-IT-01.2 focuses on enhancing Energy Community (EC) performance by analysing and forecasting the behaviour of behind-the-meter (BTM) resources such as inverters, sun-meters, and storage systems. The Energy Community Platform gathers and normalises measurement data from these assets, enabling performance ratio analysis, anomaly detection, and continuous forecasting. These features allow EC administrators to monitor KPIs and asset health through a dedicated interface.
	Target(s)	The current evaluation cycle targets improving grid operations through better prediction to prevent overloads and critical scenarios and reducing application response times to allow timely action on grid behaviour.
	Expected UC Milestones	The internal milestones to be achieved are the functional and technical requirements milestones. Those will be achieved fully, since all the specifications are laid out. Platform prototype Available & Data Models will be achieved fully also. The Use case will implement the first 4 steps of the scenario.
	Actions implemented	Several key actions were performed to implement the use case. First, BTM resources were identified and registered within the Energy Community Platform, with data gathered either directly from the field or via manufacturers' channels. This data was normalised using the appropriate ontology to ensure consistency. Subsequently, performance analysis algorithms were implemented to compute KPIs, including detailed inverter string analysis. The normalised data was also used to generate forecasts and benchmarks to support planning and operational decisions. Finally, reports and anomaly detection features were made accessible to Energy Community Administrators through the platform's user interface.
Requirements	Assumptions	The key assumptions regard that a sufficient number of energy community members (producers and prosumers) are instrumented, allowing consistent data acquisition. It also presumes that DERs have been enrolled and are capable of generating valid measurements over a meaningful timeframe. Furthermore, the evaluation process assumes a minimum 90% data availability, frequent data exchanges (every few minutes or upon specific triggers), and that data integrity and synchronisation across systems are ensured. These underlying assumptions directly affect the accuracy and reliability of the performance evaluation and forecasting activities.
	Dependencies	The key assumptions regard that a sufficient number of energy community members (producers and prosumers) are instrumented, allowing consistent data acquisition. It also presumes that DERs have been enrolled and are capable of generating valid measurements over a meaningful timeframe.
	Risks	Delays in the enrolment of energy communities.
Readiness	Deployment diagram	The deployment diagram for SUC-IT-01.02 is presented in Figure 32 below for clarity.
	Deployment preparation	The components and infrastructure must support high availability of information flows. They must enable management of different types of data to be exchanged every few minutes, and support data exchanges. Data must be managed across organisational departmental boundaries and between systems from different

		vendors. The infrastructure must ensure validation of data and models, support large volumes of data and model dependencies, guarantee that received data is up-to-date within seconds of changes, and enable verification of data accuracy.
	Deployment assessment	All the software components are deployed. The risk of not having energy communities enrolled in time is mitigated by having
Validation Activities Summary	Previous cycle	n/a
	Current cycle	The current stage involves the following main actions: measurement normalisation and notarisation by the BAL Platform, followed by performance analysis and forecasting on the FSP Platform. Based on these, anomaly detection is triggered, and periodic KPI reports are generated. These steps are carried out by key actors including the DSO, and Flexibility Service Provider.
	Future cycle	Likely, the required implementations for Transversal Use Cases.

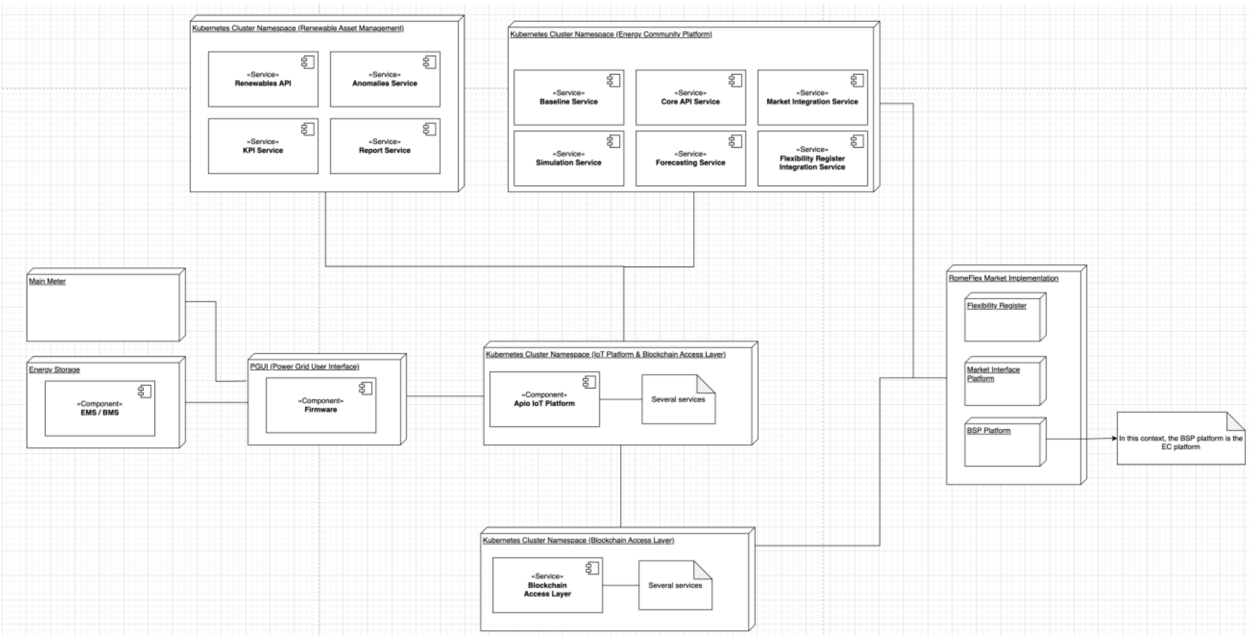


FIGURE 32: DEPLOYMENT DIAGRAM FOR SUC-IT-01.2

Service "ECP Platform – PLATFORM FOR DERS AND ENERGY COMMUNITIES" (which is described as technological enabler in D3.4) has been tested in the context of **SUC-IT-01.02**.

The main areas of testing were:

- The integration with the local flexibility market components (Market Interface Platform and Flexibility Register) to obtain market data, baselines and measurements.
- Integration with The Renewables API to retrieve behind-the-meter related measurements, KPIS and report generation for photovoltaic plants that are provided by REC members.
- The Load/Production Forecasting capabilities of the platform (described in D3.3) were tested to provide PV performance forecasting.

In this phase, since RECs are still in the process of being involved in the project, all tests were conducted with synthetic data sources (simulators).

SUC-IT-02.01 GRID BEHAVIOUR FORECASTING

Section	Subsection	Input
Overview	SUC Summary	The SUC-IT-02.1 focuses on improving the prediction of grid behaviour, both in terms of energy production and consumption, by combining real-time data from DSOs, energy communities, and consumers. Through the integration of smart meter readings, substation sensors, and weather forecasts, a machine learning model forecasts short- and mid-term load and production trends. These forecasts help improve grid stability, prevent overloads, and support operational decision-making.
	Target(s)	The current evaluation cycle targets enhanced grid operation by enabling better prediction capabilities, which increase the capacity to anticipate and prevent overloads and other critical situations. In addition, it also aims at reducing application response times; faster grid behaviour predictions provide additional operational time to effectively manage and mitigate critical scenarios.
	Expected UC Milestones	Historical data is available for ML model training; First forecast results are verified.
	Actions implemented	Forecast model is being trained using 1 year load curves with 15 minutes granularity from ~6000 customers. Additional 6 months are used for model validation.
Requirements	Assumptions	Grid measurements are available; Grid topology is updated.
	Dependencies	The SUC depends on near real-time data from PoDs and a granular distribution of sensors in both lines and substations, which are essential for feeding the forecast model. Synchronisation of the clock between systems with accuracy on seconds is also required to ensure consistent and reliable data exchange. This SUC is linked to SUC-IT-02.2, as it provides load and production forecasts for the grid, and to SUC-IT-02.3, by consuming weather forecasts to better predict PV production and consumer behaviour. These interactions underline its role as both a data consumer and provider within the overall system architecture.
	Risks	A newly trained ML model may perform sub-optimally due to biases, overfitting, or limited data. Continuous monitoring and retraining are essential to improve reliability.
Readiness	Deployment diagram	The deployment diagram for SUC-IT-02.01 is presented in Figure 33 below for clarity.
	Deployment preparation	The components and infrastructure must support Quality of Service requirements such as identifiable data age, known time skew and periodic or event-based exchanges. Availability can be scheduled, reflecting non-continuous service tolerance. From a Security standpoint, mechanisms such as certificate or shared secret authentication, VLAN segregation, and safeguards against eavesdropping and integrity violations are required. Data Management must ensure correctness, up-to-date information within minutes, and automated or semi-automated data maintenance. Validation across sources and management across departmental boundaries are also essential. The

		Configuration layer requires publish-subscribe and master-slave exchange models, Power Line Communication as media, and request-response access. Implementations are generally mature with few changes needed for legacy systems. No GDPR constraints are expected, as no personal data is processed.
	Deployment assessment	ML model is running on a standalone test environment. Validation is on a static grid and measurement, then checked again real measurements.
Validation Activities Summary	Previous cycle	n/a
	Current cycle	The current stage includes requesting grid topology and weather forecasts, which are used to compute or refine forecast data based on updated measurements. The forecasted behaviour is then made available upon request. These steps address previous recommendations by ensuring data correctness, availability, and event-based updates, while supporting secure access, validation across boundaries, and compatibility with existing systems.
	Future cycle	Integration of ML model into DSO's systems and make it programmatically invocable; Weather forecast is taken into account while predicting load and production.

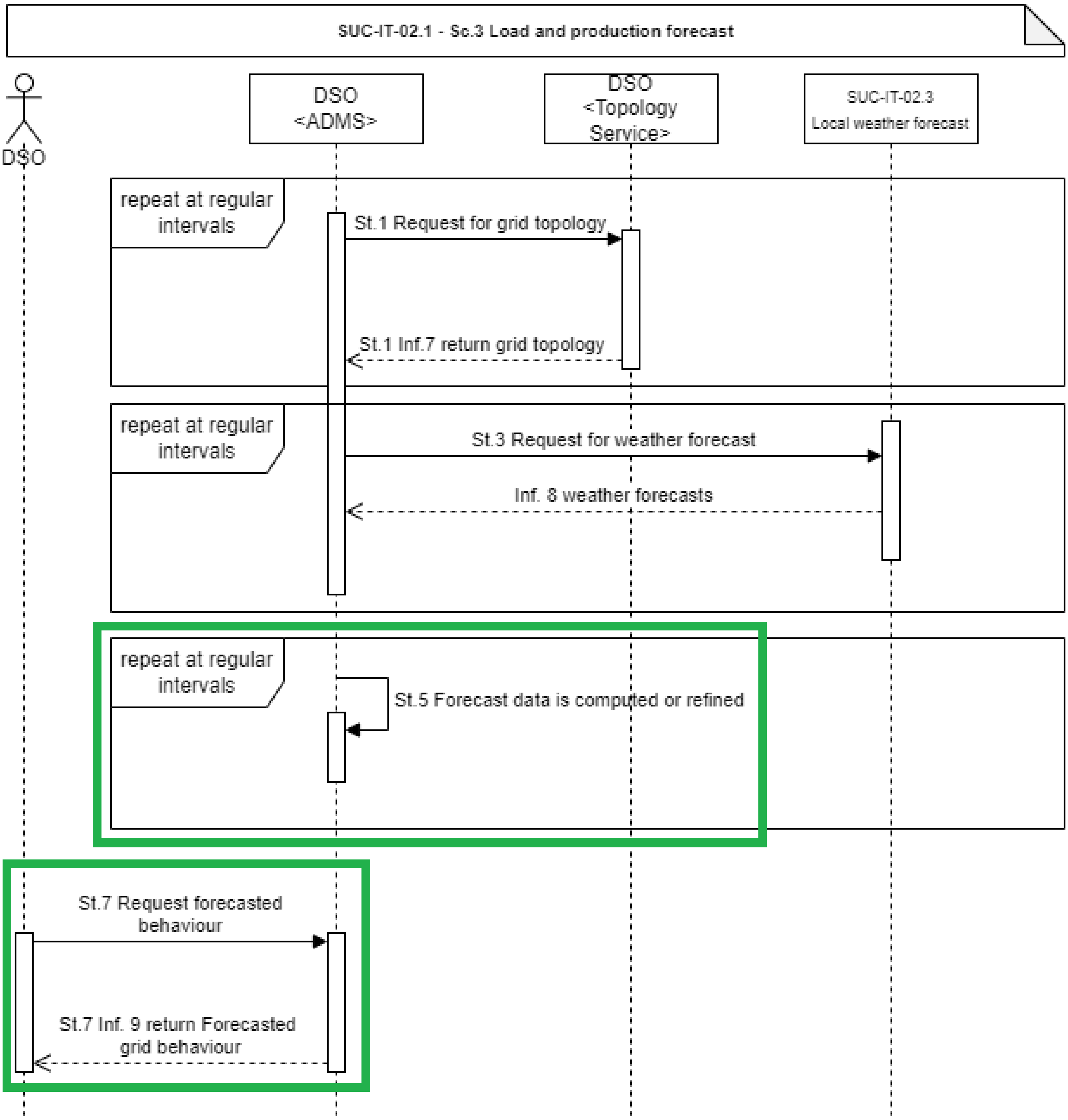


FIGURE 33: DEPLOYMENT DIAGRAM FOR SUC-IT-02.1 (ONGOING PROCESS)

SUC-IT-02.02 GRID CONGESTION COMPUTING

Section	Subsection	Input
Overview	SUC Summary	SUC-IT-02.2 demonstrates the effectiveness of forecasting grid congestion by leveraging DSO system assets and results from previous SUCs. The objective is to defer grid reinforcement investments and improve security of supply by enabling demand-response mechanisms. The Distribution Management System (DMS) uses inputs such as RT measurements, grid topology, thermal limits, baselines, and load & production forecasts to detect voltage violations and line power limitations

		through the State Estimation tool. Key components include SCADA, topology processor, dynamic line rating, flexibility database, and forecast tools.
	Target(s)	The current evaluation cycle targets improvements in real-time data sharing among stakeholders, enabling better forecast models. It also focuses on enhancing grid operational performance through improved allocation of flexibility resources in critical scenarios. Additionally, it aims to reduce application response times, allowing quicker prediction of grid behaviour. Lastly, the cycle supports increasing DERs participation in flexibility provision by reducing downtime.
	Actions implemented	During the evaluation cycle, the DSO system processed SCADA data via the topology processor and state estimation tools to assess real-time grid configuration. The dynamic line rating tool used weather forecasts to define thermal limits. Energy Community resources were registered in the flexibility database, and baselines were set using smart meter data. Forecasts of load and production were integrated to detect grid congestion and support operational decisions
Requirements	Assumptions	Forecast model is supposed as accurate; Grid topology is accurate and available in real time.
	Dependencies	The use case requires balanced distribution of flexibility in the grid area, availability of real-time data readings, and updated grid topology in near real time. These prerequisites ensure effective interaction with other services and components. This use case is closely related to others in the Italian pilot. It builds on SUC-IT-02.1 by consuming load and production forecasts to activate State Estimation algorithms across different scenarios. It is also linked to SUC-IT-02.3, from which it receives local weather conditions and forecasts to support the calculation of the dynamic grid rating. These interactions strengthen the integration and coherence of the demo environment.
	Risks	Inaccurate data may lead to false congestion detection.
Readiness	Deployment diagram	The deployment diagram for SUC-IT-02.02 is presented in Figure 34 below for clarity.
	Deployment preparation	The implementation of this use case relies on requirements spanning several domains. Quality of Service (QoS) requires data exchanges either upon events or at regular 15-minute intervals, ensuring timeliness, availability during scheduled uptime, and traceability of data age and time skew. Security (Sec) measures include protection against eavesdropping and data integrity violations, with authentication managed through certificates or shared secrets, and network segmentation via VLANs. Data Management demands high accuracy and timeliness of data, validation across departments and organisations, and a mostly automated maintenance process. Configuration (Conf) involves a publish-subscribe and request-response architecture over existing mature infrastructures, using power line communication where applicable, and accommodating legacy systems. Lastly, no GDPR constraints apply, as no personal data is processed.
	Deployment assessment	Congestion detection algorithm is linked to forecast engine; components are being validated on static data.
Validation Activities Summary	Previous cycle	n/a
	Current cycle	The main actions focused on structured data acquisition from field devices and central systems, followed by real-time grid state estimation. These steps build

		directly on recommendations from the previous cycle by ensuring updated grid topology, weather data, and DER baselines are reliably processed. The resulting estimation outcomes now provide timely insight into potential grid congestions and flexibility needs, improving responsiveness and system readiness.
	Future cycle	Integration of ML model into DSO's systems and make it programmatically invocable; Weather forecast is considered while predicting load and production.

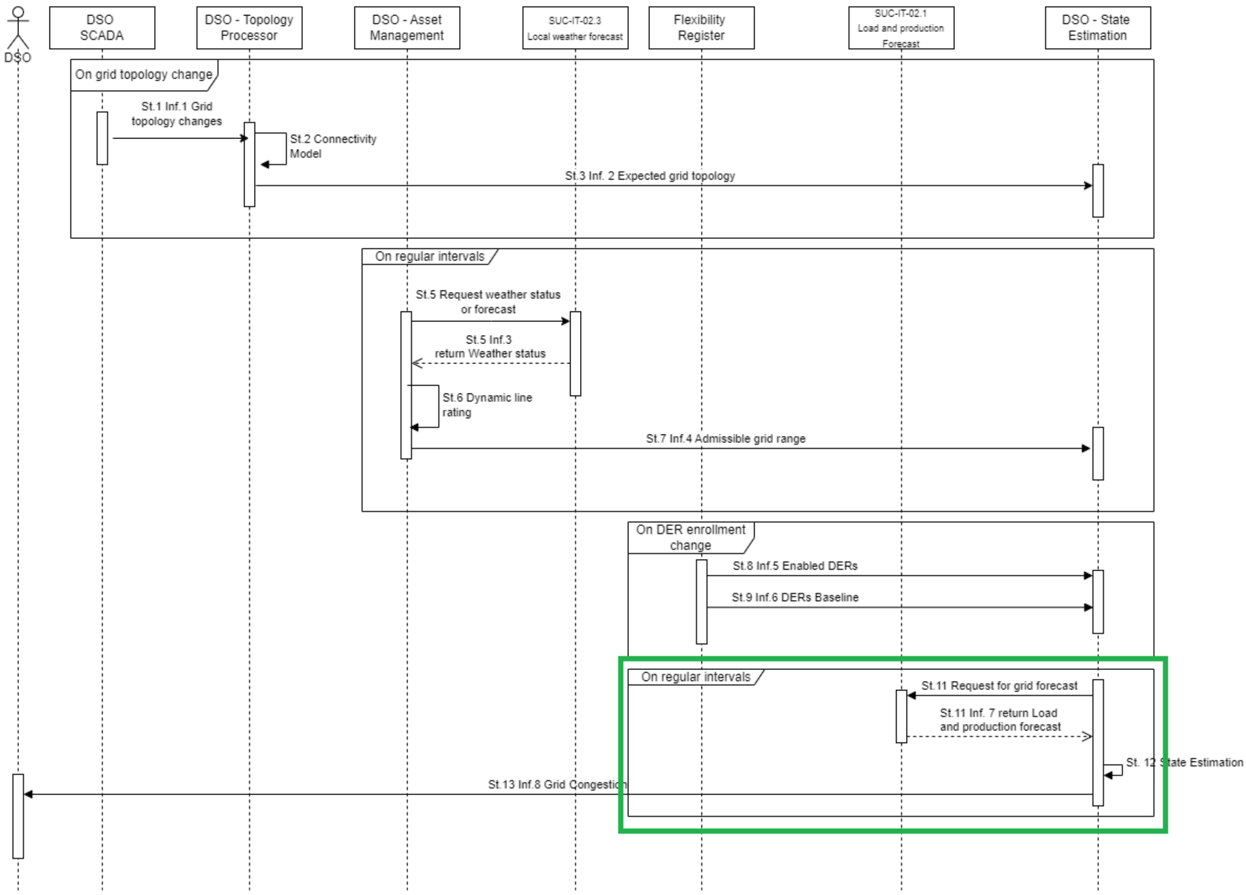


FIGURE 34: DEPLOYMENT DIAGRAM FOR SUC-IT-02.2 (ONGOING PROCESS)

SUC-IT-02.03 LOCALISED WEATHER FORECAST

Section	Subsection	Input
Overview	SUC Summary	SUC-IT-02.3 combines city-wide weather forecasts with local IoT weather stations to achieve finer predictions, accurate to individual renewable production plants or city blocks. By integrating real-time data on solar radiation, temperature, and cloud cover from IoT stations with broader forecasts, the platform develops more precise and dynamic solar energy production predictions. This enables better planning and efficiency in solar energy utilisation for DSOs and users.
	Target(s)	The current evaluation cycle targets increasing the deployment of IoT weather stations in strategic locations to improve flexibility services by enhancing load and production forecasts. It also focuses on ensuring high uptime and availability of

		these IoT/Edge/Fog sites to enable quicker responses to forecasted grid load and production changes.
	Expected UC Milestones	Weather stations are ready to be deployed (software is developed and test, connectivity is available).
	Actions implemented	Edge software has been developed and is in a testing phase.
Requirements	Assumptions	Weather station position is optimal to provide suitable data interpolation; Enough RECs join the pilot in order to provide significant data.
	Dependencies	The use case relies on the availability of an external weather service and the installation of IoT weather stations in strategic locations such as substations and areas with high DER density. These stations must be properly configured and able to communicate with the DSO's systems. Additionally, the use case is linked to SUC-IT-02.1 and SUC-IT-02.2, as it provides weather forecasts and real-time weather status at relevant locations.
	Risks	Potential factors contributing to delays include unforeseen technical difficulties, delays in equipment delivery, or inadequate site preparation
Readiness	Deployment diagram	The deployment diagram for SUC-IT-02.03 is presented in Figure 35 below for clarity.
	Deployment preparation	The components and underlying infrastructure must meet specific quality of service requirements, including availability of information flows, identifiable data age and data exchange frequency triggered by events or periodic reporting. Security is ensured through authentication and access control mechanisms based on shared secrets. Data management requires the source data to be usually correct, with proper handling across systems. Configuration considers distances between entities, a limited number of information producers, and communication protocols supporting request-response and periodic reporting. Lastly, no personal data is processed, ensuring compliance with GDPR regulations.
	Deployment assessment	Weather data acquisition is in the testing phase; REC enrolment will be completed in June 2025.
Validation Activities Summary	Previous cycle	n/a
	Current cycle	The current stage focuses on implementing the localised weather forecast scenario by integrating public weather data with DSO's IoT weather stations. Actions include scheduled retrieval of weather forecasts from external providers, continuous reporting of local weather station data, and interpolation of this data into forecast models. These steps ensure weather information is updated and available at specific points of interest, fulfilling recommendations to maintain data accuracy, availability, and secure communication as outlined in previous cycles.
	Future cycle	Deployment and integration with external forecast provider to retrieve localised weather forecast.

