Ref. Ares(2024)7811812 - 04/11/2024

HEDGE-IoT

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

D2.2
Functional Specifications of the HEDGE-IoT system

31/10/2024

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DOCUMENT CONTROL SHEET

PROJECT INFORMATION

Project Number	101136216		
Project Acronym	HEDGE-IoT		
Project Full title	Holistic Approach towards Empowerment of the Digitalization of the Energy Ecosystem through adoption of IoT solutions		
Project Start Date	01 January 2024		
Project Duration	42 months		
Funding Instrument	Horizon Europe Framework Programme	Type of action	HORIZON-IA HORIZON Innovation Actions
Call	HORIZON-CL5-2023-D3-01-15		
Topic	Supporting the green and digital transformation of the energy ecosystem and enhancing its resilience through the development and piloting of AI-IoT Edge-cloud and platform solutions		
Coordinator	European Dynamics Luxembourg SA		

DELIVERABLE INFORMATION

Deliverable No.	D2.2
Deliverable Title	Functional Specifications of the HEDGE-IoT system
Work-Package No.	WP2
Work-Package Title	Stakeholders' Requirements and System Specifications
Lead Beneficiary	TRIALOG
Main Authors	Léo Cornec (TRIALOG) Lenos Peratitis (ED) Nikolaos Bilidis (ED)
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Due date	31/10/2024

Deliverable Type	X	Document, Report (R)		Data management plan (DMP)		Websites, press & media action (DEC)		Other
Dissemination Level	X	Public (PU)		Sensitive (SEN)		Classified		
	PU: Public, fully open SEN: Sensitive, limited under the conditions of the Grant Agreement Classified R-UE/EU-R – EU RESTRICTED under the Commission Decision No2015/444 Classified C-UE/EU-C – EU CONFIDENTIAL under the Commission Decision No2015/444 Classified S-UE/EU-S – EU SECRET under the Commission Decision No2015/444							

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Document Revision History

Version	Date	Description of change	List of contributor(s)
0.1	09/08/2024	Creation of the structure of the document	Léo Cornec (TRIALOG)
0.2	22/08/2024	Added structure of the project architecture section	Lenos Peratitis (ED)
0.3	20/09/2024	Added first version of Section about SUCs	Léo Cornec (TRIALOG)
0.4	25/09/2024	Added the first version of the "SUC methodology" and "Business use case and System use case relation" sections	Léo Cornec (TRIALOG)
0.5	30/09/2024	Added the first version of the "System Use Cases Overview" and "Hedge-IOT functional requirements" sections	Léo Cornec (TRIALOG)
0.6	03/10/2024	Added the first version of the "Reference Architecture Methodology" section	Lenos Peratitis (ED) Nikolaos Bilidis (ED)
0.7	04/10/2024	Added the first version of the "Hedge-IoT functional requirements" section	Léo Cornec (TRIALOG)
0.8	07/10/2024	Added the first version of the "Introduction" and "Conclusion" sections	Léo Cornec (TRIALOG)
0.9	07/10/2024	Adjustment of the document's structure and form	Léo Cornec (TRIALOG)
0.10	09/10/2024	Refinement based on internal review by Trialog	Dune Sebilleau (TRIALOG) Léo Cornec (TRIALOG)
0.11	17/10/2024	Review by European Dynamics	Lenos Peratitis (ED) Nikos Bilidis (ED)
0.12	21/10	Review by Institut Jozefstefan	Gregor Kosec (JSI)
1.0	31/10	Full complete version, including the SUCs documents of the pilots at the end of the deliverable.	Léo Cornec (TRIALOG)

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4	EREVNITIKO PANEPISTIMIAKO INSTITOUTO SYSTIMATON EPIKOINONION KAI YPOLOGISTON	ICCS	EL
5	INESC TEC - INSTITUTO DE ENGENHARIADE SISTEMAS E COMPUTADORES, TECNOLOGIA E CIENCIA	INESC	PT
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38	ELEKTRO GORENJSKA PODJETJE ZA DISTRIBUCIJO ELEKTRICNE ENERGIJE DD	EG	SI
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EXECUTIVE SUMMARY

The goal of this document is to detail the outputs of the HEDGE-IoT Tasks 2.6, Task 2.7, and the methods used to achieve these outputs.