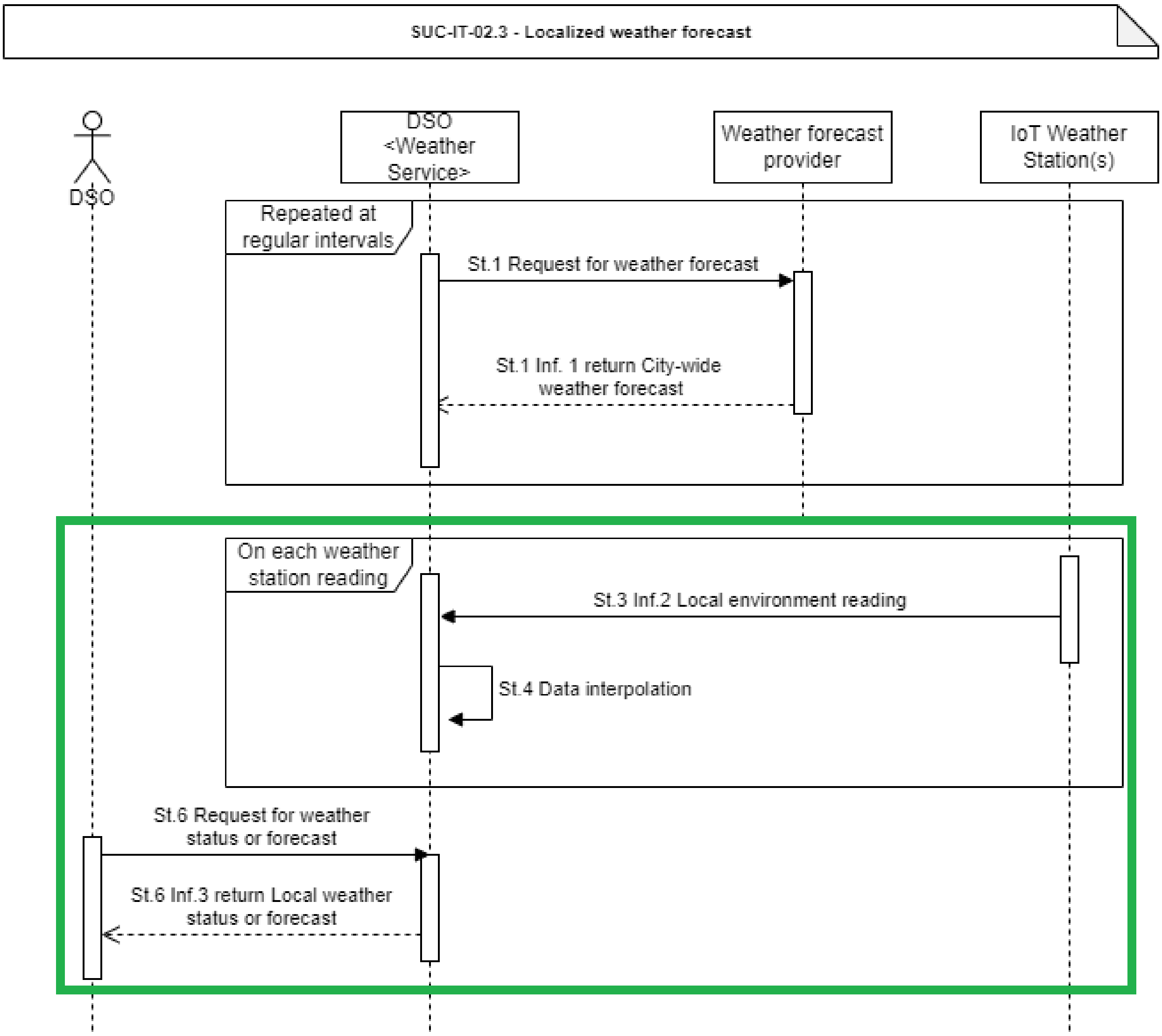


FIGURE 35: DEPLOYMENT DIAGRAM FOR SUC-IT-02.3 (HIGHLIGHTS SHOW THE ONGOING PROCESS)

3.3.3.2 Milestones and Progress

This subsection revisits the internal milestones identified in D5.1 and assesses their current status, noting any updates, delays, or partial completions observed during the Pre-Demo Phase. The information is presented in Table 15, which maps each milestone to the corresponding implementation steps and indicates the extent of progress achieved for the Italian Demo.

TABLE 15: PROGRESS ON ITALIAN DEMO INTERNAL MILESTONES LINKED TO THE IMPLEMENTATION OF SYSTEM USE CASES (SUCS) DURING THE PRE-DEMO PHASE

Internal Milestones	Month	SUC-IT-01.01	SUC-IT-01.02	SUC-IT-02.01	SUC-IT-02.02	SUC-IT-02.03
Functional Requirements	M14	Completed	Completed	Completed	Completed	Completed

Technical Requirements	M15	Completed	Completed	Completed	Completed	Completed
Field Resources Engagement	M16	Completed	-	-	-	-
Platform development and data exchange	M17	SC01 → Steps 1-4 Tested	SC01 → Steps 1-4 Tested	SC01 → Steps 1-5 Tested	-	-
Asset deployment and integration	M18	-	-	-	-	SC01→ Steps 3-4 Tested
Platform prototype Available & Data Models	M18	SC01 → Steps 1-4 Tested	SC01 → Steps 1-4 Tested	SC01 → Steps 5 Tested	SC01 → Steps 11-13 Tested	-
Input of historical data	M19	-	-	-	-	-
Beta version	M24	-	-	-	-	-
Final version	M30	-	-	-	-	-
Fully validated in the pilot	M36	-	-	-	-	-

3.3.4 Pre Demo Evaluation

3.3.4.1 Requirements Evaluation

The following section presents the requirement for each SUC, which was initially introduced in D5.1 including the description, acceptance criteria, and assigned testing partner. An additional column now captures the progress status recorded during the Pre-Demo Phase, allowing a direct comparison between the targets set in D5.1 and the results achieved to date.

SUC-IT-01.01 ENERGY COMMUNITY POWER MANAGEMENT & SUC-IT-01.02 ENERGY COMMUNITY PERFORMANCE FORECASTING

Req	Description	Acceptance Criteria	Progress
R. 1	Availability of information flows	90% + availability - Allowed outage: 1 month per year	n/a
R.2	Management of accessing different types of data to be exchanged	Each data exchange could entail different types of data (e.g. query a database) Data and models are exchanged every few minutes	Data from external software sources is coming as intended (accuracy / resolution as intended). Data from the field to be tested later

R. 3	Frequency of data exchanges	Periodicity greater than a few seconds Upon event Upon request	Data from external software sources is coming as intended (frequency as intended). Data from the field to be tested later
R.4	Management of data across organisational boundaries	Data can be accessed by external organisations	Data Flows originated from the Use Cases are available on external platforms
R.5	Validation of data exchanges	Data and models should be validated.	Data is validated during ingestion
R.6	Management of large volumes of data that are being exchanged	The solution facilitates the utilisation and management of large models along with their dependencies.	To be tested later
R. 7	Up-to-date management	Received data must be up-to-date within accepted time granularity of source data changing	To be tested later
R.8	Correctness of source data	The solution enables data accuracy verification.	To be tested later

SUC-IT-02.01 GRID BEHAVIOUR FORECASTING & SUC-IT-02.02 GRID CONGESTION COMPUTING

Req	Description	Acceptance Criteria	Progress
QoS.1	Availability of information flows	Continuous availability not required so long as downtime is scheduled	Data is currently transferred manually
QoS.2	Accuracy of data requirements	Age of data needs to be knowable	Data age is known
QoS.3	Accuracy of data requirements	Time skew of data must be known	Time skew is known
QoS.4	Frequency of data exchanges	Upon event	Data is published on expected events.
QoS.5	Frequency of data exchanges	Every 15 minutes	To be tested later
Sec.1	Eavesdropping	Standard security tests	To be tested later
Sec.2	Information integrity violation	Standard security tests	To be tested later
Sec.3	Authentication and Access Control mechanisms	Certificate	To be tested later

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	commonly used with this data exchange		
Sec.4	Authentication and Access Control mechanisms commonly used with this data exchange	Shared secret	To be tested later
Sec.5	Network security measures commonly used with this data exchange	VLAN segregation	Field VLANs are segregated
D.1	Correctness of source data	Source data is always correct (e.g. by definition)	Data is assumed correct
D.2	Correctness of source data	Source data is usually correct	To be tested later
D.3	Up-to-date management	Received data must be up-to-date within minutes of source data changing	To be tested later
D.4	Management of data across organisational boundaries	Data exchanges go across departmental boundaries	To be tested later
D.5	Data maintenance effort: human versus automation	Data maintenance is mostly automated but requires occasional intervention	Data is currently manually transferred
D.6	Validation of data exchanges	Data from different sources must be validated against each other	Data validation is currently outside of the pilot.
D.7	Management of data across organisational boundaries	Data exchanges go across organisational boundaries	Data samples are currently manually extracted and exchanged.
Conf.1	Number of Information Producers	Few to a hundred	Producers are communicating correctly.
Conf.2	Communication media	Power Line Communication (Chain2)	Data is being read via Chain2.
Conf.3	Data exchange methods	Master-slave	Used where applicable.
Conf.4	Data exchange methods	Publish-subscribe	Used where applicable.
Conf.5	Communication access services requirements	Request-response	Used where applicable.
Conf.6	Relative maturity of current implementation	TRL levels classification	TRL 6
Conf.7	Existence of legacy systems	Few changes will be needed	Changes are being worked on. Using manual intervention as workaround.

O.1	No GDPR constraints	No personal data is processed or transferred	No personal data is used.
O.2	Right to access, rectify, erasure, restriction	Data retention policy outlines the specific sensitive time period data can be retained, plus how it will be disposed of when the time to do so comes.	To be tested later.

SUC-IT-02.03 LOCALISED WEATHER FORECAST

Req	Description	Acceptance Criteria	Progress
QoS.1	Availability of information flows	Continuous availability not required so long as downtime is scheduled	To be tested later (after deployment)
QoS.2	Accuracy of data requirements	Age of data needs to be knowable	Data age is known
QoS.3	Accuracy of data requirements	Upon event	To be tested later (after deployment)
QoS.4	Frequency of data exchanges	Periodicity greater than a few seconds	Frequency is as expected
Sec.1	Eavesdropping	Standard security tests	To be tested later
D.2	Correctness of source data	Source data is usually correct	To be tested later (after deployment)
Conf.3	Communication access services requirements	Request-response	To be tested later
Conf.4	Communication access services requirements	Periodic reporting	Data is published at fixed interval
O.2	Right to access, rectify, erasure, restriction	Data retention policy outlines the specific sensitive time period data can be retained, plus how it will be disposed of when the time to do so comes.	To be tested later

3.3.4.2 KPIs Progress

The KPIs to be measured by the Italian demo, along with their description, the relevant System Use Case (SUC), and their corresponding baseline and target values, are presented in Table 16 below. A new "Progress" column has been included to document developments during the Pre-Demo Phase (M16-M18). A "0" value under the progress column indicates that no measurable data has been collected during the pre-demo phase for the respective KPI. This does not reflect underperformance but rather the fact that measurement is scheduled to begin in the Full Demo Phase.

TABLE 16: KEY PERFORMANCE INDICATORS (KPIS) DEFINED FOR THE ITALIAN DEMO, INCLUDING SUC RELEVANCE, BASELINE AND TARGET VALUES, AND REPORTED PROGRESS DURING THE PRE-DEMO PHASE

ID	KPI	Baseline	Target	Progress
KPI 4	% Of real-time data sharing among stakeholders	n/a	n/a	0
KPI5	Open source released developments related to data connector implementations	0	100	0
KPI7	Increased RES and IoT deployment for providing flexibility services	n/a	90	0
KPI8	IoT/Edge/Fog sites uptime and availability	n/a	99	0
KP9	Flexibility unlocked and transacted in markets	n/a	>=10	0
KP10	Number of consumers engaged with flexibility services	10%	n/a	0
KPI 11	Increased grid operational	n/a	10%	0
KP12	Faster application response times	n/a	24	0
KPI22	Increase DERs participation in flexibility provision	15 min	5 to 30 min	0

3.4 DEMO 4 – ARNHEMS BUITEN - ENERGY INNOVATION CAMPUS [NETHERLANDS]

3.4.1 Pre – Demo Phase Activities Summary

This section presents a structured summary of the activities that the Dutch Demo conducted during the Pre-Demo Phase (M16–M18). It expands upon the demo deployment template introduced in Chapter 2, which functions as a reference for monitoring the development of each demonstrator. The status of the pre-demo targets, the WP3 services utilised, and the key stakeholders involved during this phase are all detailed in Table 17 below. The purpose of the information is to establish the foundation for the Full Demo Phase and to evaluate the operational readiness of the demo at the conclusion of the Pre-Demo Phase.

TABLE 17: DEMO 4 PRE DEMO PHASE DEPLOYMENT STATUS

Section	Subsection	Description
Summary	Pre-Demo Phase Target	Integrating first energy nodes via SIF and expose them to concept dashboarding and upgrade of relevant SIF/SAREF components
	Status Summary	• Multiple (types of) energy nodes have been installed and integrated via the SIF (DSO/grid meters, sub metering of buildings, PV production, EV) Update of SIF. • Developed and demonstrated smart dashboards and interactive interfaces for analyses, debugging, and insight into building energy use. • Designed and developed a prototype anomaly detector, with integration with SIF, and created a training dataset.
	Services Used (from WP3)	• Semantic Interoperability Framework • AI services for local grid resilience
	Stakeholders involved during Pre-Demo	Local DSO (Electricity Campus) and system integrator

3.4.2 Infrastructure, Assets and Data Availability

Based, on the demo-deployment template that was introduced in chapter 2, a consolidated snapshot of the infrastructure and assets mobilised during the Pre-Demo Phase is provided in Table 18 for the Dutch demo. Each asset is accompanied by its technical description, deployment level, use status in months 16–18, and the WP 3 service to which it pertains.

TABLE 18: SUMMARY OF DEMO 4 INFRASTRUCTURE AND ASSETS DEPLOYED DURING THE PRE-DEMO PHASE

Asset	Description	Deployment Level	Used during Pre demo	Under which WP3 service

Edge server	Server that runs all the HEDGE-IoT edge applications	Testing	Yes	Hosts (parts of) the Semantic Interoperability Framework and the AI services for local grid resilience
Metering devices DSO	Metering points of local grid connection to DSO	Installed	Yes	Linked to the Semantic Interoperability Framework
Submetering IoT devices	IoT devices in residential switchboards with edge processing capabilities	Installed	Yes	Linked to the Semantic Interoperability Framework
Databases for data exchange	Local storage with cloud access	Deployed	Yes	Linked to the Semantic Interoperability Framework
PVs	Rooftop installation for self-consumption and flexibility provisioning	Installed	Yes	Linked to the Semantic Interoperability Framework
EVs and EV chargers	Electric mobility assets for flexibility provisioning	Installed	Yes	Linked to the Semantic Interoperability Framework
User Interfaces	Mobile app and web interface for residential consumers and aggregators	Interface for aggregator has been deployed	Yes	Linked to the Semantic Interoperability Framework
Interoperability Layer	Facilitate semantically interoperable data exchange. This includes integration with data space connectors.	Deployed, not yet integrated with data space connector	Yes	Part of the Semantic Interoperability Framework

Table 19 summarises the datasets relevant to the Pre-Demo Phase, indicating their availability, whether they were used during this period and their linkage to the corresponding WP3 technological enablers.

TABLE 19: OVERVIEW OF DATASETS RELEVANT TO THE PRE-DEMO PHASE OF THE DUTCH DEMO

Data Description	Used during Pre-Demo Phase	Under which WP3 service
DSO Grid meters	Yes	Linked to Semantic Interoperability Framework
PV Panels	Yes	Linked to Semantic interoperability Framework
Submetering	Tested, not yet deployed	Linked to Semantic interoperability Framework
Energy Nodes (sensor and building assets)	Partly deployed	Linked to Semantic Interoperability Framework
Chargers (EV)	Deployed	Linked to Semantic Interoperability Framework

3.4.3 Pre Demo Results

This section captures the status and progress of System Use Case (SUC) implementation during the Pre-Demo Phase (M16–M18) for the Dutch demo. For each SUC, key developments are outlined, including the specific actions undertaken, intermediate achievements, and alignment with the expected implementation steps and scenarios described in D2.2. In addition, the internal milestones defined in D5.1 are revisited and assessed in terms of progress and completion. This structured overview offers insight into the readiness and maturity of each SUC ahead of the upcoming demonstration cycles.

3.4.3.1 SUCs Implementation

This subsection presents the implementation progress of each System Use Case (SUC) as defined in D2.2 for the Dutch demo, highlighting the actions carried out during the Pre-Demo Phase.

SUC-NL-01.01 MONITORING & DASHBOARDS

Section	Subsection	Input
Overview	SUC Summary	Monitoring energy nodes real-time and store the data. This data will be pre-processed and combined/integrated in one or more dashboard(s).
	Target(s)	Deployment
	Expected UC Milestones	Should be completely implemented
	Actions implemented	Infrastructure to share data has been set up and data can be exchanged through the system. A dashboard has been made where (part of) this data is shown.