Task 2.6 aims to produce functional specifications starting from the formulation of System Use Cases (SUCs) derived from the HEDGE-IoT pilots' Business Use Cases (BUCs). These BUCs constitute outputs to Task 2.2 and consequently inputs of Task 2.6 of the Hedge-IoT project. This document presents the 44 SUCs defined using the methodology outlined in the IEC 62559 standard. To provide a complete overview of the project's functional specifications, generic functional requirements were extracted based on SUCs.

Task 2.7 focuses on defining the HEDGE-IoT reference architecture (RA) as an operational, interoperable framework that allows functional interconnectivity among IoT/edge devices and fog/cloud platforms. This deliverable presents the methodology that will be followed and the approach adopted for the design of the HEDGE-IoT RA in detail, as well as a preliminary high-level conceptual version of the RA, which will be refined, enhanced and updated in the upcoming WP2 deliverables. Finally, this document includes the timeline and the respective activities leading up to the submission of D2.3.

This deliverable is part of a sequence of three reports (D2.2, D2.3 and D2.4). The upcoming deliverables will provide the next results of these two tasks (T2.6 and T2.7) and, if necessary, propose updates to the information presented in this report.

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ABBREVIATIONS

ADF	Architecture Description Framework
ADL	Architecture Description Language
aFRR	Automatic Frequency Restoration Reserve
AI	Artificial Intelligence
AIOTI	Alliance for Internet of Things Innovation
API	Application Programming Interface
BAL	Blockchain Access Layer
BMS	Building Management System
BSP	Balancing Service Provider
BTM	Behind The Meter
BUC	Business Use Case
CA	Consortium Agreement
CI/CD	Continuous Integration / Continuous Deployment
CIM	Common Information Model
CM	Congestion Management
CRUD	Create-Remove-Update-Delete
DER	Distributed Energy Resources
DLR	Dynamic Line Rating
DMP	Data Management Plan
DMS	Distribution Management System
DoA	Description of the Action
DPP	Digital Platform Provider
DSO	Distribution System Operator
DTR	Dynamic Thermal Rating
EC	European Commission
EC	Energy Community
EMS	Energy Management System
ESCO	Energy Service Companies
EU	European Union
FR	Flexibility register
FSP	Flexibility Service Provider
GA	Grant Agreement
GDPR	General Data Protection Regulation
GIS	Geographic Information System
HEDGE-IoT	Holistic Approach towards Empowerment of the DiGitalization of the Energy Ecosystem through adoption of IoT solutions

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HEMRM	Harmonized Energy Market Role Model
HVAC	Heating, Ventilation, and Air Conditioning
IDSA	International Data Space Organization
IEC	International Electrotechnical Commission
IED	Intelligent Electronic Device
IoT	Internet of Things
IoT-EPI	IoT European Platforms Initiative
ISO	International Organization for Standardization
LFM	Local Flexibility Market
M2M	Machine-to-machine
mFRR	Manual Frequency Restoration Reserve
ML	Machine Learning
MO	Market Operator
MQTT	Message Queuing Telemetry Transport
MV	Medium voltage
NEMO	Nominated Electricity Market Operator
O&M	Operations and Maintenance
OBJ	Objective
PMH	Project Management Handbook
PV	Photovoltaic
QoS	Quality of Service
RA	Reference Architecture
RES	Renewable Energy Sources
RR	Reserve Resource
SAREF	Smart Applications REFerence Ontology
SCADA	Supervisory Control And Data Acquisition
SGAM	Smart Grid Architecture Model
SME	Small and Medium-sized Enterprises
SO	System Operator
SUC	System Use Case
T&D	Transmission and Distribution
TSO	Transmission System Operator
UC	Use Case
UI	User Interface
UML	Unified Modeling Language
WP	Work Package

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1 INTRODUCTION

1.1. HEDGE-IOT PROJECT INTRODUCTION AND SUMMARY

HEDGE-IoT proposes a novel digital framework that aims to deploy IoT assets at different levels of the energy system (from behind-the-meter, up to the TSO level), to add intelligence to the edge and cloud layers through advanced AI/ML tools and to bridge the cloud/edge continuum introducing federated applications governed by advanced computational orchestration solutions. The HEDGE-IoT Framework will upgrade the RES-hosting capacity of the energy systems and unleash a previously untapped flexibility potential. It will increase the resilience of the grid, create new market opportunities and promote advances in IoT standardization, by introducing and managing a plethora of diversified, interoperable energy services over scalable and highly distributed data platforms and infrastructure. The multi-dimensional framework of HEDGE-IoT comprises the following pillars: (a) the Technology Facilitator pillar – it will exploit the computational sharing by offloading applications on the grid edge, towards providing a set of AI/ML federated learning and swarm computing applications; (b) the Interoperability pillar - leverages on leading-edge interoperable architectures, such as the data space architectures; (c) the Standardisation pillar – it will enable all involved platforms, systems, tools and actors to seamlessly communicate and exchange data in standardized formats using widely used standards, such as SAREF, etc.; (d) the Digital Energy Ecosystem enabling pillar – it will ensure the creation of an ecosystem facilitating the increased integration of RES and characterised by resilience. Liaisons with EU initiatives for IoT and digitalisation will be established (e.g., the AIOTI), and the engagement of stakeholders will be ensured by addressing IoT ethics and cultivating trust among end-users, thus promoting inclusivity. Scalability and replicability studies will be performed, and connections with innovators and SMEs will be established through the open call mechanism of the project.

1.2. PURPOSE OF THE DOCUMENT

The purpose of this document is to define the first version of the HEDGE-IoT functional specifications in the form of system use cases, which will act as the foundation for all upcoming tasks and project developments.

This first version of the functional specifications will be further discussed and reviewed in deliverables D2.3 and D2.4 based on future work and feedback, especially from the pilots. Additional transversal elements may also be identified.

Another objective of this deliverable is to introduce the work to be carried out on the design of the project reference architecture. This document includes a detailed description of the methodology that will be followed and the adopted approach, paving the way towards the first version of the HEDGE-IoT Reference Architecture, which will be presented in D2.3.

1.3. REFERENCE AND APPLICABLE DOCUMENTS

Reference Documents

For the preparation of the present deliverable D2.2 "Functional Specifications of the HEDGE-IoT system", the authors used a set of reference documents, including HEDGE-IoT D2.1 "Requirements

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on an IoT Cloud/Edge System for the Energy Ecosystem" (particularly the business use cases of the pilots), as well as standards, scientific publications and technical reports, which represent valuable sources for the specific context. The full list of sources is reported in the section REFERENCES.

Applicable documents

The general guidelines for the project implementation are defined in the HEDGE-IoT Grant Agreement (GA), the Consortium Agreement (CA), the Project Management Handbook (D1.1 - PMH) and the Data Management Plan (D1.4 – DMP). As a result, the present deliverable "Functional Specifications of the HEDGE-IoT system" (D2.2) does not replace any of these applicable documents, and partners should abide by the following order of precedence:

- Grant Agreement
- Consortium Agreement
- D1.1 "Project Management Handbook"
- D1.4 "Data Management Plan"
- D2.1 "Requirements on an IoT Cloud/Edge System for the Energy Ecosystem"
- D2.2 "Functional Specifications of the HEDGE-IoT system"

1.4. STRUCTURE OF THE DOCUMENT

The structure of the document is as follows:

Chapter 2 describes the methodology used to identify and define the HEDGE-IoT functional specifications. An overview of SUCs and generic high-level technical requirements.

Chapter 3 introduces the references, methodologies and preliminary work achieved on the HEDGE-IoT reference architecture. This chapter is an introduction to deliverable D2.3.

Chapter 4 concludes with a summary of the requirements developed within this first phase of WP2.