Requirements	Assumptions	Energy nodes are available for retrieving their data
	Dependencies	no dependencies
	Risks	Already deployed
Readiness	Deployment diagram	*Implemented as specified in WP2,* Figure 36 *follows below this table*
	Deployment preparation	Edge server available to connect to energy nodes DSO Grid Meters, PV Panels, Submetering, Energy Nodes and Chargers are installed and can send data to the edge server
	Deployment assessment	The deployment is complete, KPIs need to be measured according to the plan
Validation Activities Summary	Previous cycle	n/a
	Current cycle	Data from different types of energy nodes can be exchanged through the infrastructure and can be seen in a dashboard
	Future cycle	n/a

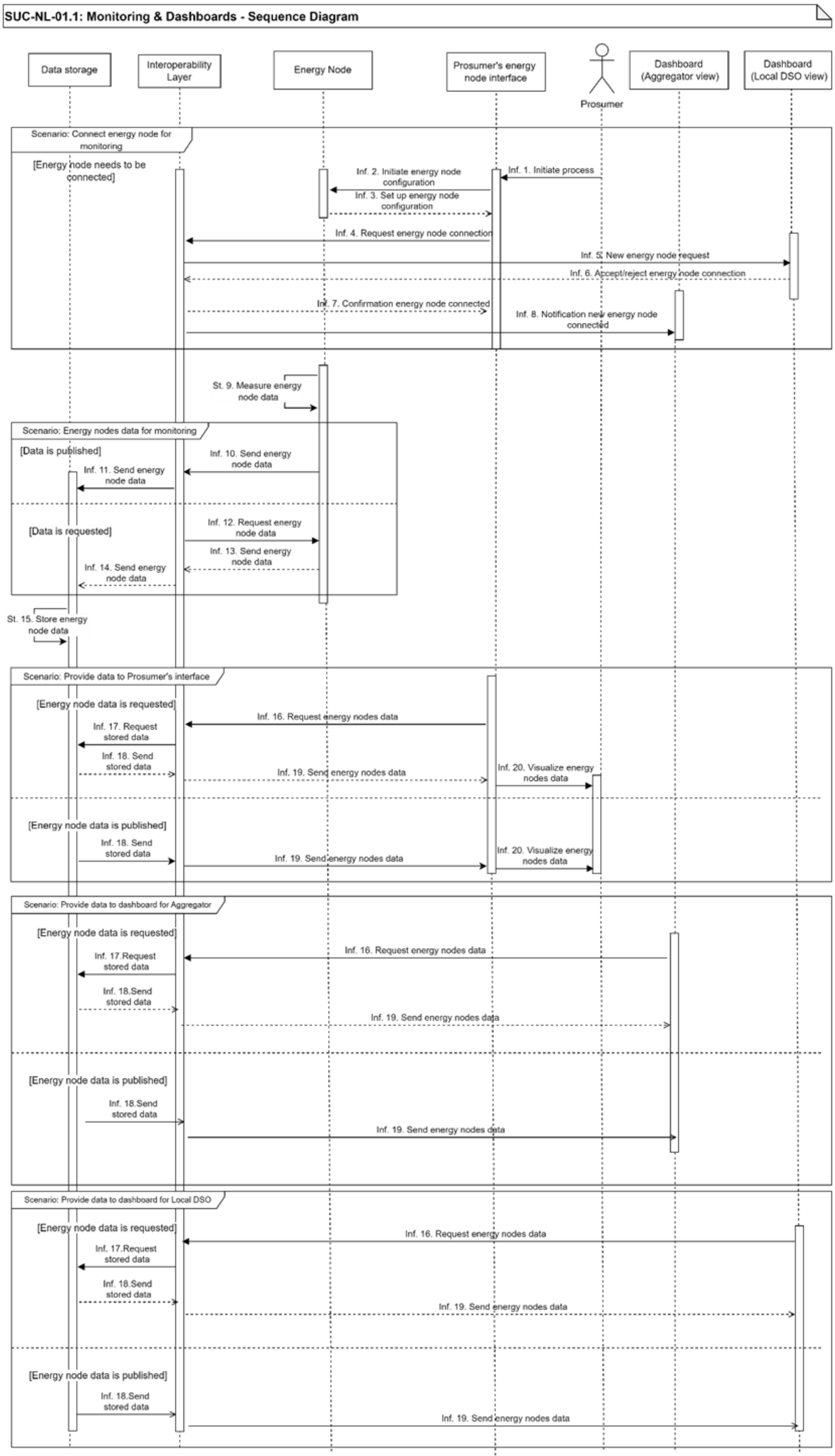

FIGURE 36: DEPLOYMENT DIAGRAM FOR SUC-NL.01.01

SUC-NL-01.02 SEMANTIC INTEGRATION ENERGY NODES

Section	Subsection	Input
Overview	SUC Summary	Integrate energy nodes and EMS/BMS via semantics for control and explainability
	Target(s)	Deployment for DSO meters, EV chargers, PV panels and sub-metering
	Expected UC Milestones	Should be able to exchange information through the Semantic Interoperability Framework in a semantically interoperable way
	Actions implemented	Data is now exchanged through the Semantic Interoperability Framework. Several semantic adapters have been developed and deployed for the energy assets such as PV panels and EV chargers.
Requirements	Assumptions	Energy nodes are available to retrieve data from
	Dependencies	Requires one (or more) Edge server(s) to be set up where components of the Semantic Interoperability Framework and the semantic adapters can be deployed. Energy assets should be linked to the network and able to exchange data.
	Risks	Incorrect semantic mappings can lead to incorrect conclusions for the services, e.g. anomaly detection, that rely on this SUC.
Readiness	Deployment diagram	*See* Figure 37 *below table, up until Inf.10 has been implemented*
	Deployment preparation	Two servers have been made available to run the various components Semantic interoperability framework is available and deployed on one of the servers Energy assets have been installed and linked to Arnhems Buiten's network
	Deployment assessment	60% complete, submetering adapters need to be connected definitively but have been tested. We will likely still develop semantic adapters for additional energy nodes, e.g. a BMS. Preparation for the connected adapters (DSO meters, EV chargers, PV panels) is complete and KPIs can be evaluated according to plan.
Validation Activities Summary	Previous cycle	n/a
	Current cycle	Semantic adapter for DSO meters, EV chargers, PV panels and submetering have been developed, tested and nearly all have been deployed.
	Future cycle	Submetering semantic adapter needs to be deployed permanently. When Arnhems Buiten's server has been connected, the semantic adapters and Semantic Interoperability Framework will be moved to this server. Need to create a semantic adapter for EMS/BMS Need to send and show recommendations in the Prosumer's interface Need to be able to show explanations for recommendations

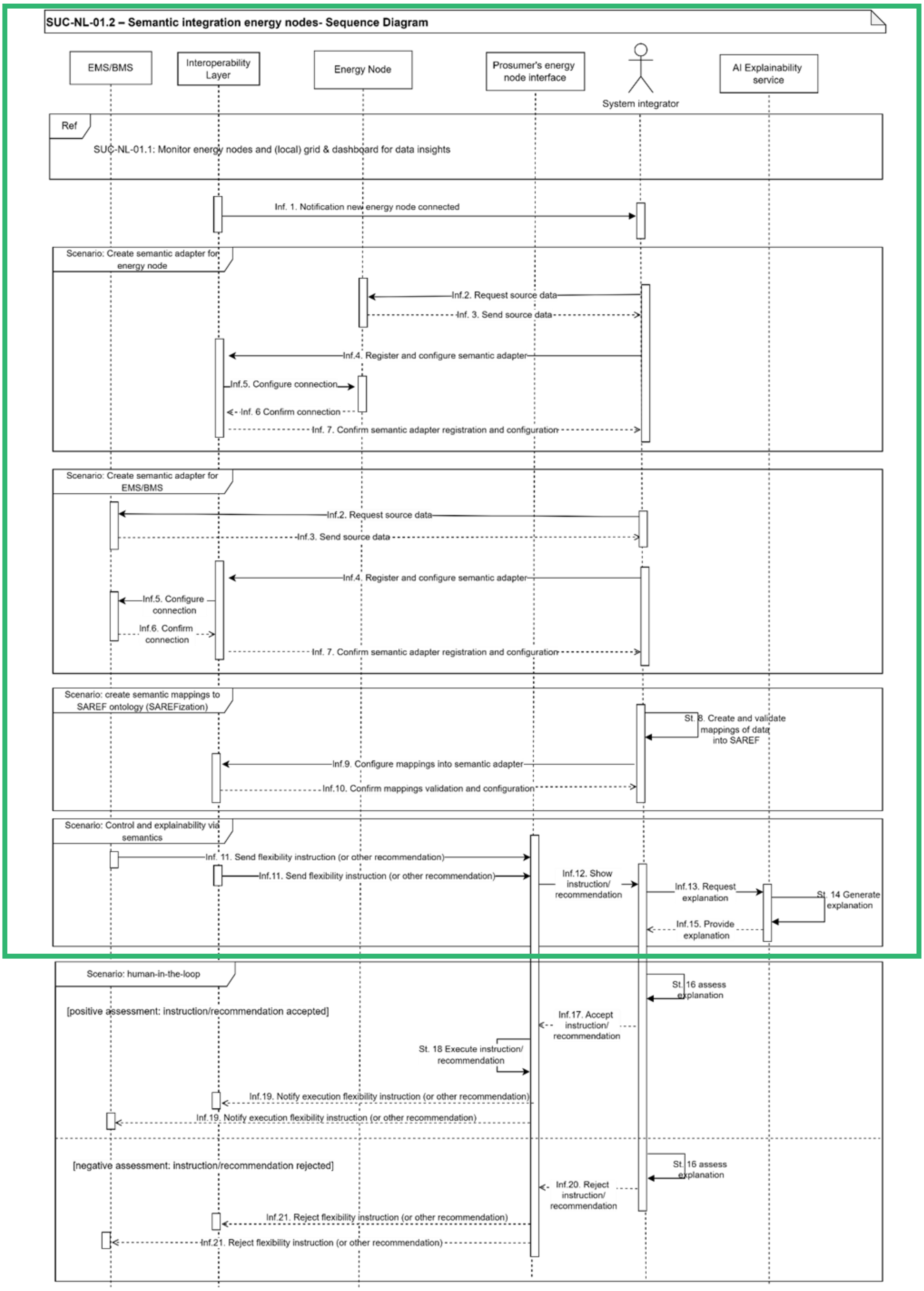

FIGURE 37: DEPLOYMENT DIAGRAM FOR SUC-NL.01.02 (ONGOING PROCESS)

SUC-NL-01.03 OPTIMIZE ENERGY PRODUCTION & CONSUMPTION

Section	Subsection	Input
Overview	SUC Summary	Optimise energy production & consumption in Arnhems Buiten's decentral grid
	Target(s)	None
	Expected UC Milestones	None for the pre-demo phase, will be implemented later as described in D2.2
	Actions implemented	-
Requirements	Assumptions	Energy usage data from the park and several energy nodes is available. Data can be exchanged through an infrastructure, preferably through semantic adapters as defined in SUC-NL-01.02
	Dependencies	Depends on the Semantic Interoperability Framework for exchanging data and sending optimisation plans. May optionally depend on an external optimisation service
	Risks	Delays in the deployment of SUC-NL-01.02 or the optimisation service can result in delays for this SUC.
Readiness	Deployment diagram	Will be implemented according to D2.2
	Deployment preparation	EMS needs to be chosen and linked to Arnhems Buiten's network to enable data exchange
	Deployment assessment	Not yet started, will continue according to plan
Validation Activities Summary	Previous cycle	n/a
	Current cycle	n/a
	Future cycle	Need to provide grid information to EMS, get energy nodes data for optimisation and send this to the EMS to give to an optimisation algorithm, and be able to send an energy optimisation plan

SUC-NL-01.04 FLEXIBILITY ALIGNMENT

Section	Subsection	Input
Overview	SUC Summary	Implement a flexibility alignment system at Electricity Campus Arnhems Buiten, enabling prosumers and aggregators to exchange and execute energy optimisation plans, utilising smart grid technologies to optimise energy use and demonstrate flexibility benefits

	Target(s)	None
	Expected UC Milestones	None for the pre-demo phase will be implemented later as described in D2.2
	Actions implemented	n/a
Requirements	Assumptions	Semantic Interoperability Framework and energy nodes' data is available.
	Dependencies	Depends on the Semantic Interoperability Framework to exchange data and send optimisation plans. Grid Energy Management System (GEMS) needs to be available
	Risks	Delayed deployment of the Semantic Interoperability Framework as well as the GEMS may result in delays
Readiness	Deployment diagram	Will be implemented according to D2.2
	Deployment preparation	Semantic Interoperability Framework needs to be deployed and energy assets need to be connected to it to exchange data about, e.g., their energy usage. Need to be able to control energy assets through the Semantic Interoperability Framework Grid Energy Management System (GEMS) needs to be available
	Deployment assessment	Semantic Interoperability Framework and energy assets have been deployed and are ready. Still need to check our ability to control energy assets through the Semantic Interoperability Framework. GEMS need to be chosen and integrated.
Validation Activities Summary	Previous cycle	n/a
	Current cycle	n/a
	Future cycle	Need to be able to update the execution status of an energy optimisation plan

SUC-NL-02.01 & SUC-NL-02.02 ANOMALY DETECTION & PREDICTIVE MAINTENANCE

Section	Subsection	Input
Overview	SUC Summary	Real-time monitoring of data streams between energy nodes, aiming to detect technical failures within the system on time and with possible explanations.
	Target(s)	To be defined

	Expected UC Milestones	To be defined
	Actions implemented	To be defined
Requirements	Assumptions	All input data is assumed to be formatted as directed graphs that adhere to the RDF data model.
	Dependencies	The service is dependent on the various Knowledge Engine runtime(s) to route and convert the messages send by the subscribed smart devices.
	Risks	False positives might induce stakeholders to act incorrectly.
Readiness	Deployment diagram	See below Figure 38
	Deployment preparation	Deployment requires a server that hosts the service, plus one or more Knowledge Engine runtime(s) to be available on the network.
	Deployment assessment	Deployment preparation is in full effect: servers are currently being set up and Knowledge Engine runtimes are ready to be deployed.
Validation Activities Summary	Previous cycle	Requirement analysis and design lineage were created, a controlled environment with training data was set up, and a prototype implementation was developed.
	Current cycle	Debugging of prototype implementation and testing in controlled environment, finetuning of parameters.
	Future cycle	Further extending of capabilities and complete validation in controlled environment. Next, deploy in demo infrastructure and test on real data.

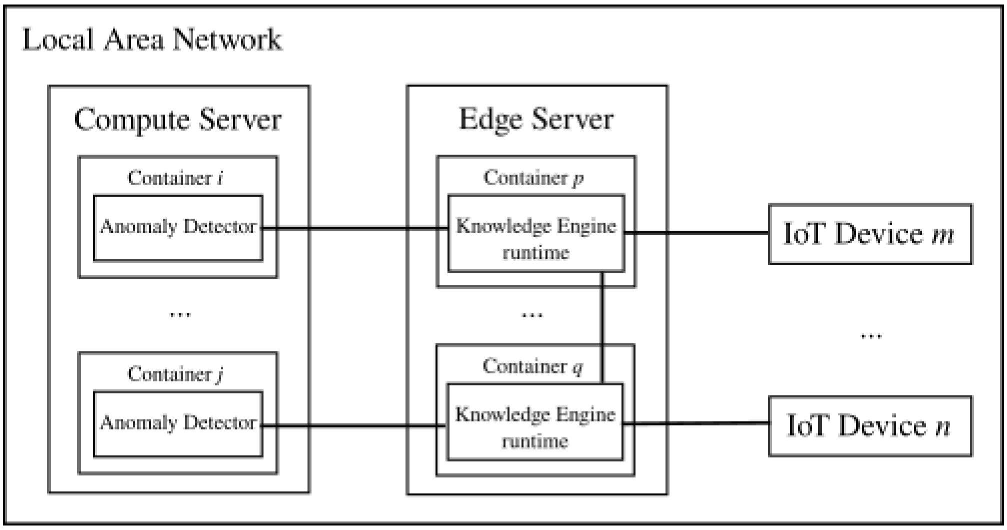

FIGURE 38: DEPLOYMENT DIAGRAM FOR SUC-NL.02.01 & SUC-NL.02.02

The Semantic Interoperability Framework in SUCs NL-01.2 - NL-01.6 utilises the Edge server asset and links to various devices, including PV panels, submetering, and energy nodes. It serves as the primary data exchange platform for the pilot. In the pre-demo phase, we have set up an edge server that runs the necessary components and is connected to the various devices. This setup has been tested. The focus was on establishing a reliable data exchange mechanism connected to multiple assets, which is a key component needed to support SUCs 01.3, 01.4, 02.1, and 02.2.

3.4.3.2 Milestones and Progress

This subsection revisits the internal milestones identified in D5.1 and assesses their current status, noting any updates, delays, or partial completions observed during the Pre-Demo Phase. The information is presented in Table 20, which maps each milestone to the corresponding implementation steps and indicates the extent of progress achieved for the Dutch Demo:

TABLE 20: PROGRESS ON DUTCH DEMO INTERNAL MILESTONES LINKED TO THE IMPLEMENTATION OF SYSTEM USE CASES (SUCS) DURING THE PRE-DEMO PHASE

Internal Milestones	Month	SUC-NL-01.01	SUC-NL-01.02	SUC-NL-01.03	SUC-NL-01.04
Finalisation of required data sources	M9	-	-	-	-
Initial testing with data sample	M10	Sc.1, Sc. 2 -> All steps Sc.3 -> Steps 10,12,13 Sc. 4 -> Steps 16,18,19 Sc. 5 -> All steps	Sc.1, Sc. 2, Sc. 4 -> All steps	-	-
Alpha version	M12	-	-	-	-
Complete connection points with data-sources	M15	Sc. 3 -> Steps 11, 14, 15	-	-	-
Beta version	M20	N/A	N/A	N/A	N/A
Final version	M26	N/A	N/A	N/A	N/A
Fully validated in the demo	M36	N/A	N/A	N/A	N/A

3.4.4 Pre-Demo Evaluation

3.4.4.1 Requirements Evaluation

This subsection presents the progress in meeting the functional and non-functional requirements defined for each System Use Case in Deliverable D5.1. Service development activities are primarily carried out within WP3, and comprehensive documentation of the development process will be provided in the corresponding deliverables, notably D3.4 (due M19). In the tables below, the requirements relevant to the Dutch demo are outlined, including their description, acceptance criteria, and the designated testing partner. A new column has been added to indicate the current progress status of each requirement, as observed during the pre-demo phase. Only one requirements-evaluation table is presented for the Dutch pilot. During the Pre-Demo phase (M16 – M18), the Dutch team focused on the semantic integration workflow (SUC-NL-01), which involved bringing live data from DSO meters, PV inverters, and EV chargers into the Semantic Interoperability Framework and visualising it on dashboards. The remaining SUCs—optimisation, flexibility activation, and advanced anomaly detection—remain in the infrastructure-build stage and, therefore, have no progress at this point. Separate requirements tables will be added for those SUCs in the Full-Demo report (D5.3) once functional testing can be performed.

SUC-NL-01.01 MONITORING & DASHBOARDS

Req	Description	Acceptance Criteria	Progress
QoS.2	Elapsed response time requirements for exchanging data	Intended granularity	So far acceptable, need to continue monitoring
QoS.3	Availability of information flows	Max. 10 times per month interrupted availability when required	To be evaluated in later stages
QoS.4	Accuracy of data requirements	At least 75% of all data is accompanied by a timestamp	To be evaluated in later stages
QoS.5	Frequency of data exchanges	When an event is generated, data exchange(s) occur(s)	So far acceptable, need to continue monitoring
Sec.2	Eavesdropping	No data values are logged in the Interoperability layer No access to the network without credentials Use dataspace connector	Network is protected with credentials, not yet using a dataspace connector
Sec.3	Information integrity violation	Test that 90% of data is the same on the receiver and sender side	Information integrity violation
Sec.4	Authentication and Access Control mechanisms commonly used with this data exchange	Use data space connector Use HTTPS	Using HTTPS, not yet using data space connector
Sec.5	Network security measures commonly used with this data exchange	Use IP whitelist	Servers are installed, security measures are being planned to be implemented

D.2	Correctness of source data	Assumed by definition	To be evaluated in later stages
D.3	Up-to-date management	At least 75% of all data is accompanied by a timestamp	To be evaluated in later stages
D.5	Management of data across organisational boundaries	At least 1 organisational boundary is crossed	Implemented
D.6	Data maintenance effort: human versus automation	Max. 10 per month human intervention needed	To be evaluated in later stages
Conf.2	Distance between entities	Any distance is acceptable	- To be evaluated in later stages
Conf.3	Number of Information Producers	At least 10 energy nodes	To be evaluated in later stages
Conf.4	Number of Information Receivers	At least 2	To be evaluated in later stages
Conf.5	Communication media	Wired and wireless and Bluetooth connections are available	To be evaluated in later stages
Conf.6	Data exchange methods	Publish-subscribe data exchange is available	Implemented
Conf.7	Communication access services requirements	Request-response data exchange is available	Implemented
Conf.8	Commonly used communication protocol	REST API and Knowledge Engine are available	Implemented
O.2	All constraints also apply.	Processed personal data has at least one legal basis	To be evaluated in later stages
O.3	Right to access, rectify, erasure, restriction	Data retention policy has been defined	To be defined
O.4	Data transfer consent	-	Implemented
O.5	Data retention policy	No personal data is transferred to a third party	Implemented

3.4.4.2 KPIs Progress

The KPIs to be measured by the Dutch demo, their corresponding baseline and target values, are presented in Table 21 below. A new "Progress" column has been included to document developments during the Pre-Demo Phase (M16–M18). A "0" value under the progress column indicates that no measurable data has been collected during the pre-demo phase for the respective KPI. This does not reflect underperformance but rather the fact that measurement is scheduled to begin in the Full Demo Phase.

TABLE 21: KEY PERFORMANCE INDICATORS (KPIS) DEFINED FOR THE DUTCH DEMO, INCLUDING SUC RELEVANCE, BASELINE AND TARGET VALUES, AND REPORTED PROGRESS DURING THE PRE-DEMO PHASE

ID	KPI	Baseline	Target	Progress
OB1	Different types of IoT/edge devices to be exploited in Demo Areas e.g., Smart Meter, HEMS, Sensors, inverter	0	>5	15 smart meters, 2 edge servers, 1 BMS
OB4	Users involved in the piloting	0	20% at M18, 60% at M32, 100% at M42	100% (for 1 one building/BMS)
KPI3	% Of planned usage of HEDGE-IoT tools/data services (e.g., transactions, periodicity) in field demos	0	10% Y1, 40% Y2, 60% Y3, 100% Y4	0
KPI4	Real-time data sharing among stakeholders	0	10% Y1, 40% Y2, 60% Y3, 100% Y4	20% (streams of DSO grid meters, PV, submeters and one building, and EV data collection)
KPI5	Open source released developments related to data connector implementations	0	2 Y1, 3 Y2, 5 Y3	4 releases
KPI6	End-users' bill reduction by offering flexibility services	0	10% Y1, 20% Y2, 25% Y3, 40% Y 4	0%
KP10	Number of consumers engaged with flexibility services	0	>1000 end users	0
KPI22	Increase DERs participation in flexibility provision	0	5% Y1, 10% Y2, 15% Y3, 20% Y4, 25% Y5+	5% (first heat pump with buffering)

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3.5 DEMO 5 – LIVING LAB FOR INTEROPERABLE AI-BASED ENERGY SERVICES [PORTUGAL]

3.5.1 Pre – Demo Phase Activities Summary

This section presents a structured summary of the activities that the Portuguese Demo conducted during the Pre-Demo Phase (M16–M18). It expands upon the demo deployment template introduced in Chapter 2, which functions as a reference for monitoring the development of each demonstrator. The status of the pre-demo targets, the WP3 services utilised, and the key stakeholders involved during this phase are all detailed in Table 22 below. The purpose of the information is to establish the foundation for the Full Demo Phase and to evaluate the operational readiness of the demo at the conclusion of the Pre-Demo Phase.

TABLE 22: DEMO 5 PRE-DEMO PHASE DEPLOYMENT STATUS

Section	Subsection	Description
Summary	Pre-Demo Phase Target	• Prepare the demo infrastructure, enabling integration of digital platforms such as EdgeConnect and Community Manager. • Set up the onboarding of residential and industrial consumers and prosumers for participation in flexibility services. • Establish interoperable data exchange and align system operators and aggregators for testing flexibility.
	Status Summary	The demonstration will take place in the northern region of Portugal, in the CEVE concession area, involving residential and industrial participants. The demo setup includes digital platforms such as EdgeConnect and Community Manager to onboard consumers, enable interoperability, and manage flexibility assets. Services are defined for onboarding, data sharing, flexibility modelling, bidding, activation, and settlement.
	Services Used (from WP3)	• EdgeConnect • Residential Community Manager • Market Simulator
	Stakeholders involved during Pre-Demo	• INESC TEC • CEVE (DSO & Retailer) • REN / RDNester (TSO) • SONAE MC • ELERGONE • Local residential participants

3.5.2 Infrastructure, Assets and Data Availability

Based, on the demo-deployment template that was introduced in chapter 2, a consolidated snapshot of the infrastructure and assets mobilised during the Pre-Demo Phase is provided in Table 23 for the Portuguese demo. Each asset is accompanied by its technical description, deployment level, use status in months 16–18, and the WP 3 service to which it pertains.

TABLE 23: SUMMARY OF DEMO 5 INFRASTRUCTURE AND ASSETS DEPLOYED DURING THE PRE-DEMO PHASE

Asset	Description	Deployment Level	Used during Pre demo	Under which WP3 service
Heat pump	Ability to control via API / control capacity through home automation application	*Testing*	*Partly*	*HEMS*[*]
Wallbox Chargers	Control capacity through API and home automation application	*Testing*	*Partly*	*HEMS*[*]
Batteries and inverters	Control capacity through API and home automation application	*Testing*	*No*	*HEMS*[*]
Metering	Smart Metering	Already installed	*No*	Flexibility Optimisation Service
HVAC	Tertiary building heat and air conditioning units. Controllable through EnergyBox	Already installed	No	Flexibility Optimisation Service
Industrial Cooling	Tertiary building cooling system for frozen and fresh food conditioning. Controllable through EnergyBox	Already installed	No	Flexibility Optimisation Service
Energy Storage	Energy chemical storage system – lithium ion. Controllable through EnergyBox	Under development	*No*	Flexibility Optimisation Service
EnergyBox	A controller that integrates data from different assets of the building and exposes this data to the cloud. Acts as a gateway for Flexibility Service Provider.	Installed	*No*	Flexibility Optimisation Service

Table 24 summarises the datasets relevant to the Pre-Demo Phase, indicating their availability, whether they were used during this period and their linkage to the corresponding WP3 technological enablers.

TABLE 24: OVERVIEW OF DATASETS RELEVANT TO THE PRE-DEMO PHASE OF THE PORTUGUESE DEMO

Data Description	Used during Pre-Demo Phase	Under which WP3 service
Current measurements from all pilot area substation bays	Data Sample, full data	To showcase the connection with WP3 edge/cloud services, if applicable, provide a bit more context under which WP3 service it they have been used
Household Consumption Data	Partially	Vector Autoregressive Model for Energy Time Series Forecasting

3.5.3 Pre Demo Results

[*] *The HEMS (Home Energy Management System) service, although not listed in D5.1 or D3.3, was integrated during the Pre-Demo Phase to enable local control of heat pumps, wallboxes, and batteries. Its architecture and functionalities will be formally documented in Deliverable D3.4 as part of the updated WP3 technological components*

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This section captures the status and progress of System Use Case (SUC) implementation during the Pre-Demo Phase (M16–M18) for the Portuguese Demo. For each SUC, key developments are outlined, including the specific actions undertaken, intermediate achievements, and alignment with the expected implementation steps and scenarios described in D2.2. In addition, the internal milestones defined in D5.1 are revisited and assessed in terms of progress and completion. This structured overview offers insight into the readiness and maturity of each SUC ahead of the upcoming demonstration cycles. In Figure 39, the technical layout of the pre-demo phase is depicted, as described in Table 25.

TABLE 25: SUMMARY OF PRE-DEMO RESULTS OF THE PORTUGUESE DEMO

BUC	Related SUC	Pre Demo Results
***BUC-PT-01*: GreenVale: Harnessing the potential of energy communities by leveraging Federated Learning strategies.**	**SUC-PT-01.01 Connect flexibility providers across the DPP flexibility value chain**	Development of the core functionalities of the platform. Integration with acquisition of data from field assets under way; ongoing lab testing with consumers and assets.
	SUC-PT-01.02 Enable Data Exchange via Data Spaces	Specification of internal data representations on flexible assets which will be targeted by the data interoperability mechanism. Preparatory tests for the deployment of the EDC Data Space connector. Integration with the platform backend system under preliminary development
	SUC-PT -01.03 Mobilizing Energy Flexibility	Integration on EdgeConnect of RECreation community platform as flexibility aggregator (two services on the PT pilot); Initial integration tests with market platform done. Design of the integration with the TSO Market, for alignment with the interoperable standards
	SUC-PT-01.04 Activation of Energy Flexibility	Most of the developments of the HEMS done; Lab tests with residential assets ongoing and mostly finished.
***BUC-PT-02*: Participation of industrial and residential energy communities in ancillary services market for the TSO**	**SUC-PT-02.01 Bidding & Selection**	Internal developments. Although not used during the pre-demo phase
	SUC-PT-02.02 aFRR/mFRR Activation	Internal developments. Although not used during the pre-demo phase
	SUC-PT-02.03 aFRR/mFRR Settlement	Internal developments. Although not used during the pre-demo phase
***BUC-PT-03*: Flexibility aggregation at tertiary buildings**	**SUC-PT-03.1 Integrate flexible assets from commercial buildings**	EnergyBox is installed in the 3 pilot stores. A specific VLAN was created to connect all assets and EnergyBox, but integrations of assets in this VLAN are still in progress.
	SUC-PT-03.2 Default valorisation scenario based on price edging	Data still need to be integrated to be able to produce default scenario.
	SUC-PT-03.3 TSO Valorisation scenario	Integrations with Edge connect have not started.

The core result showcased is the **EdgeConnect platform**, which is the direct outcome of **BUC-PT-01 and its corresponding System Use Cases (SUCs)**. Within the following figure, solid lines represent connections that have been fully integrated and tested. Conversely, dashed lines indicate connections whose integration and testing will be delivered in upcoming pilot demo stages. The comprehensive details of the SUC diagrams are further elaborated within WP2's deliverables.

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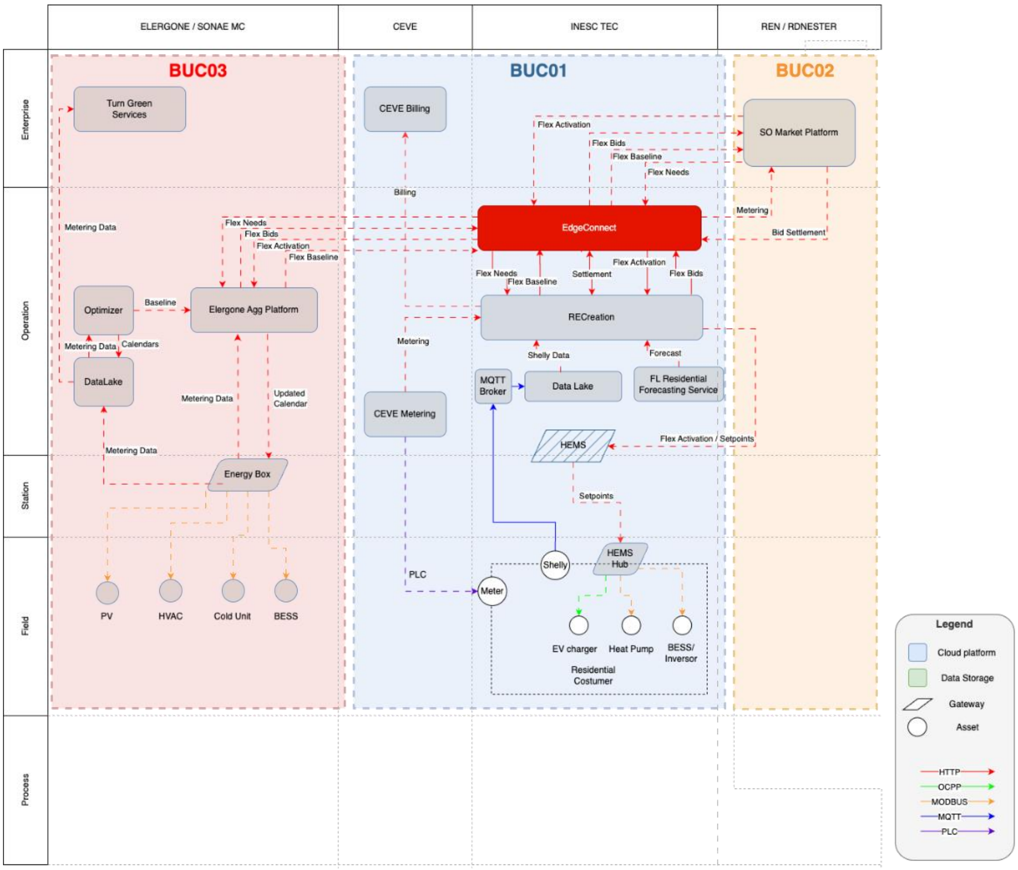

FIGURE 39: TECHNICAL LAYOUT OF THE PORTUGUESE PILOT

3.5.3.1 SUCs Implementation

This subsection presents the implementation progress of each System Use Case (SUC) as defined in D2.2 for the Portuguese Demo, highlighting the actions carried out during the Pre-Demo Phase. Please note that no deployment diagrams are currently provided for the Portuguese pilot in the following tables. During the Pre-Demo Phase, the EdgeConnect platform is still hosted in a lab environment. The IEC 62325 interface and EDC data-space connector are under validation, and only a subset of residential and tertiary assets have been installed. Because network topology, VLAN assignments, and gateway placement will change as the full device roll-out proceeds, any diagram produced now would be obsolete almost immediately. Complete, production-grade deployment diagrams—covering EdgeConnect instances, data-space connectors, TSO/BSP interfaces, and all enrolled assets—will therefore be included in the Full-Demo Report (D5.3) once the architecture is finalised.

SUC-PT-01.01 CONNECT FLEXIBILITY PROVIDERS ACROSS THE DPP FLEXIBILITY VALUE CHAIN

Section	Subsection	Description
Overview	SUC Summary	SUC-PT-01.01 Connect flexibility providers across the DPP flexibility value chain
	Target(s)	• Design, development and roll out of the core functionalities of the EdgeConnect DPP enabler platform.

		• Initial formulation and development of federated learning concepts and methodologies for energy consumption forecasting. • Testing and validation of relevant components (such as the RECreation platform or parts of EdgeConnect) in lab environments or with data not necessarily from the final pilot. • Baseline establishment activities for the relevant KPIs of Demo 5. • Initial work on integrating interoperability enablers and setting up the necessary data flows between assets, the community platform, and EdgeConnect, as defined by the SUCs. • Preparation and setup of the necessary infrastructure for the pilot at the Demo 5 location. • Lab testing of integration of residential household assets with HEMS solution.
	Expected UC Milestones	Adaptation of EdgeConnect components. M14.
	Actions implemented	For the milestone "Adaptation of EdgeConnect components" (M14), the corresponding activities are Steps 1-3 of Scenario 1 of SUC-PT-01.01. This initial phase (M1-M18) involved technological specification, development and deployment of the platform. Moreover, data collection and monitoring mechanisms using IoT sensors was integrated and set up. Activities in this phase included the implementation and initial validation of EdgeConnect core functionalities relevant to the SUC, such as login and registration on the digital platform (DPP), the development of adaptations to the flexibility value chain interface towards the TSO market, registration of services and assets.
Requirements	Assumptions	The operational computational environment to deploy the platform is operational. Moreover, at this stage no direct market integration is active, thus the bidding process as part of the market operation is simulated on the side of EdgeConnect.
	Dependencies	• Service providers have their own technical platforms which they integrate with the interfaces for the DPP. • Consumers have internet connection and interface with the systems via their browsers, mobile applications, or other available interfaces/means.
	Risks	• Lack of consumer engagement. • Lack of interoperability between components. • Delays in development. • Unavailability of connectivity among digital services.
Readiness	Deployment diagram	n/a
	Deployment preparation	Requirements: • Users to participate in the pilot • Assets integrated in household • Connectivity for the HEMS • EdgeConnect deployed in INESC TEC cloud
	Deployment assessment	Pre-demo phase was concluded successfully. No risks were activated. EdgeConnect was properly developed, deployed and tested. Initial batch of participants were assembled, and first few assets were installed in the households.
Validation Activities Summary	Previous cycle	This is the first cycle
	Current cycle	• EdgeConnect tested and initial work towards deployment done. • First batch of clients gathered.

		• Integration of EdgeConnect with RECreation core functionalities • Initial work towards the installation of flexible assets in the residential households of the clients.
	Future cycle	• Full deployment of EdgeConnect. Finish developments of RECreation and HEMS. • Integration of EdgeConnect with TSO market operation and respective interoperability testing. • Test services with initial batch of clients (beta testers). • Continue the work towards gathering more clients. • Install a wider variety and more quantity of assets.

SUC-PT-01.02 ENABLE DATA EXCHANGE VIA DATA SPACES

Section	Subsection	Description
Overview	SUC Summary	SUC-PT-01.02 Enable Data Exchange via Data Spaces
	Target(s)	Deployment of semantic interoperability connectors (Foreseen in M20). This target implies the crucial step of implementing the components required for enabling standardised and interoperable data exchange, which is the core function of the SUC-PT-01.02 within the data space context. Achieving this involves setting up the necessary infrastructure to allow different systems and platforms to understand and share data effectively by deploying these connectors.
	Expected UC Milestones	This SUC is not expected to be achieved at this stage.
	Actions implemented	Design and preliminary integration plan of the Data Space connector with the Edge Connect backend. Focus in considering if dedicated data and control planes will be required or if generic and already available ones exist.
Requirements	Assumptions	A running version of the EDC Data Space connector, which can be deployed and tested in a stag environment
	Dependencies	EDC connector dependencies and technical specification of EdgeConnect.
	Risks	EdgeConnect data representation and data availability model shows not to be compatible with Data Spaces data sovereign data model and strategy.
Readiness	Deployment diagram	n/a
	Deployment preparation	Requirements: • Users to participate in EdgeConnect deployed in INESC TEC cloud • EDC reference implementation and specification available.
	Deployment assessment	• Pre-demo phase was concluded successfully. No risks were activated yet. • EdgeConnect was properly developed and tested. Initial batch of participants were gathered, and first few assets were installed in the households. • EDC documentation and stag deployment completed in INESC TEC's infrastructure.
Validation Activities Summary	Previous cycle	This is the first cycle
	Current cycle	• EdgeConnect tested and initial work towards deployment done. • Successful deployment of an EDC deployment for testing purposes.
	Future cycle	• Decision to establish or no dedicated control and data planes. • Technical integration with between a local instance of EDC and Edge Connect • Inclusion of data assets in the data space originating from Edge Connect.

SUC-PT-01.03 MOBILIZING ENERGY FLEXIBILITY

Section	Subsection	Description
Overview	SUC Summary	SUC-PT -01.03 Mobilizing Energy Flexibility
	Target(s)	Validation of EdgeConnect's flexibility value chain applicability in pilot context
	Expected UC Milestones	Adaptation of EdgeConnect components. M14.
	Actions implemented	Specification and technical alignment with incorporating a new type of market (TSO). Interoperability constraints and impact analysis on data messages and overall process fit. Preparation of data messaging
Requirements	Assumptions	The baseline operation and integration of EdgeConnect is done.
	Dependencies	• Actors already have their data space identities and connectors ready. • Consumers already have their assets registered in EdgeConnect ready to be integrated by the FSP. • The assets are within the premises of the consumer and have access to the internet around the clock.
	Risks	• Lack of interoperability between components. • Delays in development. • EDC ecosystem not ready or unavailable for testing
Readiness	Deployment diagram	n/a
	Deployment preparation	Requirements: • EdgeConnect deployed in INESC TEC cloud • EDC connector deployed in stag environment
	Deployment assessment	• Pre-demo phase was concluded successfully. No risks were activated yet. • Preliminary testing of the EDC to showcase alignment was successfully complete
Validation Activities Summary	Previous cycle	n/a
	Current cycle	• EdgeConnect tested and core work towards deployment done. • EDC tests to align the integration among the components.
	Future cycle	• Development of custom data and control planes. Establishment of data access policies depending on the data assets to be made available. • Test of the integration and validation of requests arriving form the data space are correctly satisfied.

SUC-PT-01.04 ACTIVATION OF ENERGY FLEXIBILITY

Section	Subsection	Description
Overview	SUC Summary	SUC-PT-01.04 Activation of Energy Flexibility
	Target(s)	Test EdgeConnect's flexibility dispatch module
	Expected UC Milestones	Adaptation of EdgeConnect components. M14.
	Actions implemented	For the milestone "Adaptation of EdgeConnect components" (M14), the corresponding activities included in Scenario 1 of SUC-PT-01.04. These steps involve changes to accommodate a new type of flexibility market, in this case of TSOs, where previously an integration with DSO aligned markets was present. Moreover, besides the conceptual and direct integration changes according to IEC 62325 standard.
Requirements	Assumptions	The baseline operation and integration of EdgeConnect is done
	Dependencies	• Consumers are present in the areas where the FSPs operate in the operational database of edge connect,

		• Data exchange has been enabled for all the actors participating in the use case.
	Risks	Impossibility to accommodate the existing operational and business data model of EdgeConnect against the required representations of IEC62325.
Readiness	Deployment diagram	n/a
	Deployment preparation	Requirements: • EdgeConnect deployed in INESC TEC cloud • Data modelling in operational database including flexibility zones to allow mock bids to be issued.
	Deployment assessment	• Pre-demo phase was concluded successfully. No risks were activated yet. • Preliminary tests for the integration of IEC62325 messaging was completed. Adjustments will be required to ensure conformity.
Validation Activities Summary	Previous cycle	n/a
	Current cycle	EdgeConnect tested and initial work towards deployment done.
	Future cycle	• Full deployment of EdgeConnect. Finish core developments of RECreation and HEMS. • Complete integration of IEC62325 messaging and integration testing with the real operational market platform.

SUC-PT-02.01 BIDDING & SELECTION

Section	Subsection	Description
Overview	SUC Summary	SUC-PT-02.01 Bidding & Selection Processes involved in soliciting bids from reserve capacity providers and selecting the most appropriate bid to maintain network stability and frequency regulation
	Target(s)	No pilot-level targets in the current evaluation cycle
	Expected UC Milestones	• Adaptation of EdgeConnect components: Sessions on uniformisation of data to be exchanged and the methods to do so. • Development of bilateral contract mechanism: Market simulator is agnostic with regard of the contract agreed among BSP, aggregators and operators. • Integration with demo stakeholder's digital platforms: Ongoing • Adoption of interoperability mechanisms: Implementations made around the standard IEC 62325 • Adoption of market platform: Ongoing
	Actions implemented	Internal developments. Adaptation for accepting different granularity bids, i.e. 15 and 60 minutes. Improvement of the clearing function. Evaluation of methods to acquire historic information available in ENTSO-E Transparency Platform.
Requirements	Assumptions	The bids that are going to be submitted in the pilot are assumed indivisible and are, either, accepted or rejected as a whole.
	Dependencies	No dependencies.
	Risks	Development delays were identified as risks given the internal workload of the tasks responsible. Frequent status reviews are being carried out.
Readiness	Deployment diagram	n/a
	Deployment preparation	Previous version of the Market simulator deployed in cloud, up and running. When a new version with the developed improvements is tested it can be deployed in cloud.
	Deployment assessment	Developments are being carried out as expected with minimum delays with the objective to be ready for interoperability test before the next evaluation cycle.