This document is not standalone and refers to 6 SUCs documents, one for each pilot. These documents can be found at the end of this deliverable Appendix C: Pilots' System Use Cases Documents. The order of the documents is as follows:

- **Document 1: Deliverable 2.2**
- Annex Document 1: Finnish Pilot SUCs
- Annex Document 2: Greek Pilot SUCs
- Annex Document 3: Italian Pilot SUCs
- Annex Document 4: Dutch Pilot SUCs
- Annex Document 5: Portuguese Pilot SUCs
- Annex Document 6: Slovenian Pilot SUCs

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2 FUNCTIONAL SPECIFICATIONS - SYSTEM USE CASES OF THE HEDGE-IOT DEMONSTRATOR

In this section, the first part of the results of Task 2.6 are presented. One of the two main objectives was to design the functional specifications of the project in the form of System Use Cases (SUCs) based on Business Use cases (BUCs). Functional requirements will be identified and defined based on the SUCs to complete the specifications. These outputs will be used as input for the reference architecture design and as a reference for all future project activities and development.

2.1. METHODOLOGY

Business Use Case (BUC) and System Use Case (SUC)

A use case (UC) describes the interactions of various actors in a system to achieve specific goals. A business use case (BUC) depicts a business process, while a system use case (SUC) depicts a function that supports one or more business processes. Both types of UCs are essential for the description of a system and can be used for the system architecture definition. For HEDGE-IoT, the BUCs were the starting point for the pilots to define SUCs and will also be used for the definition of the reference architecture. In this deliverable, only the SUCs from the demonstrators are presented. The BUCs are part of Deliverable D2.1.

IEC 62559 Standard – Use case methodology

The SUCs from the HEDGE-IoT demonstrators were designed following the standardized IEC 62559-2 template [1], which was also used for the BUCs. The full template is provided in Appendix A: IEC 62559-2 use case template and has the following seven main sections:

1. Description of the use case
2. Diagrams of the use case
3. Technical details
4. Step-by-step analysis of the use case
5. Information exchanged
6. Requirements
7. Common terms and definitions

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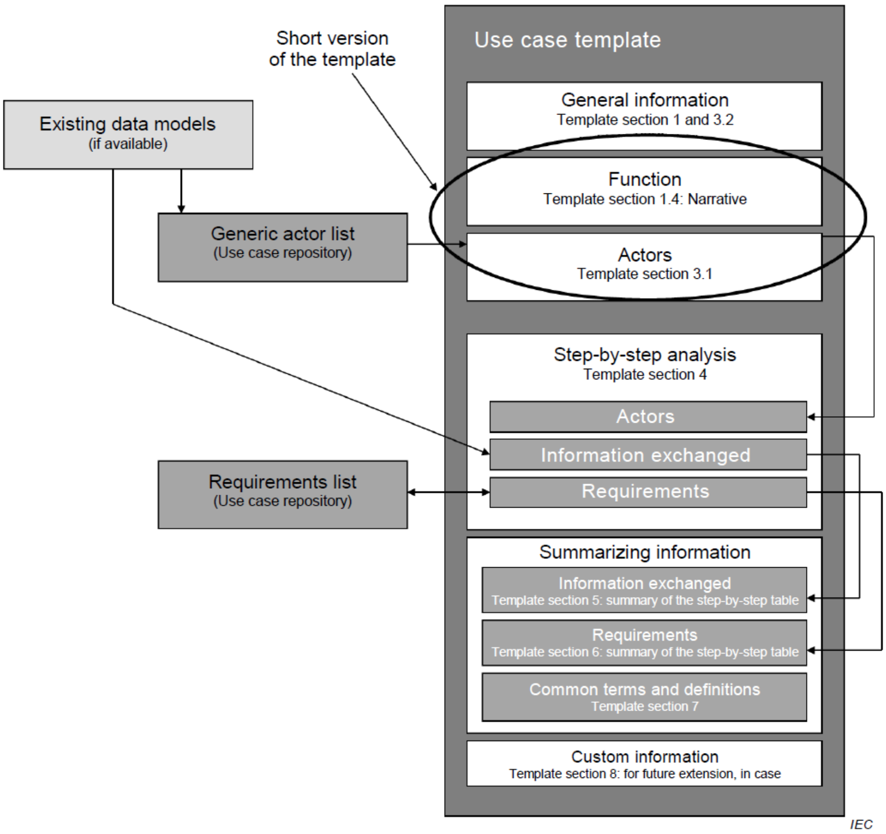