Validation Activities Summary	Previous cycle	This is the first cycle
	Current cycle	Internal developments related with the functioning of the Market Simulator and the improvements required for it to fulfil the expected objectives.
	Future cycle	Next steps involve finalising the Market Simulator in a version that is ready for interoperation with the other tools inside the pilot. The full-demo phase must demonstrate a complete flow-stream end-to-end of the exchanged data.

SUC-PT-02.02 AFRR/MFRR ACTIVATION

Section	Subsection	Description
Overview	SUC Summary	SUC-PT-02.02 aFRR/mFRR Activation
	Target(s)	No pilot-level targets in the current evaluation cycle
	Expected UC Milestones	• Adaptation of EdgeConnect components: Sessions on uniformisation of data to be exchanged and the methods to do so. • Development of bilateral contract mechanism: Market simulator is agnostic with regard of the contract agreed among BSP, aggregators and operators. • Integration with demo stakeholder's digital platforms: Ongoing • Adoption of interoperability mechanisms: Implementations made around the standard IEC 62325 • Adoption of market platform: Ongoing
	Actions implemented	Activation processes are being completely improved from the previous version. They involve the creation of a new activation file as described in the standard. The communication for the result of each bid is also being improved.
Requirements	Assumptions	It is assumed that the target endpoints in each partner are going to be always available, and no recovery method is going to be implemented
	Dependencies	The activation processes are only initiated after the gate closure time for a given market time unit. Additionally, the process is executed only when minimum one bid was submitted.
	Risks	• Development delays were identified as risks given the internal workload of the tasks responsible. Frequent status reviews are being carried out. • Communication failures among the platforms could damage the pilot execution. Coordination sessions among the partners are expected to happen.
Readiness	Deployment diagram	n/a
	Deployment preparation	- Previous version of the Market simulator deployed in cloud, up and running. When a new version with the developed improvements is tested it can be deployed in cloud. - Endpoints are being tested by a simulated external platform.
	Deployment assessment	Developments are being carried out as expected with minimum delays with the objective to be ready for interoperability test before the next evaluation cycle.
Validation Activities Summary	Previous cycle	n/a
	Current cycle	Internal developments related with the functioning of the Market Simulator and the improvements required for it to fulfil the expected objectives.
	Future cycle	Next steps involve finalising the Market Simulator in a version that is ready for interoperation with the other tools inside the pilot. The full-demo phase must demonstrate a complete flow-stream end-to-end of the exchanged data.

SUC-PT-02.03 AFRR/MFRR SETTLEMENT

Section	Subsection	Description
Overview	SUC Summary	SUC-PT-02.03 aFRR/mFRR Settlement
	Target(s)	No pilot-level targets in the current evaluation cycle
	Expected UC Milestones	• Adaptation of EdgeConnect components: Sessions on uniformisation of data to be exchanged and the methods to do so. • Development of bilateral contract mechanism: Market simulator is agnostic with regard of the contract agreed among BSP, aggregators and operators. • Integration with demo stakeholder's digital platforms: Ongoing • Adoption of interoperability mechanisms: Implementations made around the standard IEC 62325 • Adoption of market platform: Ongoing
	Actions implemented	Baseline calculation definition for settlement calculations was defined.
Requirements	Assumptions	Measured data from each BSP's associated measuring point must be collected and available.
	Dependencies	Dependencies on other pilot's partners for providing the measurements of their assets in order to calculate and contrast the bids offered, bids selected, and power effectively delivered or consumed.
	Risks	Availability of the measurement data is a risk that has being mitigated by constant updates with the partners responsible for the collection and communication of that data.
Readiness	Deployment diagram	n/a
	Deployment preparation	Previous version of the Market simulator deployed in cloud, up and running. When a new version with the developed improvements is tested it can be deployed in cloud.
	Deployment assessment	Developments are being carried out as expected with minimum delays with the objective to be ready for interoperability test before the next evaluation cycle.
Validation Activities Summary	Previous cycle	This is the first cycle
	Current cycle	Settlement calculations processes are being defined and implemented in an ongoing status.
	Future cycle	Next steps involve finalising the Market Simulator in a version that is ready for interoperation with the other tools inside the pilot. The full-demo phase must demonstrate a complete flow-stream end-to-end of the exchanged data.

SUC-PT-03.01 INTEGRATE FLEXIBLE ASSETS FROM COMMERCIAL BUILDINGS

Section	Subsection	Description
Overview	SUC Summary	SUC-PT-03.1 Integrate flexible assets from commercial buildings Architecture and data flows at building level and cloud level that allows integration of flexible assets data.
	Target(s)	Integrate flexible assets from commercial buildings
	Expected UC Milestones	• EnergyBox installation • Integration of assets with EnergyBox • Integration of assets (through EnergyBox) with OptiFlex and EdgeConnect
	Actions implemented	• Validation and Creation of VLANs • Validation of Firewall Rules and Accesses • Definition of data models for algorithms and optimisation purposes

Requirements	Assumptions	- The reserve resources predicted to be integrated are: HVAC's, cooling systems, batteries and PV. All reserve resources should be tested to validate their integration with energybox. - All resource resources and energybox should be connected to the same VLAN.
	Dependencies	Dependence on Third Party suppliers (including technical capacity and availability) for the resource assets integration.
	Risks	Evaluate possible overlay between the technical aggregator and EdgeConnect Platform.
Readiness	Deployment diagram	n/a
	Deployment preparation	• Guarantee that VLAN95 is available and all assets and energybox are connected there. • Equipment integration within VLAN (EnergyBox and resource assets) • Assets integration with Enterprise Server, Technical Aggregator and Edge Connect
	Deployment assessment	VLAN 95 created and EnergyBox installed in the 3 pilot stores.
Validation Activities Summary	Previous cycle	n/a
	Current cycle	• Guarantee that VLAN95 is available and all assets and energybox are connected there. • Equipment integration within VLAN (EnergyBox and resource assets) • Assets integration with Enterprise Server, Technical Aggregator and Edge Connect
	Future cycle	• Integration with technical aggregator • Pre-qualification of assets in EdgeConnect

The implementation activities of the Portuguese Demo are technically supported by the EdgeConnect platform, which enables service delivery for several SUCs. The EdgeConnect platform was first deployed in INESCTEC's cloud infrastructure to validate the operation of the platform's core functionalities. A preliminary check of service availability was performed to ensure that the components were correctly deployed and gained access to the two required databases: one for operational data and the other for business information, specifically for stakeholder identification. After the technical availability tests for the platform, the tests provided in each SUC were performed through a combination of issued requests using a Postman collection that sent individual REST-based requests to EdgeConnect's backend system, as well as direct usage of the platform's GUI. Technical integration tests with the RECreation platform were also conducted, where the latter system took on the role of an aggregator, receiving flexibility needs, issuing flexibility bids, and collecting flexibility activation requests.

3.5.3.2 Milestones and Progress

This subsection revisits the internal milestones identified in D5.1 and assesses their current status, noting any updates, delays, or partial completions observed during the Pre-Demo Phase. The information is presented in Table 26, which maps each milestone to the corresponding implementation steps and indicates the extent of progress achieved for the Portuguese Demo:

TABLE 26: PROGRESS ON PORTUGUESE DEMO INTERNAL MILESTONES LINKED TO THE IMPLEMENTATION OF SYSTEM USE CASES (SUCS) DURING THE PRE-DEMO PHASE

Internal Milestones	Month	SUC-PT-01.01	SUC-PT-01.02	SUC-PT-01.03	SUC-PT-01.04	SUC-PT-02.01	SUC-PT-02.02	SUC-PT-02.03	SUC-PT-03.1	SUC-PT-03.2	SUC-PT-03.3
Adaptation of EdgeConnect components	M14	*Sc.1, 2 and 3 developed and tested*	*First tests conducted*	*First tests conducted*	*First tests conducted*	-	-	-	-	-	-
Number of reserve resources	M16								*Step 1 and 2*	*n/a*	*n/a*
Data availability during pilot	M18								*Step 3*	*n/a*	*n/a*
Number of reserve resources enrolled in DPP	M20								*Step 4*	*n/a*	*n/a*
Adoption of market platform	M24					*St .6 to St .10 developed and tested*	*mFRR activation message is ongoing. AFRR activation message has not started yet*	*Not started yet*			
Adoption of interoperability mechanisms	M24	*Not started*	*Sc. 1 developed and tested*	*Not started*	*Not related*	*St .5 Data template to be used defined among the partners*	*Same as SUC 02.01*	*Not started yet*	-	-	-

3.5.4 Pre-Demo Evaluation

3.5.4.1 Requirements Evaluation

The following section presents the requirement for each SUC, which was initially introduced in D5.1 including the description, acceptance criteria, and assigned testing partner. An additional column now captures the progress status recorded during the Pre-Demo Phase, allowing a direct comparison between the targets set in D5.1 and the results achieved to date.

SUC-PT-01.01 CONNECT FLEXIBILITY PROVIDERS ACROSS THE DPP FLEXIBILITY VALUE CHAIN

Req	Description	Acceptance Criteria	Progress
F.1	Login in the DPP	Login is successful	Login is successful
F.2	Registration in the DPP	Registration completes and user can login	Registration form operational and user gets registered
F.3	Access to the service	The DPP is accessible to pilot partners	The platform's local URL is available and reachable.
F.4	Consumer/prosumer energy consumption data	Consumer data is accessible via the DPP	Dummy metering data is consulted in EdgeConnect as part of a consumer profile.
F.4-1	Consumer/prosumer PV production data	PV production data is accessible via the DPP	Dummy asset data is available, but live data feed-in is not yet available.
F.4-2	Consumer/prosumer geographical coordinates for the energy consumed	Consumer profile information is available in the DPP.	Profile information is available.
F.5	Consumer flexible assets available	Consumer profile information is available in the DPP.	Consumer profile displays available assets
F.6	Digital service available on the DPP platform	The DPP shows each digital service.	The service catalogue displays available services.
F.7	Service provider controls assets of subscribed consumers/prosumers	The DPP shows asset's information from consumers in the context of a service.	Not yet operational.
F.8	Consumers/prosumers can share their flexibility capacity with third-party services	Consumers have access to a service that allows them to share their data.	Consumer profile includes data authorisations that can be granted and revoked.
F.9	Consumers/prosumers have a profile that characterises them	The DPP holds a profile information for each profile.	Service providers can check consumer profiles and do an advanced search by several criteria.
F.11	Unique ID for grid users and aggregator	Each user profile holds a unique identifier.	Upon onboarding in the platform
F.12	Request metadata sent to semantic system	Verify that metadata arrives at the metadata broker.	Not yet integrated
F.13	Consumer is subscribed to service	Consumer identifier is available as onboarded in the service profile.	For dummy consumer accounts that onboarded a given service, they become visible in the service admin page
F.14	Access to consumer's geographical location	Consumer's location of assets is available to grid stakeholders.	The consumer relative grid connection identifier is included as information for service providers.

SUC-PT-01.02 ENABLE DATA EXCHANGE VIA DATA SPACES

Req	Description	Acceptance Criteria	Progress
F.1	Asset is represented in an interoperable format	Each data asset is mapped in the metadata broker.	n/a
F.2	Identity certificates issued in X.509 format	Each user holds an identity certificate for authentication.	n/a

SUC-PT-01.03 MOBILIZING ENERGY FLEXIBILITY

Req	Description	Acceptance Criteria	Progress

F.1	Login in the DPP	Login is successful	Login is successful
F.2	Registration in the DPP	Registration completes and user can login	Registration form operational and user gets registered
F.3	Access to the service	The DPP is accessible to pilot partners	The platform's local URL is available and reachable.
F.4	Consumer flexible assets available	Consumer data is accessible via the DPP	Consumer profile displays available assets
F.5	Digital service available on the DPP platform	The DPP shows each digital service.	The service catalogue displays available services.
F.6	Service provider controls assets of subscribed consumers/prosumers	The DPP shows asset's information from consumers and can change their preferences.	Not yet operational.
F.7	Consumers/prosumers can share their flexibility capacity with third-party services	Consumers have access to a service that allows them to share their data.	Consumer profile includes data authorisations that can be granted and revoked.
F.8	Consumers/prosumers have a profile that characterises them	The DPP holds a profile information for each profile.	Service providers can check consumer profiles and do an advanced search by several criteria.
F.10	Request metadata sent to semantic system	Verify that metadata arrives at the metadata broker.	Not yet integrated
F.11	Consumer is subscribed to service	Consumer identifier is available as onboarded in the service profile.	For dummy consumer accounts that onboarded a given service, they become visible in the service admin page
F.12	Service contract between stakeholders on the DPP platform	A digital contract for the data being exchange exists and is valid.	Not yet deployed.
F.13	Permission to activate/deactivate the subscription of a service	Each user can enable/disable the permission to share data.	Not yet implemented.

SUC-PT-01.04 ACTIVATION OF ENERGY FLEXIBILITY

Req	Description	Acceptance Criteria	Progress
F.1	Login in the DPP	Login is successful	Login is successful
F.2	Consumer/prosumer energy consumption data	Metering data for the consumer can be fetched.	Dummy metering data is consulted in EdgeConnect as part of a consumer profile.
F.2-1	Consumer/prosumer PV production data	PV production data can be fetched.	Dummy asset data is available, but live data feed-in is not yet available.
F.2-2	Consumer/prosumer geographical coordinates for the energy consumed	Consumer's assets coordinates are available.	Profile information is available.
F.3	Digital service available on the DPP platform	The DPP shows each digital service.	The service catalogue displays available services.
F.4	Service provider controls assets of subscribed consumers/prosumers	The DPP shows asset's information from consumers and can change their preferences.	Implemented but not yet deployed for testing

F.6	Service contract between stakeholders on the DPP platform	A digital contract for the data being exchange exists and is valid.	Not yet deployed.

SUC-PT-02.01 BIDDING & SELECTION

Req	Description	Acceptance Criteria	Progress
D.2	Validation of data exchanges	All data reception must be notified on each data exchange	Ongoing. Tested internally.
Conf.2	aFRR product configuration	Minimum bid size: 0.1 MW Bid granularity: 0.01 MW Price of the bid: €/MWh, with resolution of 0.01 €/MWh	Defined but not implemented
Conf.3	mFRR product configuration	Minimum bid size: 0.1 MW Bid granularity: 0.01 MW Price of the bid: €/MWh, with resolution of 0.01 €/MWh	Defined and implemented
QoS.3	Availability of information flows	99.9% + availability – Measured on the number of connections requested due to the on-demand nature of the pilot	Ongoing. Not measured yet.

SUC-PT-02.02 AFRR/MFRR ACTIVATION

Req	Description	Acceptance Criteria	Progress
D.2	Validation of data exchanges	All data reception must be notified on each data exchange	Ongoing. Tested internally.
QoS.3	Availability of information flows	99.9% + availability – Measured on the number of connections requested due to the on-demand nature of the pilot	Ongoing. Not measured yet.
QoS.4	Elapsed time of data exchange	Elapsed time response requirements for exchanging data from 1-2 seconds	Not measured yet.

SUC-PT-03.01 INTEGRATE FLEXIBLE ASSETS FROM COMMERCIAL BUILDINGS

Req	Description	Acceptance Criteria	Progress
CONN-1 VLAN	All assets connected to the same VLAN within the building	Connectivity within the defined VLAN	Under accuracy testing
CONN-2 Variable binding	Variables mapped and binded into the EnergyBox	Validate variables values in EcoStruxure Platform	To be tested later
CONN-3 Buildings mapping	Buildings data must be mapped as well as its assets	Validate buildings information with MC tools	To be tested later
CONN-4 Internet connection	Assets shall have secure and stable connection to the internet	Validate internet connection in the store	To be tested later
GPDR-1 Data protection and privacy	Applicable data protection and privacy rules must be fulfilled	Validate with MC specified teams	To be tested later

SUC-PT-03.02 DEFAULT VALORISATION SCENARIO BASED ON PRICE HEDGING

Requirement	Description	Acceptance Criteria	Progress
CONN-1 VLAN	All assets connected to the same VLAN within the building	Connectivity within the defined VLAN	Under accuracy testing

CONN-2 Variable binding	Variables mapped and binded into the EnergyBox	Validate variables values in EcoStruxure Platform	To be tested later
CONN-3 Buildings mapping	Buildings data must be mapped as well as its assets	Validate buildings information with MC tools	*To be tested later*
CONN-4 Internet connection	Assets shall have secure and stable connection to the internet	Validate internet connection in the store	To be tested later
GPDR-1 Data protection and privacy	Applicable data protection and privacy rules must be fulfilled	Validate with MC specified teams	To be tested later

SUC-PT-03.03 TSO VALORISATION SCENARIO

Requirement	Description	Acceptance Criteria	Progress
CONN-1 VLAN	All assets connected to the same VLAN within the building	Connectivity within the defined VLAN	Under accuracy testing
CONN-2 Variable binding	Variables mapped and binded into the EnergyBox	Validate variables values in EcoStruxure Platform	To be tested later
CONN-3 Buildings mapping	Buildings data must be mapped as well as its assets	Validate buildings information with MC tools	To be tested later
CONN-4 Internet connection	Assets shall have secure and stable connection to the internet	Validate internet connection in the store	To be tested later
GPDR-1 Data protection and privacy	Applicable data protection and privacy rules must be fulfilled	Validate with MC specified teams	To be tested later

3.5.4.2 KPIs Progress

The KPIs to be measured by the Portuguese demo, their corresponding baseline and target values, are presented in Table 27 below. A new "Progress" column has been included to document developments during the Pre-Demo Phase (M16–M18). A "0" value under the progress column indicates that no measurable data has been collected during the pre-demo phase for the respective KPI. This does not reflect underperformance but rather the fact that measurement is scheduled to begin in the Full Demo Phase.

TABLE 27: KEY PERFORMANCE INDICATORS (KPIS) DEFINED FOR THE PORTUGUESE DEMO, INCLUDING SUC RELEVANCE, BASELINE AND TARGET VALUES, AND REPORTED PROGRESS DURING THE PRE-DEMO PHASE

ID	KPIs	Baseline	Target	Progress
K-PT-01.1-1	Number of community participants	n/a	30	0
K-PT-01.1-2	Number of flexible assets registered	15	30	0
K-PT-01.1-3	Different types of IoT/edge devices to be exploited in Demo Areas	2	4	0
K-PT-01.1-4	Users involved in the pilot	n/a	30	12
K-PT-01.1-5	% Of planned usage of HEDGE-IoT tools/data services (e.g., transactions, periodicity) in field demos	n/a	60	0

K-PT-01.1-6	Increased RES and IoT deployment for providing flexibility services	30	45	0
K-PT-01.1-7	IoT/Edge/Fog sites uptime and availability	1 Month	6 Months	0
K-PT-01.1-8	Increased RES investments from residential users firmed with DERs enable by IoT	n/a	Up to 5%	0
K-PT-01.2-1	Number of services onboarded using the connector	2	4	0
K-PT-01.2-2	Number of data assets published	10	20	0
K-PT-01.2-3	Number of transactions	n/a	300	0
K-PT-01.2-4	Real-time data sharing among stakeholders	n/a	10	0
K-PT-01.3-1	*Registered participants in flex services*	n/a	30	0
K-PT-01.3-2	*Number of assets to provide flexibility*	10%	25	0
K-PT-01.3-3	*Differentiated incentives to consumers*	n/a	Up to 2	0
K-PT-01.4-1	End-users' benefits by offering flexibility services	n/a	Up to 10%	0
K-PT-01.4-2	Flexibility unlocked and transacted in markets	n/a	Up to 25%	0
K-PT-01.4-3	Number of consumers engaged with flexibility services	n/a	Up to 15	0
K-PT-02.1-1	Increased flexibility incorporation enabled by IoT/Edge technologies for grid security	n/a	Increase flexibility accepted in the market	0
K-PT-02.2-1	Faster application response time	n/a	<1 min	0
K-PT-02.3-1	Flexibility delivery accuracy	n/a	>85%	0
K-PT-02.3-2	Discrepancy rate	n/a	Limit discrepancy rate to less than 5%	0
K-PT-02.3-3	Correction Factor/Penalty rate	n/a	Reduce penalty rate for under-delivery to less than 5%	0
K-PT-03.1-1	Number of reserve resources	n/a	10 assets	10
K-PT-03.1-2	Data availability during pilot	n/a	>1h/month	0
K-PT-03.1-3	Number of reserve resources enrolled in DPP	n/a	6 assets	
K-PT-03.2-1	Monetary impact	n/a	€12,000/annual	0

K-PT-03.2-2	Valorisation scenarios generated	n/a	1 scenario/day	
K-PT-03.2-3	Valorisation scenario activated	n/a	> 80%	0
K-PT-03.2-4	Schedule deviation	n/a	<10%	
K-PT-03.3-1	TSO requests	5 requests/month	20 requests/month	0
K-PT-03.3-2	% of activations of TSO requests	n/a	> 40%	0
K-PT-03.3-3	TSO requests valorisation	€1,000/month	€10,000/month	0

3.6 DEMO 6 – ENHANCED LOCAL FLEXIBILITY SERVICES FOR IMPROVED ASSET LIFETIME [SLOVENIA]

3.6.1 Pre – Demo Phase Activities Summary

This section presents a structured summary of the activities that the Slovenian Demo conducted during the Pre-Demo Phase (M16–M18). It expands upon the demo deployment template introduced in Chapter 2, which functions as a reference for monitoring the development of each demonstrator. The status of the pre-demo targets, the WP3 services utilised, and the key stakeholders involved during this phase are all detailed in Table 28 below. The purpose of the information is to establish the foundation for the Full Demo Phase and to evaluate the operational readiness of the demo at the conclusion of the Pre-Demo Phase.