FIGURE 1: IEC 62559-2 TEMPLATE OVERVIEW [1]

IEC 62559 implementation for HEDGE-IoT SUCs

For the HEDGE-IoT project, the following sections and subsections of the template were defined as mandatory to be filled out by the pilot demonstrators for the SUCs:

1. Description of the use case
    1.1. Name of the use case
    1.2. Scope and objectives of the use case
    1.3. Narrative of the use case
2. Diagrams of the use case
3. Technical details
    3.1. Actors
4. Step-by-step analysis of the use case
    4.1. Overview of scenarios
    4.2. Steps - scenarios
5. Information exchanged
6. Requirements

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The design and writing process of the SUCs was done in four steps, each resulting in a different and more complete version of the SUCs, shown in Figure 2.

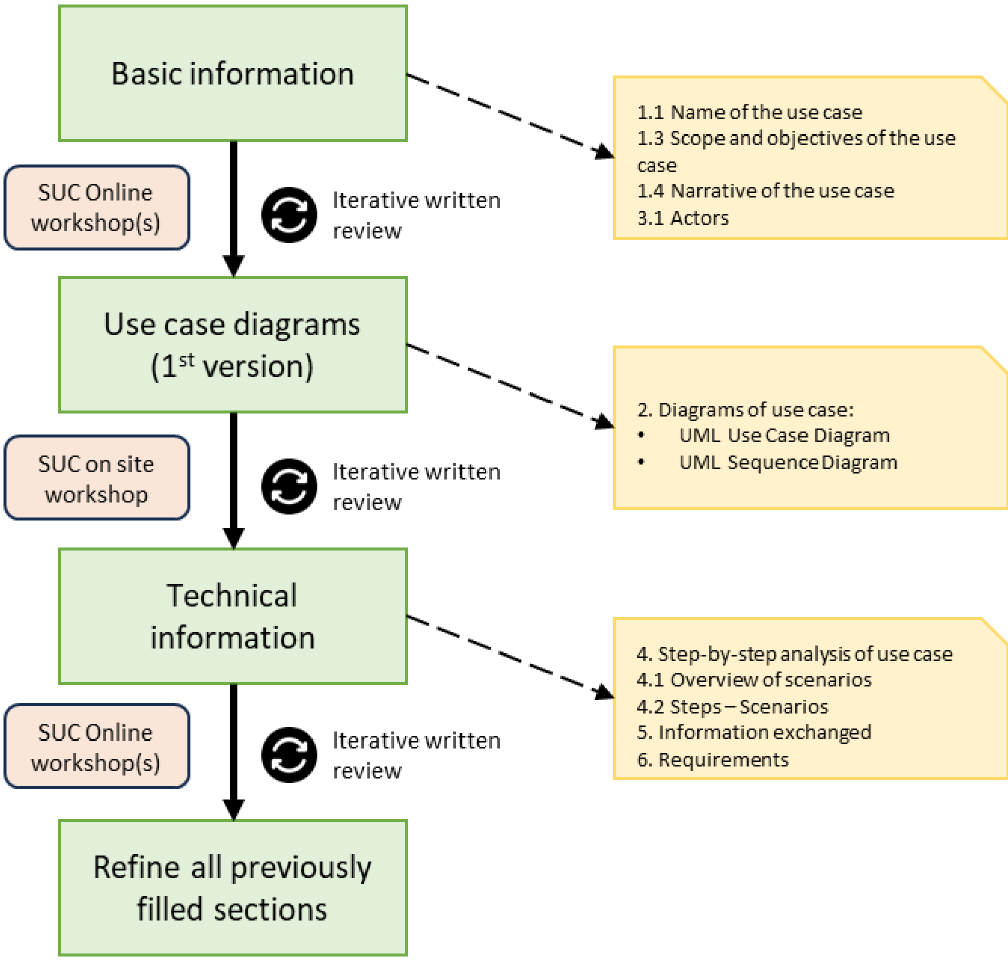

FIGURE 2: SYSTEM USE CASE DEFINITION METHODOLOGY

The minimum number of SUCs for each BUC was set to one. Initially, each pilot defined their SUCs, describing the scope, objectives, narrative and actors involved. The Harmonized Energy Market Role Model (HEMRM) [2] was recommended (when possible) to standardize the naming of actors and systems across all SUCs for all pilots. An online workshop was set up for each pilot to review SUCs' progress and relation to their respective BUCs.

> Note: In some BUCs it could happen that a function is not defined as a SUC as it is either not planned for development within the scope of the project or has already been developed.

The second step of completing the template for each SUC was creating the diagrams. For this step, the pilot partners designed the initial version of the UML (Unified Modelling Language) use case diagram and the UML sequence diagram. The UML use case diagram illustrates how the actors interact within the use case and participate in technical functions. The sequence diagram shows the sequence of activities involved in a functionality, a illustrating a scenario of the use case. A template was defined and shared with the partners to ensure maximum consistency among pilots' diagrams. With these sections completed, the progress and content of the SUCs and the BUCs were discussed during an in-person workshop that had the participation of at least two representatives from each pilot.

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Once the basic information of the use case and an initial version of the diagrams was completed, the next step was to identify and define the scenarios within several sections of the template ("Overview of scenarios", "Steps – Scenarios", "Information exchanged" and "Requirements"). In these sections, the pilots specified the details of the use case, the information flow and the requirements involved in each possible scenario. Another online workshop was set up for each pilot to review the progress and content of the SUCs.

Finally, the last version of each SUC was established after refining all the previously completed sections.

Requirements

Requirements can be separated into two categories: functional requirements and non-functional requirements. These two categories are detailed in the following chapters.

FUNCTIONAL REQUIREMENTS

They describe what the system must do:

- They are actions in response to events, or actions performed autonomously
- They represent operations and features provided
- Mainly concern interfaces supporting all applications
- Mainly focus on the capabilities of the interfaces of the different roles/functions

They constitute each step of a SUC scenario.

A generic list was extracted based on all pilots' SUCs to identify a first set of HEDGE-IoT general functional requirements.

NON-FUNCTIONAL REQUIREMENTS

They describe what qualities the system must contain from mainly an execution and performance perspective:

- These are also known as "constraints", "behavior", "criteria", "performance targets", etc.
- They set limits or assess how well the system complies to the functional requirements.
- They relate to reliability, security, usability, upgradeability, expandability, scalability, deployment, compatibility, safety, performance, conformance and can also include abstract requirements such as equity and fairness

Non-functional requirements are referenced and detailed in dedicated fields of the IEC 62559-2 template for both scenario steps and information exchanges. Non-functional requirements define additional common services that must be implemented by the pilots or provided as a common service package by the project.

The identification of the initial set of non-functional requirements was performed based on an INTEGRID document [3] to avoid reinventing the wheel. This document provides a generic list and corresponding values for non-functional requirements. This list of non-functional requirements was then completed when needed with additional ones.

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REQUIREMENT QUALITY

Functional and non-functional requirements follow the same rules to be considered as well defined:

- A requirement should be synthetic and easily understandable.
- A requirement must express a single property.
- A requirement can only be "True" or "False". It can be validated.

2.2. BUSINESS USE CASE AND SYSTEM USE CASE RELATIONS

Table 1 is a reminder about all the BUCs implemented within HEDGE-IoT.