TABLE 28: DEMO 6 PRE-DEMO PHASE DEPLOYMENT STATUS

Section	Subsection	Description
Summary	Pre-Demo Phase Target	The focus in Pre-Demo phase is to test all services and IoT devices in a laboratory environment, using dummy data.
	Status Summary	• IoT device has been tested in laboratory environment • Anomaly detection algorithm 90% done with dummy data • Forecast algorithm 90% done with dummy data • Detection of DER in LV grid 30% done • Data connection between devices is done theoretically • DTR-DLR algorithm on edge has been tested in lab environment • Working on weather forecast algorithm
	Services Used (from WP3)	• Service 3.1 – Enhanced Network Management and Planning • Service 3.2 – DTR-DLR on Edge
	Stakeholders involved during Pre-Demo	Actors involved in the pre-demo phase: DSO, Metering Centre, Ambient temperature sensor, TSO, Smart meters, CIM model, Data analyst, Service provider, Environment model, Semantic model of substation

3.6.2 Infrastructure, Assets and Data Availability

Based, on the demo-deployment template that was introduced in chapter 2, a consolidated snapshot of the infrastructure and assets mobilised during the Pre-Demo Phase is provided in Table 29 for the Slovenian demo. Each asset is accompanied by its technical description, deployment level, use status in months 16–18, and the WP 3 service to which it pertains.

TABLE 29: SUMMARY OF DEMO 6 INFRASTRUCTURE AND ASSETS DEPLOYED DURING THE PRE-DEMO PHASE

Asset	Description	Deployment Level	Used during Pre demo	Under which WP3 service
DTR/DLR IoT devices	IoT devices in DSO secondary transformer stations and TSO power lines with edge processing capabilities and Thermal Rating calculation	Tested in laboratory by M16 Deployment by M20	Partly	Service 3.2 – DTR-DLR on edge
Metering centre in DSO	DSO metering centre in secondary transformer substation providing data needed for DTR calculation	Already deployed within the DSO grid. First connection with IoT device by M18	Yes	Service 3.2 – DTR-DLR on edge
Power quality meter in TSO	TSO PQ meter in overhead power lines providing data for DLR calculation	Already deployed in within TSO grid. First connection with IoT device by M18	Yes	Service 3.2 – DTR-DLR on edge
Weather data sensors	Sensors at the edge measuring ambient temperature, used for DTR calculation	Tested in lab environments M16. Full deployment by M20	Partly	Service 3.2 – DTR-DLR on edge
Weather station	Weather station in TSO grid providing data that is used for DLR calculation	Already deployed in TSO grid. First connection by M18	Partly	Service 3.2 – DTR-DLR on edge
Validation sensors	Temperature sensors at the edge used for DTR/DLR calculation validation	Tested in laboratory by M18. First deployment in M18-M20	Partly	Service 3.2 – DTR-DLR on edge
Sumo Cloud Database	Cloud storage for saving DTR data and data used in the calculation	First connection by M18. Deployed by M20	Partly	Service 3.2 – DTR-DLR on edge
PowerCIM	Semantic model of secondary transformer substation including DTR and MC data. Additionally, it will include a database where data will be saved.	First deployment with preliminary data by M18. Full scale by M22	Partly	n/a
ML/AI algorithms	Three ML algorithms used for: Anomaly detection in LV grid, Forecasting of electrical measurements in the secondary transformer, DER detection on the LV grid	First tests with dummy data finished by M16. Deployed with real data by M22-M24 after the integration of IoT devices and full deployment of PowerCIM	Yes	Service 3.1 - Enhanced Network Management and Planning

Table 30 summarises the datasets relevant to the Pre-Demo Phase, indicating their availability, whether they were used during this period and their linkage to the corresponding WP3 technological enablers.

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TABLE 30: OVERVIEW OF DATASETS RELEVANT TO THE PRE-DEMO PHASE OF THE SLOVENIAN DEMO

Data Description	Used during Pre-Demo Phase	Under which WP3 service
Distribution transformer current measurements	Data samples and one transformer full data stream from MC	Service 3.2 (Current data is used for DTR calculation on edge. In the testing period data sample will be used. Afterwards MC will be directly connected to IoT device)
Distribution Transformer voltage measurements	Data samples and one transformer full data stream from MC	Service 3.1 (Voltage data is used for ML algorithms. In the testing period data samples will be used)
Distribution transformer active power measurements	Data samples and one transformer full data stream from MC	Service 3.1 (Active power data is used for ML algorithms. In the testing period data samples will be used)
Distribution transformer reactive power measurements	Data samples and one transformer full data stream from MC	Service 3.1 (Reactive power data is used for ML algorithms. In the testing period data samples will be used)
DTR data for distribution transformer	Data samples (calculated from dummy data) will be available in the pre-demo phase. Full data available after M20	Service 3.2 (DTR data is the output of Service 3.2)
Ambient temperature data	Data samples will be available in pre-demo phase. Full integration by M20	Service 3.2 (Ambient temperature sensors will be used for DTR calculation)
DLR data for transmission power lines	Data samples (calculated from dummy data) will be available in the pre-demo phase. Full data available after M20	Service 3.2 (DLR data is the output of Service 3.2)
Transmission power line current measurements	Data samples and one transformer full data stream from MC	Service 3.2 (Current data is used for DTR calculation on edge. In the testing period data sample will be used. Afterwards MC will be directly connected to IoT device)
Weather data for DLR calculation	Full data will be available in the pre-demo phase. Integration with IoT devices by M20	Service 3.2 (Weather data is used for DLR calculation)
DSO secondary substation CIM model with DTR data	Samples of CIM model will be available in pre demo phase. Full data/CIM by M20	Service 3.1 (ML algorithms will gather data from PowerCIM where the CIM model of DTR will be saved)

3.6.3 Pre Demo Results

This section captures the status and progress of System Use Case (SUC) implementation during the Pre-Demo Phase (M16–M18) for the Slovenian Demo. For each SUC, key developments are outlined, including the specific actions undertaken, intermediate achievements, and alignment with the expected implementation steps and scenarios described in D2.2. In addition, the internal milestones defined in D5.1 are revisited and assessed in terms of progress and completion. This structured overview offers insight into the readiness and maturity of each SUC ahead of the upcoming demonstration cycles.

3.6.3.1 SUCs Implementation

This subsection presents the implementation progress of each System Use Case (SUC) as defined in D2.2 for the Slovenian Demo, highlighting the actions carried out during the Pre-Demo Phase.:

SUC-SL-01.01 DYNAMIC THERMAL RATING EDGE CALCULATION

Section	Subsection	Description
Overview	SUC Summary	Dynamic Thermal rating edge calculation
	Target(s)	Test IoT device in laboratory environment with static data, to see if the IoT device can host the DTR algorithm on edge. Finalise all necessary data connections between different system (IoT device, temperature sensors, MC meters, cloud)
	Expected UC Milestones	• Finalising of required data sources • Initial testing with data samples • Alpha version • One device connected to grid to test alpha version
	Actions implemented	**Finalisation of required data sources:** For this milestone, we held internal meetings to define all the data needed for the UC. After defining the data, the main objective was to determine the connection of these data on the edge. What protocols will be used, and how to ensure the privacy needed for all the data. **Initial testing with data samples:** The testing of IoT devices with data samples was a major part of the Pre-demo phase for SUC-SL-01.01. The IoT device used for the SUC needed to be tested to see if it could host the DTR algorithm on edge with all the input data. Testing was done in a lab environment using sample data. After the initial tests were successful, we additionally connected Temperature sensors to the IoT device to check the data connection. **Alpha version:** The alpha version is planned by M16, where the tested IoT device will be implemented in the DSO grid on one secondary transformer station. With the alpha version, we will need to add a data connection between the IoT device and the existing MC meter. The alpha version will provide us with feedback for the final version and integration.
Require ments	Assumptions	• IoT device can host the algorithm on edge • The data connection between the IoT device and MC will be done via TCP protocol.
	Dependencies	SUC is dependent on Service 3.2 of WP3. SUC-SL-02-01 and SUC-SL-02-01 are dependent on the SUC-SL-01-01

	Risks	Risk of safe connection between IoT device and existing MC. Need to define safe connection that does not pose any threats for the existing DSO, this could pose a potential risk of a delayed deployment of edge calculation.
Readiness	Deployment diagram	The deployment diagram for SUC-SL-01.01 is presented in Figure 40 below for clarity
	Deployment preparation	**Service 3.2 -DTR/DLR on edge preparation**: Collect off-line data for algorithm testing (.xml files with current measurement) Create sensor connection to IoT device in laboratory environment (testing connection between IoT device and sensors) Crate a connection with MC in laboratory environment. (Connect MC to IoT device and define TCP ports) Define the output data flow (protocols security, etc.) Adapt DTR calculation to IoT edge device. Host DTR calculation algorithm on IoT device IoT device installation preparation: Find locations with free second TCP on MC and high loads in winter (for the edge device) Define TCP ports on MC to send current data
	Deployment assessment	**Service 3.2 DTR/DLR on edge preparation**: Collection of off-line data will be completed in this cycle. Sensors have been connected to IoT device in laboratory environments Connection between different data sources will be tested in laboratory environment DTR calculation will be adapted to the edge IoT device DTR algorithm will be hosted on IoT device The product of SUC-SL-01-01 will be tested in laboratory environment **Possible risk and mitigation:** The main risk will be the connection of all data sources on edge to fulfil the security of connections for DSO. The mitigation of the risk will be possible with the first solution of IoT device that will be able to get current data from cloud. So, the calculation can be tested on edge, without the need to wait on the defining the full security of the data connection
Validation Activities Summary	Previous cycle	n/a
	Current cycle	The focus on the current evaluation cycle is to prepare DTR calculation on the IoT edge device. Adapting DTR algorithm, select IoT device, define connections of data sources to IoT device and test the connections. The first iteration cycle will prepare the edge solution for DTR calculation.
	Future cycle	The future cycle will focus on the actual integration of the IoT devices to DSO grid and the collection of data for SUC-SL-02-01 and SUC-SL-02-02 PowerCIM and ML/AI algorithm

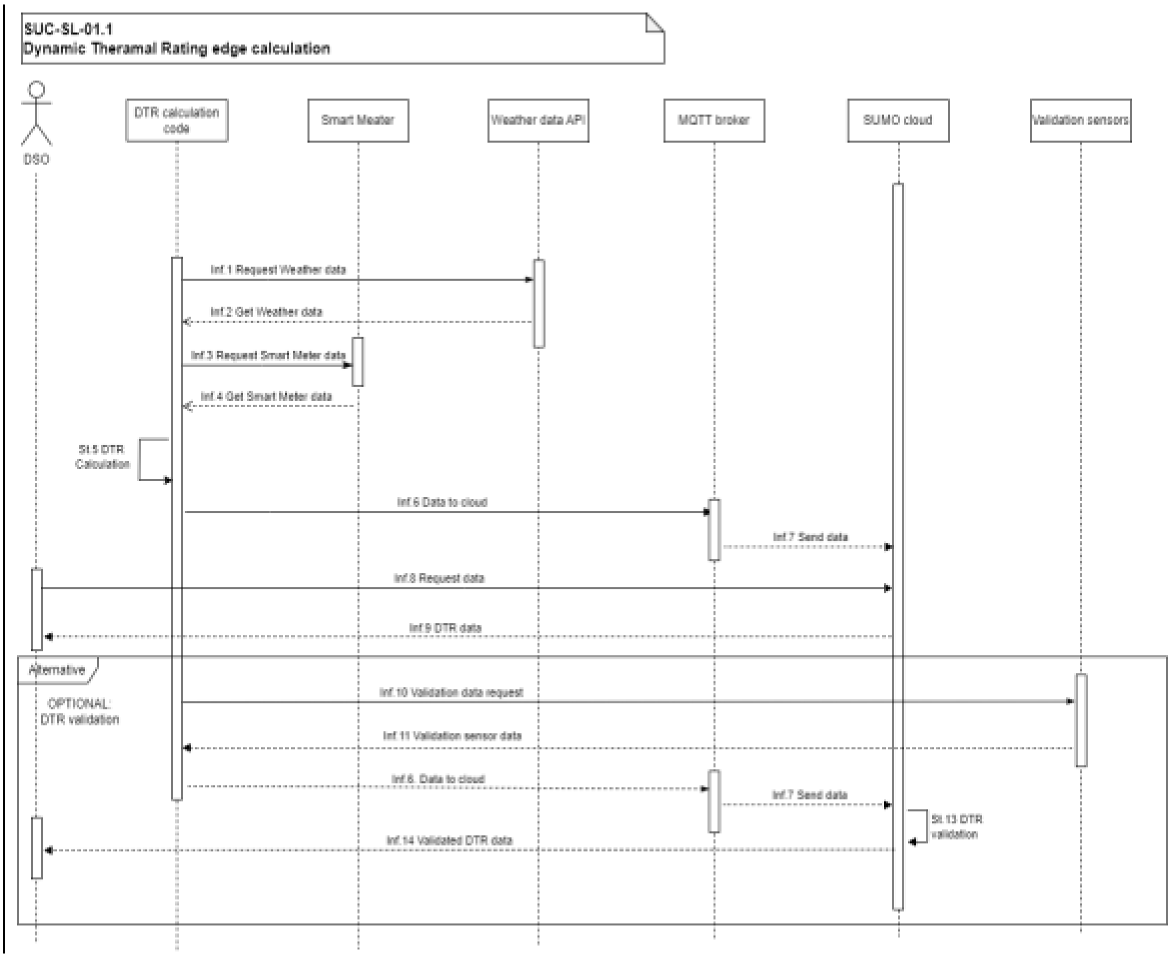

FIGURE 40: DEPLOYMENT DIAGRAM FOR SUC-SL-01.1 (ONGOING PROCESS)

SUC-SL-01.02 DYNAMIC LINE RATING EDGE CALCULATION

Section	Subsection	Description
Overview	SUC Summary	Dynamic Line Rating edge calculation
	Target(s)	Testing the edge device in a laboratorial environment
	Expected UC Milestones	Analysis and usage of relevant data Initial testing using the starting parameters (data) Single device connectivity showing promising results
	Actions implemented	Multilateral meetings were performed in order to establish the inputs required for the execution of the use case. The testing of the data was performed by giving access to the weather station (the data includes wind, temperature and solar radiation)
Requirements	Assumptions	Edge device is capable of providing real time evaluation based on the data provided (input)

	Dependencies	Use case is intertwined with the SUC-SL-01.01
	Risks	The risk is present within the realm of data accuracy (actual temperature and wind). Additionally, the connection of the edge device must be completely safe to be implemented to the existing devices.
Readiness	Deployment diagram	The deployment diagram for SUC-SL-01.02 is presented in Figure 41 below for clarity
	Deployment preparation	The underlying infrastructure consists of collected data relevant to the use case (off-device data such as temperature and wind), connecting aforementioned data to the edge device (in a laboratory environment) and later using and adjusting the DLR with the edge device. The actual device will be in the proper infrastructure (location) that has a pre-equipped weather measurement station
	Deployment assessment	Data collection is a part of currently expected timeline. Testing of this use case will be performed in a laboratory environment (from all data sources). The calculations performed by DLR will be synchronised with the edge device. Risk factors include data accuracy and safety of the actual implementation of the device on any relevant pre-existing devices.
Validation Activities Summary	Previous cycle	n/a
	Current cycle	This stage includes data gathering and its applicability to edge device in accordance with the pre-existing DLR calculations.
	Future cycle	Live integration in a fully operational TSO environment (substation, transformer, powerline)

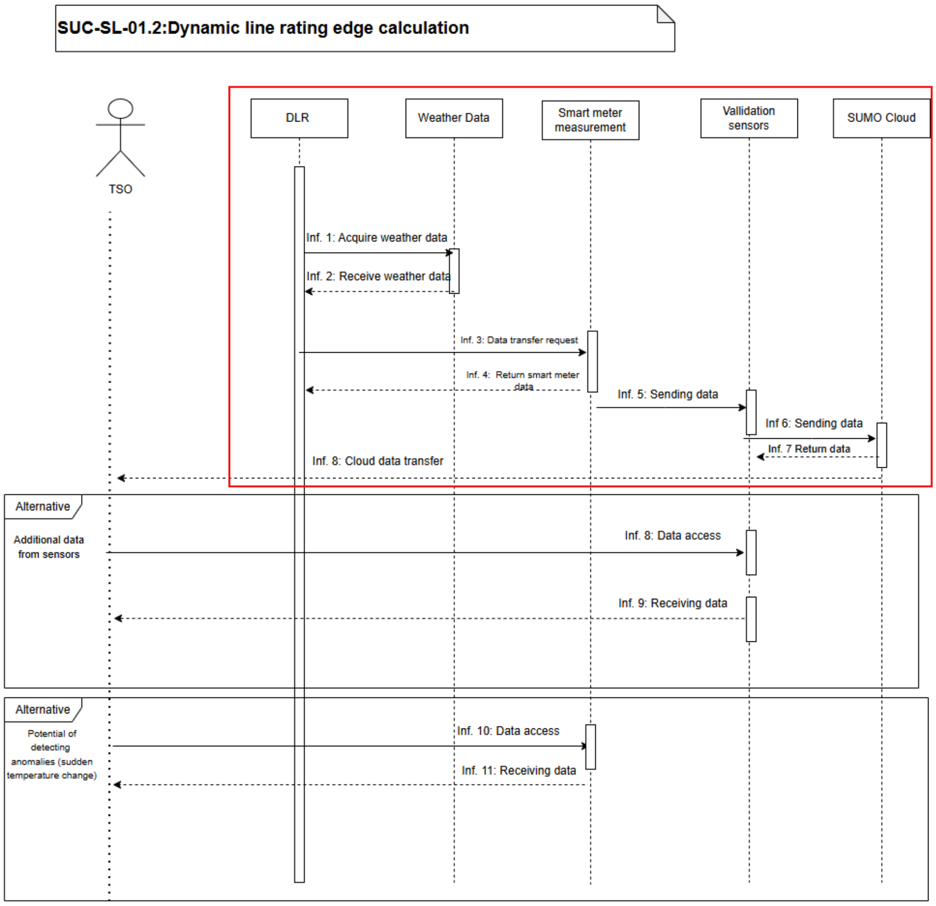

FIGURE 41: DEPLOYMENT DIAGRAM FOR SUC-SL-01.2 (HIGHLIGHTS SHOW THE ONGOING PROCESS)

SUC-SL-02.01 SEMANTIC MODEL OF THE SUBSTATION

Section	Subsection	Description
Overview	SUC Summary	Semantic model of the substation
	Target(s)	Preliminary data from various systems are currently being integrated and merged into a single semantic model. The solution is being tested under laboratory conditions.
	Expected UC Milestones	Finalising of required data sources Initial testing with data samples Alpha version
	Actions implemented	Finalisation of Required Data Sources: As part of a project milestone, internal meetings were held within the pilot to define which data and formats would be used for designing the semantic model. Additionally, the approach for providing data to create the model within the PowerCIM platform was established. Initial Testing with Data Samples:

		Test data from various systems was imported for one substation, which will be used in the test version. Different data formats were used and integrated into a single, unified semantic model of the substation. Alpha Version: The alpha version is planned for **M16**. In this phase, the imported models from different systems will be merged into a single, unified semantic model in a standardized format compliant with the IEC CIM standard.
Requirements	Assumptions	Data obtained from different systems will be able to be integrated in the PowerCIM and connected into a single unified model.
	Dependencies	SUC-SL-02-01 is dependent on the SUC-SL-01-01. SUC-SL-02-02 will use results from SUC-SL-02-01.
	Risks	A potential risk is missing data and the inability to match the time series with the model. Another risk is the dependency on SUC-SL-01-01, as its output data, specifically the DTR results, are being used.
Readiness	Deployment diagram	The deployment diagram for SUC-SL-02.01 is presented in Figure 42 below for clarity
	Deployment preparation	**PowerCIM platform**: Collect off-line data for testing (CIM XML and CSV files) Import models from different systems Merge models into a unified semantic model and verify the data Import time series data and manually merge it with the CIM model Export data in a standardised format
	Deployment assessment	Import of test data in various formats Integration of CIM models, time series, and DTR results into a unified model. Export of data in a standardised format Possible risk and mitigation: A possible risk is that the data will be incomplete and that the time series cannot be linked to the CIM model. The mitigation of this risk is conducting a test phase with preliminary data under laboratory conditions, after which the importing of real data - resulting from DTR edge calculations - will begin.
Validation Activities Summary	Previous cycle	n/a
	Current cycle	The current focus is on data processing and integrating the models within the PowerCIM platform.
	Future cycle	The next cycle will focus on preparing for data import obtained as a result of the SUC-SL-01-01. Additionally, a cross-reference will be imported to enable automatic linking of the models.

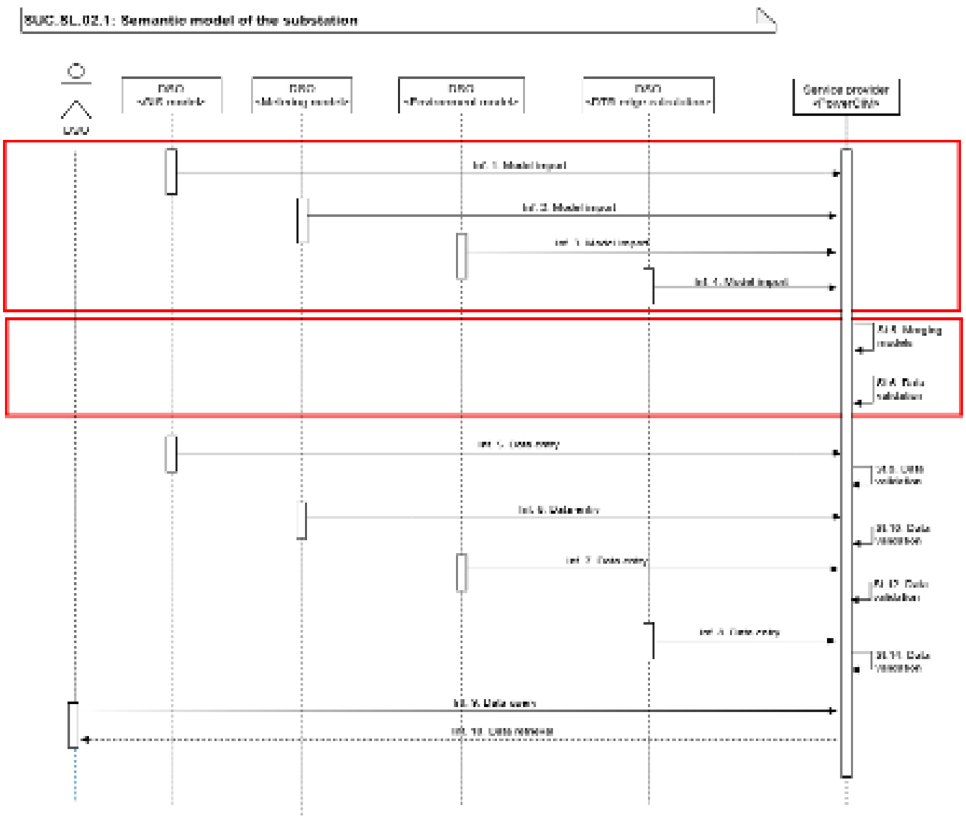

FIGURE 42: DEPLOYMENT DIAGRAM FOR SUC-SL-02.01 (HIGHLIGHTS SHOW THE ONGOING PROCESS)

SUC-SL-02.02 ML ALGORITHM FOR ENHANCED NETWORK MANAGEMENT AND PLANNING

Section	Subsection	Description
Overview	SUC Summary	ML algorithm for enhanced network management and planning
	Target(s)	Specify the format of data exchange. Test all developed algorithms on dummy data. Start preparing algorithms for tests using real-world data collected at the site.
	Expected UC Milestones	Finalisation of required data sources Initial testing with data sample Alpha version
	Actions implemented	**Finalisation of required data sources:** over a few internal meetings in the demo site, there was a discussion about available data that is collected in the demo site. In the final discussion, data provider and service developer agreed on the dataset that will be used in she specific SUC. **Initial testing with data sample:** after the agreement on data that will be used in SUC, synthetic data representing real-world measurements was created.

		Alpha version: ML algorithms needed for SUC were developed and tested on created representative data set. The accuracy of the developed tool was verified, which is a prerequisite for further development.
Requirements	Assumptions	IoT device can host the algorithm on edge. All requested data will be available.
	Dependencies	SUC is dependent on SUC-SL-02-01
	Risks	There is a risk that IoT devices will not collect enough data needed to implement algorithms in a real-world environment.
Readiness	Deployment diagram	The deployment diagram for SUC-SL-02.02 is presented in Figure 43 below for clarity.
	Deployment preparation	Service 3.1. Enhanced Network Manageability and Observability Creating synthetic dataset for algorithm testing Defining the data exchange format Verification of the algorithms on created representative dataset Collection of data from already installed IoT devices IoT device installation preparation: Specifying locations (substations) where IoT devices will be installed
	Deployment assessment	Service 3.1. Enhanced Network Manageability and Observability Collection of off-line historical real-world data Adaptation of developed algorithms to data from IoT devices Simulating all calculation on edge-level Ensuring connection between different data sources Verifying the accuracy of the algorithm on new dataset. **Possible risk and mitigation:** The main risk will be integration of all data and unavailability to perform all calculation on edge-level. Therefore, we will test on solutions on cloud-level to ensure backup solution
Validation Activities Summary	Previous cycle	n/a
	Current cycle	The focus of the current cycle is to develop needed ML algorithms and verify their accuracy on created synthetic data and to prepare algorithms for integration with real-world data connected from IoT devices installed in the demo site
	Future cycle	Testing the algorithms on real-world historical data Further modification and improvements of the ML algorithms if necessary Integration of different data streams

		Implementation of the algorithm on the cloud-level Preparation for integration on the edge-level

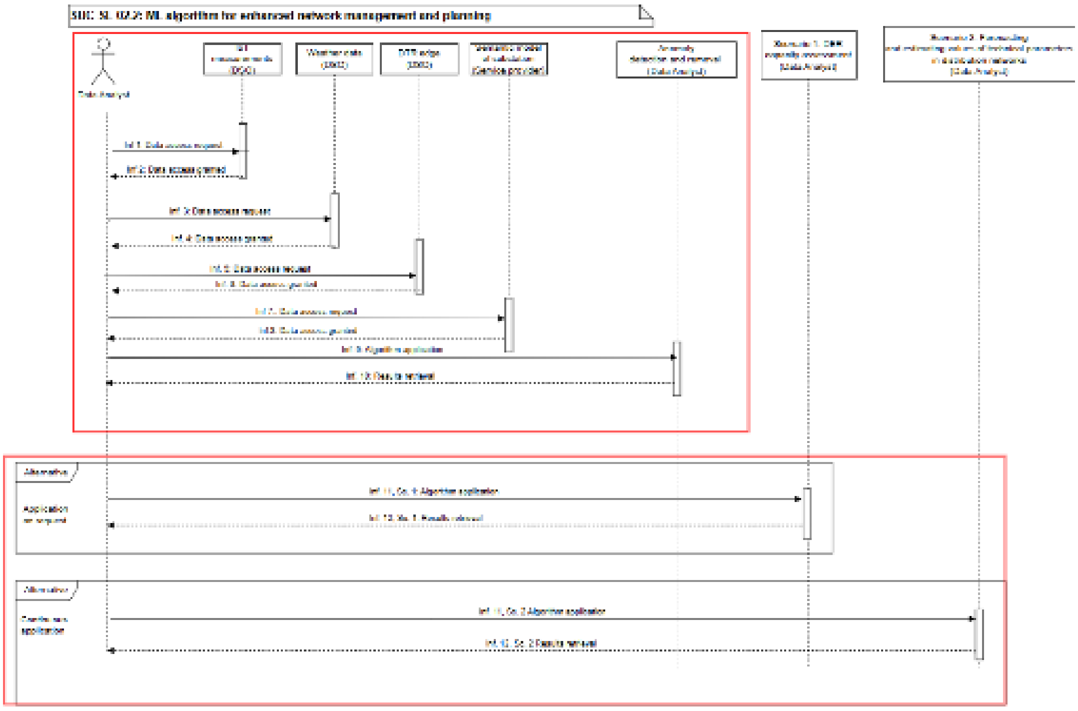

FIGURE 43: DEPLOYMENT DIAGRAM FOR SUC-SL-02.2 (HIGHLIGHTS SHOW THE ONGOING PROCESS)

Within the Pre-Demo Phase, the following services were tested within the Slovenian demo.

Service 3.1- Enhanced Network Management and Planning in the SUC-SL-02-02

Available and needed datasets were discussed and confirmed. ML algorithms for data anomaly detection, demand forecast, and DER detection in secondary distribution networks were developed and tested on a created representative dataset. Through several iterations, algorithms were enhanced.

Furthermore, a historical dataset representing the measurements that will be available once the installation of IoT devices was collected. Adaptations of the algorithms to be suitable for use with this data were started in the pre-demo phase.

Service 3.2 – DTR-DLR on edge in the SUC-SL-01-01 and SUC-SL-01-02

The IoT devices were selected. The DLR and DTR algorithms were adapted for the IoT devices, and some benchmark tests with sample data were run in the laboratory to confirm that the performance is suitable for use in the field. For DTR case, the DSO provided the temperature and the MC sensor. The temperature sensor has been successfully connected to the IoT device, and the MC sensor connection is being worked on. For the DLR case, the TSO still needs to provide the data specifications and the sensors.

Additionally, work has begun on the development of local weather forecast algorithms. Preliminary tests were performed with offline data. Currently, efforts are focused on deploying the algorithms on the IoT devices, and once successful, further development of the algorithms will be carried out.

3.6.3.2 Milestones and Progress

This subsection revisits the internal milestones identified in D5.1 and assesses their current status, noting any updates, delays, or partial completions observed during the Pre-Demo Phase. The information is presented in Table 31, which maps each milestone to the corresponding implementation steps and indicates the extent of progress achieved for the Slovenian demo:

TABLE 31: PROGRESS ON SLOVENIAN DEMO INTERNAL MILESTONES LINKED TO THE IMPLEMENTATION OF SYSTEM USE CASES (SUCS) DURING THE PRE-DEMO PHASE

Internal Milestones	Month	SUC-SL-01-01	SUC-SL-01-02	SUC-SL-02-01	SUC-SL-02-02
Finalisation of required data sources	M9	-	-		
Initial testing with data samples	M14	SC1 Steps 1,2,3,4,5 tested	SC1 Steps 1,2,3,4 tested	SC1 Steps 1,2,3,4 tested	SC1: Steps 1, 2, 6, 7, 8 SC2: Steps 1, 2, 6, 7, 8 tested
Alpha version	M15	SC1 Steps 1,2,3,4,5,6,7 tested	SC1 Steps 1,2,3,4,10,11 tested	SC1 Steps 1,2,3,4,6,7,8 tested	SC1: Steps 1, 2, 6, 7, 8 SC2: Steps 1, 2, 6, 7, 8 tested
Complete connection points with data sources	M20	-	-	-	-
Beta version	M22	-	-	-	-
Final version	M26	-	-	-	-
Fully validated in the pilot	M36	-	-	-	-

3.6.4 Pre-Demo Evaluation

3.6.4.1 Requirements Evaluation

The following section presents the requirement for each SUC, which was initially introduced in D5.1 including the description, acceptance criteria, and assigned testing partner. An additional column now captures the progress status recorded during the Pre-Demo Phase, allowing a direct comparison between the targets set in D5.1 and the results achieved to date.

SUC-SL-01.01 DYNAMIC THERMAL RATING EDGE CALCULATION

Req	Description	Acceptance Criteria	Progress
QoS.1	IoT device uptime	99%	Device has not yet been integrated
QoS.2	DTR accuracy	+/- 5°C	Device has not yet been integrated
QoS.3	Real-time data export	IoT device must be able to collect data from sources in real time	Device has not yet been integrated, Temperature sensors are already tested, and the data collection is real time
QoS.4	Frequency of data exchange	Data exchange happens upon event request	Device has not yet been integrated
Sec.1	Ensuring confidentiality	Quite important	Prepared the data flow that follows DSO regulations
Sec.2	Authentication and Access control	Public key encryption (SSL/TLS)	IoT device will be locked also the connection to cloud will be encrypted based on DSO regulations
D.1	Correctness of source data	Source data is usually correct	Data is accepted only in the right format.
D.2	Up-to-data management	Received data must be up to data within second of source data changing	n/a
D.3	IoT device specification	IoT device must meet technological specifications, including processor capabilities, memory, sensor type and connectivity options for efficient edge computing	IoT device has been tested with different tests for hosting capabilities of DTR/DLR algorithms.
Conf.1	System integration	IoT device must be compatible and seamlessly integrated wit existing DSO grid infrastructure	Prepared a document with the optimal connectivity of the device to existing infrastructure.
Conf.2	Communication media	Both wireless and wired communication must be supported	The device has both options of wired and wireless communication. In the scope of the project most of the communication will be wired. (On edge)
O.1	Compliance with standards	Devices and processes must comply with European standards	Currently tested and planned processes all comply with EU standards

SUC-SL-01.02 DYNAMIC LINE RATING EDGE CALCULATION

Req	Description	Acceptance Criteria	Progress
QoS.1	IoT device uptime	95%	Device has not yet been integrated
QoS.2	Real time data collection	Collecting real-time weather data from meters	Device has not yet been integrated
QoS.3	Response time	Below 1s for general and critical operations	Device has not yet been integrated Solar, wind and temperature sensors are being tested
QoS.4	DLR accuracy	Mean skin temperature error +/- 5°C.	Device has not yet been integrated
Sec.1	Ensuring confidentiality	Very Important	Data is in accordance with TSO regulations
Sec.2	Information integrity violation prevention	Quite important	Data with cloud is safely encrypted
D.1	Validity of source data	Data source must be correct	Fully accessible and accepted
D.2	Real-time access	Data available within seconds of change	Not available within this stage
D.3	Data consistency	Instant synchronisation	Constantly present
Conf.1	Distance and location to the substation/powerline	The device must be in close vicinity to the provided powerline and substation	Exact location to be determined
Conf.2	Number of devices	Up to 5 devices	Exact location to be determined
O.1	Compliance with standards	Devices are in compliance with European standards	All in accordance with EU standards

SUC-SL-02.01 SEMANTIC MODEL OF THE SUBSTATION

Req	Description	Acceptance Criteria	Progress
D.1	Correctness of source data	Data should be correct.	Data is accepted only in the right format.
D.2	Management of accessing different	Data and models exchanges go every few days or weeks.	n/a

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	types of data to be exchanged		
D.3	Management of data across organisational boundaries	Data exchanges go across boundaries between system developed by different vendors.	The preliminary data used for testing has been obtained across different organisational boundaries.
D.4	Naming of data items	Components need to be assigned unique identifiers.	At this stage, unique identifiers are assigned manually.
D.5	Validation of data exchanges	All data must be validated on each data exchange.	Validation is tested on preliminary data from different systems.
D.6	Management of large volumes of data that are being exchanged	The solution facilitates the utilisation and management of large models along with their dependencies.	At this stage, it was tested on preliminary data.
D.7	Data verification	The solution enables data accuracy verification.	This functionality is being tested on preliminary data.
Conf.1	Commonly used data model	The semantic model of the substation is aligned with the IEC CIM standard.	Results from testing phase are aligned with the IEC CIM standard.
O.1	Data privacy	Devices and processes must comply with European standards	Currently tested and planned processes all comply with EU standards

SUC-SL-02.02 ML ALGORITHM FOR ENHANCED NETWORK MANAGEMENT AND PLANNING

Req	Description	Acceptance Criteria	Progress
QoS.1	Elapsed time response requirements for exchanging data	More than 10 seconds	Device has not yet been integrated
QoS.2	Availability of information flows	90% + availability - Allowed outage: 1 month per year	Device has not yet been integrated
QoS.3	Accuracy of data requirements	Requires quality flag indicating at least normal and not normal	Device has not yet been integrated
QoS.4	Frequency of data exchanges	Periodicity greater than a few seconds	Device has not yet been integrated
Sec.1	Eavesdropping: Ensuring confidentiality, avoiding illegitimate use of data, and preventing	Quite important	Device has not yet been integrated

	unauthorised reading of data, is:		
Sec.2	Information integrity violation: Ensuring that data is not changed or destroyed is:	Quite important	Device has not yet been integrated
D.1	Correctness of source data	Source data is usually correct	Device has not yet been integrated
D.2	Up-to-date management	Received data must be up-to-date within minutes of source data changing	Device has not yet been integrated
D.3	Data consistency and synchronisation management across systems	Minute-by-minute synchronisation	Device has not yet been integrated
D.4	Management of data across organisational boundaries	Data exchanges go across boundaries between system developed by different vendors	Device has not yet been integrated
D.5	Data maintenance effort: human versus automation	Data maintenance is partially automated but involves some human time and manual data entries	Device has not yet been integrated
D.6	Validation of data exchanges	Data from different sources must be validated against each other	Device has not yet been integrated
D.7	Management of large volumes of data that are being exchanged	Major part of step involves handling large volumes of data	Device has not yet been integrated
D.8	Management of accessing different types of data to be exchanged	Numbers or types of data being exchanged are changed or updated every few minutes	Device has not yet been integrated
Conf.1	Distance between entities	Varies and/or is not relevant	Device has not yet been integrated
Conf.2	Number of Information Producers	Two to a few	Device has not yet been integrated
Conf.3	Number of Information Receivers	Two to a few	Device has not yet been integrated
Conf.4	Communication media	Any	Device has not yet been integrated
Conf.5	Data exchange methods	Any	Device has not yet been integrated

Conf.6	Communication access services requirements	Any or all	Device has not yet been integrated
Conf.7	Commonly used communication protocol	MQQT	Device has not yet been integrated

3.6.4.2 KPIs Progress

The KPIs to be measured by the Slovenian demo, their corresponding baseline and target values, are presented in Table 32 below. A new "Progress" column has been included to document developments during the Pre-Demo Phase (M16–M18). A "0" value under the progress column indicates that no measurable data has been collected during the pre-demo phase for the respective KPI. This does not reflect underperformance but rather the fact that measurement is scheduled to begin in the Full Demo Phase.

TABLE 32: KEY PERFORMANCE INDICATORS (KPIS) DEFINED FOR THE SLOVENIAN DEMO, INCLUDING SUC RELEVANCE, BASELINE AND TARGET VALUES, AND REPORTED PROGRESS DURING THE PRE-DEMO PHASE

ID	KPI	Baseline	Target	Progress
OB1	Different types of IoT/edge devices to be exploited in Demo Areas e.g., Smart Meter, HEMS, Sensors, inverter	0	>5	One device is being tested in laboratory environment. By the end of pre-demo phase one device will be implemented in DSO grid
KPI1	Number of AI/ML tools edge-cloud tools for consumers	0	>3	Currently 2 algorithms are 90% done with dummy data, last algorithm is currently 30% done with dummy data
KPI3	% of planned usage of HEDGE-IoT tools/data services (e.g. transactions. periodicity) in field demos	0	>5	First service 3.1 is 70% done with real data, but not yet with the data from IoT devices. Service 3.2 has been developed and tested on IoT device in laboratory environment. The aim is to test the service on one IoT device in the grid for the pre-demo phase One IoT device will be tested in grid for the pre-demo phase PowerCIM tool will be tested with dummy data in the pre-demo phase
KPI4	% of real-time data sharing among stakeholders	0	5-15%	Even though the device has not been implemented yet, the data sharing amongst stakeholders is currently on pace with the predicted timeline for year 1
KPI8	IoT/Edge/fog sites uptime and availability	0	95%	Currently the IoT device has not been tested in the actual grid.

KPI11	Increased grid operational performance	0% (Without DTR / DLR calculation)	Up to 15-25% more capacity in favourable conditions	Currently the IoT device has not been tested in the actual grid
KPI12	Faster application response times	0% (DTR / DLR algorithms before adapting them to IoT)	>10%	KPI achieved. The algorithms have been adapted for IoT, which resulted in better performance and faster response times.
KPI22	Increased DER participation in flexibility provision	n/a	5% Y1, 10% Y2, 15% Y3, 20% Y4, 25% Y5	This service is based on the final ML algorithm which still has not been fully tested.
KPIX (Demo 6 specific)	Number of systems integrated in unified semantic models	0	>3	At this stage, PowerCIM is being tested with preliminary data. Once the first IoT device is installed in the actual network, results from DTR edge calculations will be used.

4 PRE-DEMO PHASE ASSESSMENT

4.1 OPERATIONAL ASSESSMENT

4.1.1 Demos Impact

The Pre-Demo evaluation applied the common KPI set agreed in D5.1 to gauge how far each pilot has begun to deliver real-world value—whether in data availability, user engagement, grid flexibility or AI performance. Results vary because each site stands at a different point on the deployment curve; where a KPI remains at baseline, the cause is typically either incomplete asset roll-out or a dependency on external interfaces that will come online in the next cycle.

The primary objective of the Finnish demo is to improve the resilience of the distribution grid by developing next-generation automation solutions that leverage IoT and edge/cloud data. The demonstration aims to enhance the grid's capacity to host Distributed Energy Resources (DERs) and enable the use of small-scale flexibility resources through active DSO coordination. During this Pre-Demo phase, the operational impact was foundational, with progress on exploiting different types of IoT/edge devices (OB1), such as IEDs and edge servers. While the functionality for real-time data sharing (KPI4) is under development, most impact-oriented KPIs, such as those measuring flexibility unlocked (KPI9) and grid performance improvements (KPI11), are currently at a baseline of "0" as formal measurement is scheduled for the Full Demo Phase.

The Greek demo aims to leverage IoT and Edge Computing to foster the development of Local Flexibility Markets (LFM), demonstrating AI-IoT Edge-Cloud data exchange and flexibility services in a real-world setting involving 100 buildings under an aggregator. This objective has already been translated into measurable operational impact. Key Performance Indicators show significant progress, with 40 users actively involved in the pilot (OB4) and real-time data being shared from their devices every second (KPI4). The technical infrastructure has proven reliable, with cloud components achieving approximately 96% uptime and availability (KPI8), and application response times for user interactions are already performing well at 100-200ms (KPI12).

The Italian demo is focused on digitalising Energy Communities (ECs) and EV stations to enhance grid resilience, increase RES hosting capacity, and socialise surplus renewable energy to vulnerable consumers through a P2P blockchain marketplace. While the operational framework and platform components have been developed and tested using simulators, no measurable impact against the defined KPIs has been reported in this phase. This is an expected outcome, as the operational prerequisite for impact measurement is the real-world enrollment of the energy communities, which is still in progress.

The Dutch demo's objective is to enhance local grid flexibility on the Arnhems Buiten Energy Innovation Campus by digitising diverse assets and incorporating SAREF-based interoperable monitoring and control. This has led to tangible operational impact, with progress shown across several KPIs. The demo has successfully integrated multiple IoT device types (OB1) and achieved 100% user involvement for one of its target buildings (OB4). Real-time data sharing among stakeholders (KPI4) is at 20% completion, with live streams from DSO meters, PV, and EV chargers now available. The demo reports a 5% increase in DER participation (KPI22) through the integration of a heat pump.

The Portuguese demo's objective is to create a "Living Lab for Interoperable AI-based Energy Services" that harnesses flexibility from a smart energy community to enable participation in both

DSO and TSO grid services. The primary operational impact measured in this phase relates to user engagement, with the pilot successfully onboarding 12 of the targeted 30 participants (K-PT-01.1-4). Most other impact KPIs, particularly those related to the volume of flexibility transactions and RES investments, currently remain at their baseline of 0%, as their measurement is contingent upon the full deployment of assets and market integration planned for subsequent project phases.

The Slovenian demo is aimed at providing "Enhanced Local Flexibility Services for Improved Asset Lifetime Extension Planning" by advancing Dynamic Thermal Rating (DTR/DLR) algorithms with edge computing and increasing LV network observability. The operational impact in this phase is reflected in progress on development-focused KPIs. The demo reports that the development of its core AI/ML tools is 90% complete using dummy data (KPI1), and lab tests have already demonstrated faster application response times (KPI12) by adapting the DTR/DLR algorithms for edge devices. There is also initial progress on integrating different IoT device types (OB1), with one device having been successfully tested in the lab environment.

In conclusion, each demo has initiated quantitative progress on at least one KPI indicator. Unpopulated indicators can be attributed to well-defined next steps that may include asset installation, interface activation or extended data gathering, meaning that this iterative emergence of impact is in accordance with the project plan and confirms that each site is set on course to provide measurable value upon its transition to large-scale operation.

The European Commission's Digitalisation of the Energy Action Plan[2] sets five strategic priorities:

- the creation of a common Energy Data Space
- the promotion of demand-side flexibility
- the reinforcement of grid resilience
- the accelerated integration of renewables and distributed energy resources (RES/DERs), and continuous digital innovation with active user participation.

Although formal work on the project's contributions to the Action Plan will begin in later months, the Pre-Demo Phase measurements gathered already demonstrate progress under each priority and establish a calibrated baseline for the forthcoming impact analysis. In **the data-space domain**, three pilots—Finland, Greece, and the Netherlands—now exchange live data streams through secure, interoperable channels. Finnish IEC 61850 devices feed an edge broker; Greek smart-meter gateways publish one-second MQTT payloads; and the Dutch Semantic Interoperability Framework translates PV, EV charger, and sub-meter readings into SAREF triples that reach a SPARQL endpoint in under a second. Latency and bandwidth metrics confirm that end-to-end performance meets the design targets set in D5.1. At the same time, device diversity indicators show that heterogeneous assets can coexist in a common Energy Data Space.

Demand-side flexibility is also gaining momentum. In Greece, the Local Flexibility Market has already cleared revenue-positive bids in sandbox tests, showing that household flexibility can create tangible economic headroom. In addition, Portugal, meanwhile, has recruited its first batch of twelve households for the EdgeConnect marketplace; although commercial transactions await the completion of IEC 62325 integration, the user base required for monetised services is now in place. The project is likewise advancing the **grid-resilience** aspect. Finland's hybrid-LSTM anomaly detector and Slovenia's edge-based Dynamic Thermal Rating engine have completed their first live evaluations, publishing device uptime, operational performance, and latency metrics that feed the

[2] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52022DC0552&qid=1666369684560

resilience line of the Action Plan. These pilots demonstrate how edge analytics can enhance grid visibility and fault anticipation without relying solely on centralised infrastructure.

Progress on **RES and DER integration** is most visible on the Dutch Arnhem Buiten campus, where semantic adapters have boosted active DER participation by five percentage points. Italy, for its part, has recorded an initial intent-to-invest metric in its community-enrolment form, indicating that additional rooftop PV and storage are likely to enter the pilot once the legal agreements are finalised. Greece's PV forecasts are already being fed into the local dispatch optimiser, demonstrating that accurate renewable forecasting is both technically feasible and operationally valuable.

Digital innovation and user participation remain a unifying theme across all sites. Every pilot now records engagement figures for its front-end tools, and all have begun logging cross-service usage in accordance with the KPI framework. Italy's blockchain-enabled platform is designed to channel surplus PV to vulnerable households, and the Dutch campus dashboard will soon make live energy data publicly accessible, underscoring the project's commitment to inclusive, consumer-centric innovation. Two early benefit signals are already visible. Economically, the Greek pilot has shown that household flexibility can be monetised in practice, and Portugal's EdgeConnect platform has established the participant cohort necessary for future paid services. Socially, Italy's community platform is poised to deliver surplus renewable energy to consumers at risk of energy poverty, and the Dutch demo is preparing to democratise access to real-time campus energy data.

These early examples foreshadow the broader economic and societal gains that are expected as the pilots scale in size and operation. Given that, as the project moves into the Full-Demo phase, the same set of KPIs will be refreshed and expanded, enabling an evidence-based contribution to the Action Plan.

4.1.2 Demos Progress & Timeline

The Finnish demo has successfully reached its "pre-demo up-and-running" milestone. Specifically, an anomaly-detection service is now active on the substation edge server, and a runtime environment for the Hybrid Long Short-Term Memory (HLSTM) fault-forecasting model is in place. During the current development cycle, new monitoring functions were integrated into the HLSTM codebase. Looking ahead, the next sprint will focus on integrating an RTDS real-time simulator, which will allow live fault scenarios to be streamed into the model for on-the-fly validation.

Foundational tasks for the Greek demo, including data-source wiring and the development of first-cut algorithms, are now complete. In this pre-demo phase, the Reinforcement Learning (RL) Dispatch Optimiser was fully backtested, and the data acquisition pipeline was validated. Building on this progress, the upcoming cycle will enhance the optimiser to manage multiple customer portfolios and will embed a probabilistic "prosumer-acceptance" layer into its core decision logic.

Regarding the Italian demo, the demo has met its initial milestones, with functional and technical requirements now formally signed off. Furthermore, a platform prototype has successfully passed initial "Flexibility Offer" tests using software simulators. Consequently, the next development window will focus on activating transversal use-case modules and connecting the platform to live Energy Community assets as soon as participant enrolment is confirmed.

About the Dutch demo, a key milestone has been achieved, as data endpoints are now wired, enabling live semantic dashboards for monitoring. Recent efforts have focused on delivering adapters for PV, EV, and sub-meter data streams. The forthcoming sprint will build on this by permanently installing the sub-metering adapter, adding an EMS/BMS connector, and implementing the functionality to push control recommendations back to users via the UI.

In Portugal, the core EdgeConnect components have been successfully adapted, deployed, and tested, marking the achievement of the key pre-demo milestone. In parallel with this platform readiness, flexible assets are already being installed in consumer households. Accordingly, the next cycle will finalise the TSO-market interface and roll out the EdgeConnect platform and additional devices at scale.

In the Slovenia demo, the alpha firmware for the edge Dynamic Thermal Rating (DTR) device has cleared laboratory tests, and data connections to the PowerCIM semantic model are confirmed. With this lab validation complete, attention now turns to field deployment. In the next phase, IoT units will be installed on live feeders, real-world data will begin to populate the semantic model, and the full ML toolkit will be validated under operational conditions.

4.2 TECHNICAL ASSESSMENT

Regarding the Finnish Demo, the technical focus has been on preparing the physical and edge infrastructure, which is now substantially complete. Key milestones were achieved with the deployment of an edge server, updated IEDs that provide data via the IEC 61850 standard, and a high-speed fiber network. While the advanced HLSTM algorithm is still in development, a preliminary version of the anomaly detection service is running on the edge server as part of the deployed SSC600 SW solution. In summary, the physical and edge hardware is technically ready for the next stage of software deployment. Future technical work will focus on integrating a real-time digital simulator (RTDS) to stream live fault scenarios into the HLSTM model and setting up a cloud environment with a message broker to initiate testing of the predictive congestion management services.

Regarding the Greek Demo, the core technical stack for the flexibility market is now operational. The platforms for the Local Flexibility Market (LFM) and the Aggregator have been developed and deployed in a cloud environment, successfully passing initial tests for user registration and trade execution. A crucial technical achievement is the operational data pipeline from the installed edge-IoT devices to the cloud databases, which supports the validated demand and production forecasting modules. The next technical cycle will focus on enhancing the platform's sophistication by extending the optimiser to manage multiple customer portfolios, improving forecasting models, and critically enabling data space interoperability, as well as integrating with the HENEX developed platform.

In the Italian Demo, the key software components, including the Energy Community Platform (ECP) and Blockchain Access Layer, have been technically developed as containerised microservices with RESTful JSON APIs, making them ready for both local and cloud deployment. The technical viability of the platform has been confirmed through successful tests in a simulated environment, and the grid behavior forecasting model has been trained on a large, real-world dataset. The primary technical challenge for the future is integrating these validated components with live field assets from the enrolled Energy Communities and deploying external weather forecasting services to enhance the platform's predictive capabilities.

Regarding the Dutch Demo, the technical core is the Semantic Interoperability Framework (SIF), which is deployed and operational. A significant technical achievement has been the development and deployment of semantic adapters for various assets, such as DSO meters, PV, and EV chargers, which enable semantically rich data exchange. Furthermore, a prototype of the Anomaly Detector service has been developed and integrated with SIF, proving the viability of the technical pipeline from sensor to AI service. Future technical efforts will focus on moving from monitoring to control by extending the Semantic Interoperability Framework to send optimisation recommendations back to the user interface and deploying the anomaly detection service on the live demo infrastructure to validate it with real-time data streams.

In the Portuguese Demo, the central technical enabler of the "EdgeConnect" digital platform has been deployed in a cloud environment and has passed initial validation tests. The technical feasibility of activating flexibility at the device level was also confirmed through the successful lab-based integration of a Home Energy Management System (HEMS) with residential assets. The core platform is, therefore, technically stable, and key integrations have been proven in a lab setting. The upcoming technical cycle is ambitious, focusing on scaling up the deployment of the EdgeConnect platform, completing the TSO market integration with full IEC62325 messaging, and testing the Data Space connector to manage data access policies.

In the Slovenian Demo, the technical assessment shows that readiness at the component level is high, with individual technologies successfully de-risked in a laboratory environment. A key milestone was the lab validation, which confirmed that the selected IoT device is capable of hosting DTR/DLR algorithms at the edge. In parallel, the PowerCIM tool for creating a unified semantic model has been tested with preliminary data, and the ML algorithms for network management have been validated on synthetic data. The following technical phase marks a critical transition from the lab to the field, focusing on the physical grid integration of IoT devices, the collection of real-world historical data to test and refine ML algorithms, and the automatic linking of the PowerCIM semantic model with live data streams.

Overall, the six demo sites have made substantial progress in hardware roll-out, established the first phase of edge-cloud services, and identified specific actions and well-defined tasks for the upcoming Full-Demo Phase.

4.3 RISK ASSESSMENT

A proactive risk assessment was conducted across all demonstration sites to identify potential technical and operational challenges ahead of the Full Demo Phase. The following paragraphs consolidate the site-specific risk registers compiled at M18. For each demo, the principal technical or operational threats that could affect Full-Demo readiness, along with the mitigation actions already initiated, are outlined below.

Regarding the Finnish Demo, the primary technical risks relate to algorithm development and system integration. For anomaly detection SUCs, challenges include the difficulty of reproducing results with frequently changing algorithms and potential data versioning inconsistencies that could bias model outcomes. For congestion management SUCs, risks include the limited availability of DER flexibility and the potential for piloting edge solutions to delay the allocation of resources to cloud-based services. To address these challenges, the project's mitigation strategy includes placing the purchase order for the RTDS simulator while concurrently using a backup test bench with recorded files to keep model training on track. Furthermore, firmware updates are now bundled with routine IED service visits to avoid extra outages.

Regarding the Greek Demo, the identified risks are centred on data quality, algorithmic performance, and user engagement. Several SUCs highlight the risks of incomplete data from IoT devices, potential latency issues, and the need to maintain GDPR compliance. A key market risk is the potential failure of the DSO to provide realistic network data. The project's mitigation efforts are focused on launching an outreach campaign with financial incentives to ensure consumer participation. Meanwhile, the LFM platform is being container-tested against the HENEX sandbox to mitigate any last-minute interoperability issues with the market API.

Regarding the Italian Demo, the most significant operational risk identified across its Energy Community SUCs is a potential delay in enrolling real-world communities, which would impact the transition from simulated to live data testing. Technically, there is a risk that newly trained machine learning models may perform sub-optimally due to data biases. As part of the mitigation plan, legal support has been allocated to expedite community contracts, and a public ECMWF API will be integrated as a fallback data source to ensure the PV model has access to live irradiance data.

Regarding the Netherlands Demo, the risks are primarily focused on semantic interoperability and the reliability of AI-driven services. A key technical risk is that incorrect semantic mappings within the Interoperability Framework could lead to erroneous conclusions for dependent services, and any delay in the prototype EMS/BMS adapter could cascade into closed-loop control tests. The mitigation strategy involves re-prioritising the adapter development schedule and proactively booking a joint security audit with the campus IT team to address any security concerns related to pushing control commands.

Regarding the Portuguese Demo, the risks span interoperability, scalability, and development dependencies. A recurring challenge is adapting the EdgeConnect data model to align with both Data Space principles and the IEC 62325 standard, which could reveal message-mapping gaps late in the process. There is also a risk of performance bottlenecks when scaling from a dozen to over one hundred assets. Mitigation activities are already in place, with load-testing scripts prepared for 150-asset stress run and a joint workshop scheduled with the TSO to review each B2B message and ensure compliance.

Regarding the Slovenian Demo, the main risks involve the transition from laboratory to field deployment. These include ensuring a secure and reliable data connection to legacy DSO and TSO infrastructure, the ruggedisation of edge devices for harsh winter temperatures, and aligning the physical installation of IoT units with tight DSO operational windows. The project's mitigation plan addresses these logistical challenges by pre-booking installation slots in the DSO maintenance calendar and scheduling a temperature-cycle test for the edge device in an environmental chamber.

5 CONCLUSIONS

Within the HEDGE-IoT project all six demo sites have effectively transitioned from design and specification to implementation during the Pre-Demo Phase (M16–M18). All six demo sites are now operating the common edge-cloud stack.

The deployment of foundational technical infrastructure across the pilot sites has been a success of this phase as it encompasses the deployment of semantic adapters in the Netherlands to harmonise data from PV, EV, and meter sources, the installation of operational edge servers and upgraded Intelligent Electronic Devices (IEDs) in Finland, and the establishment of residential IoT gateways that stream encrypted load traces in Greece. This advancement serves as confirmation of the project's capacity to integrate a variety of tangible assets into a unified digital framework.

Crucially, the project has transitioned key AI and machine learning algorithms from simulation to practical application on edge hardware. In Slovenia, the edge-deployed Dynamic Thermal Rating (DTR) algorithm has been lab-validated to deliver estimates with high accuracy, while in Greece, the reinforcement-learning optimiser has been successfully back-tested for clearing profitable flexibility bids. This demonstrates that the project is successfully embedding intelligence at the network edge.

Additionally, substantial progress has been achieved in the development of platforms that will engage end-users and facilitate the development of new energy markets. The EdgeConnect platform in Portugal and the Local Flexibility Market portal in Greece have been deployed and have successfully passed initial tests. Additionally, Italy's Energy Community Platform, which is supported by blockchain technology, has successfully completed end-to-end simulator tests. These accomplishments are essential in the development of the new data-driven energy services that HEDGE-IoT envisions.

This phase has also been crucial in identifying operational and technical risks, and proactive mitigation is currently underway. Clear stakeholders, timelines, and defined fallback measures are now in place for outstanding issues, including simulator delivery in Finland, asset onboarding in Italy, and adapter hardening in the Netherlands. Entering the Full-Demo Phase (M19–M30), the upcoming work encompasses:

- Completing the asset roll-out, each demo will install its remaining smart meters, edge gateways, flexible loads, and grid sensors, then run them continuously to confirm that data flow and hardware performance are stable under real-world conditions.
- Upgrading to the latest WP 3 and WP 4 releases replacing prototype containers and ad-hoc connectors with the production-grade AI services and IDS middleware specified in those releases, ensuring a uniform, supportable software stack across all sites.
- Scaling user and stakeholder engagement through household enrollment, energy-community onboarding, and campus stakeholder sessions, providing a statistically significant user base and enabling the reliable measurement of user-centric KPIs, such as participation rates and satisfaction levels.
- Activation of continuous KPI monitoring, as with assets in place and services running 24/7, will enable each demo to begin streaming high-resolution KPI data to the WP5 dashboard, providing WP 6 with the evidence it needs for impact assessment and the forthcoming contribution to the Digitalization of the Energy Action Plan.

APPENDIX I: Demo Deployment Template

Section	Subsection	Description
Overview	Use Case Summary	Brief description of the demo Use Case
	Target(s)	Description of the target(s) of current the evaluation cycle
	Expected UC Milestones	Description of the expected milestones that are expected to be achieved (as described on D5.1)
	Actions to be implemented	Description of the actions/activities that will take place during the evaluation cycle, to reach the expected targets
Requirements	Assumptions	Description of the assumptions that are made results on the evaluation cycle
	Dependencies	Description of interactions with other developed services or components (or pre-requisites)
	Risks	Description of potential risk factors identified that pose risks in the successful deployment of the components to be tested.
Readiness	Deployment diagram	Diagram summary of the necessary steps for deployment
	Deployment preparation	Description of the requirements for the components and the underlying infrastructure (consisting of both demo internal and HEDGE-IoT assets to be used)
	Deployment assessment	Assessment of the completeness of the preparation for the evaluation cycle and the mitigation of the possible identified risks
Validation Activities Summary	Previous cycle	Summary of the achievements and main actions of previous stages and the identified next steps
	Current cycle	Summary of the main actions of the current stage as identified, and how they fulfil the recommendations of the previous iteration cycle
	Future cycle	Summary of next steps (if any) and what needs to be achieved by the next cycle for improvements, optimisations, or refinement (if identified)
Documentation	Training documents	Creation of documents that explain the main functionalities of the technology enablers under the demo UCs

	Developer documents	Creation of documents that extensively covers the main parts of the service, and facilitates the integration of new services
	Operation and Maintenance	Creation of documents that covers the procedures for usage, start and restart of the services

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