TABLE 1: BUSINESS USE CASES BY PILOT

Pilot	BUC ID	BUC name
1-Finnish	BUC-FI-01	Anomaly detection and fault forecasting to increase Medium Voltage (MV) distribution network resilience
	BUC-FI-02	Predictive and real-time congestion management (CM) to increase network hosting capacity
2-Greek	BUC-GR-01	Flexibility management through active prosumers/consumers engagement
	BUC-GR-02	Leveraging data exchange and AI edge algorithms for energy forecasting and prevention of critical grid events
	BUC-GR-03	Flexibility trading platform for mitigating problems of the T&D networks
3-Italian	BUC-IT-01	Energy flow optimisation with dynamic grid limits
	BUC-IT-02	Flexibility provided by Energy Community to solve a local congestion
4-Dutch	BUC-NL-01	Energy Flexibility at business park
	BUC-NL-02	Enhance local grid resilience through detection & prevention
5-Portuguese	BUC-PT-01	GreenVale: Harnessing the potential of energy communities by leveraging Federated Learning strategies
	BUC-PT-02	Participation of industrial and residential energy communities in ancillary services market for the TSO
	BUC-PT-03	Flexibility aggregation at tertiary buildings
6-Slovenian	BUC-SI-01	Maximizing asset capacity for increased lifetime of DSO and TSO equipment
	BUC-SI-02	Enhanced Network Manageability and Observability

The following sub-sections list the SUCs of each pilot and describe their relations within the BUCs.

BUCs UML use case diagrams coming from HEDGE-IoT deliverable D2.1 are also available to provide a complete vision of the links among the SUCs.

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Finnish Pilot

TABLE 2: FINNISH PILOT SUCS

BUC ID & BUC name	SUC ID	SUC name
BUC-FI-01 Anomaly detection and fault forecasting to increase Medium Voltage (MV) distribution network resilience	SUC-FI-01.1	Data collection and anomaly detection
	SUC-FI-01.2	Fault forecasting
BUC-FI-02 Predictive and real-time congestion management (CM) to increase network hosting capacity	SUC-FI-02.1	Congestion prediction in distribution grids
	SUC-FI-02.2	Congestion management planning in distribution grids
	SUC-FI-02.3	State monitoring of the distribution grid
	SUC-FI-02.4	Congestion management decision-making in real-time

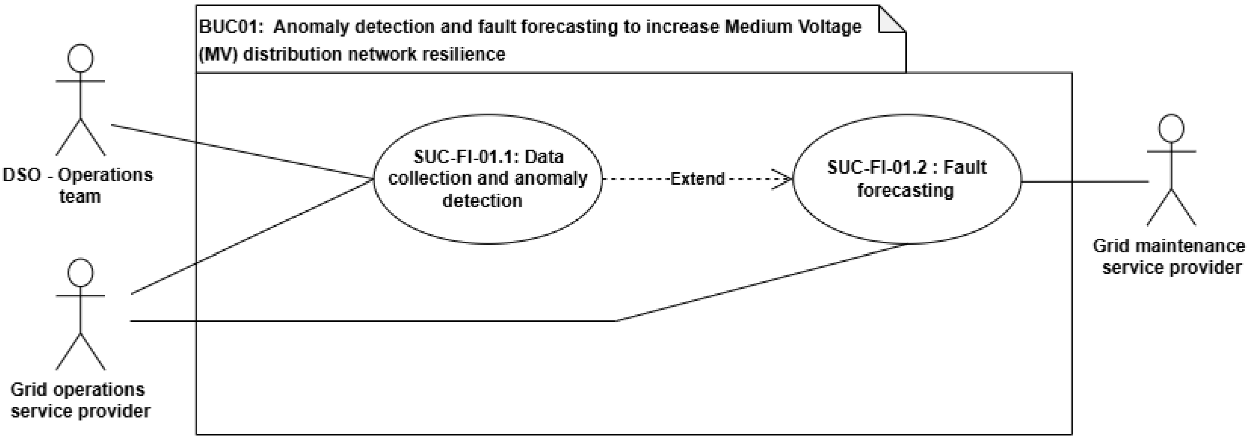

FIGURE 3: BUC-FI-01 UML USE CASE DIAGRAM

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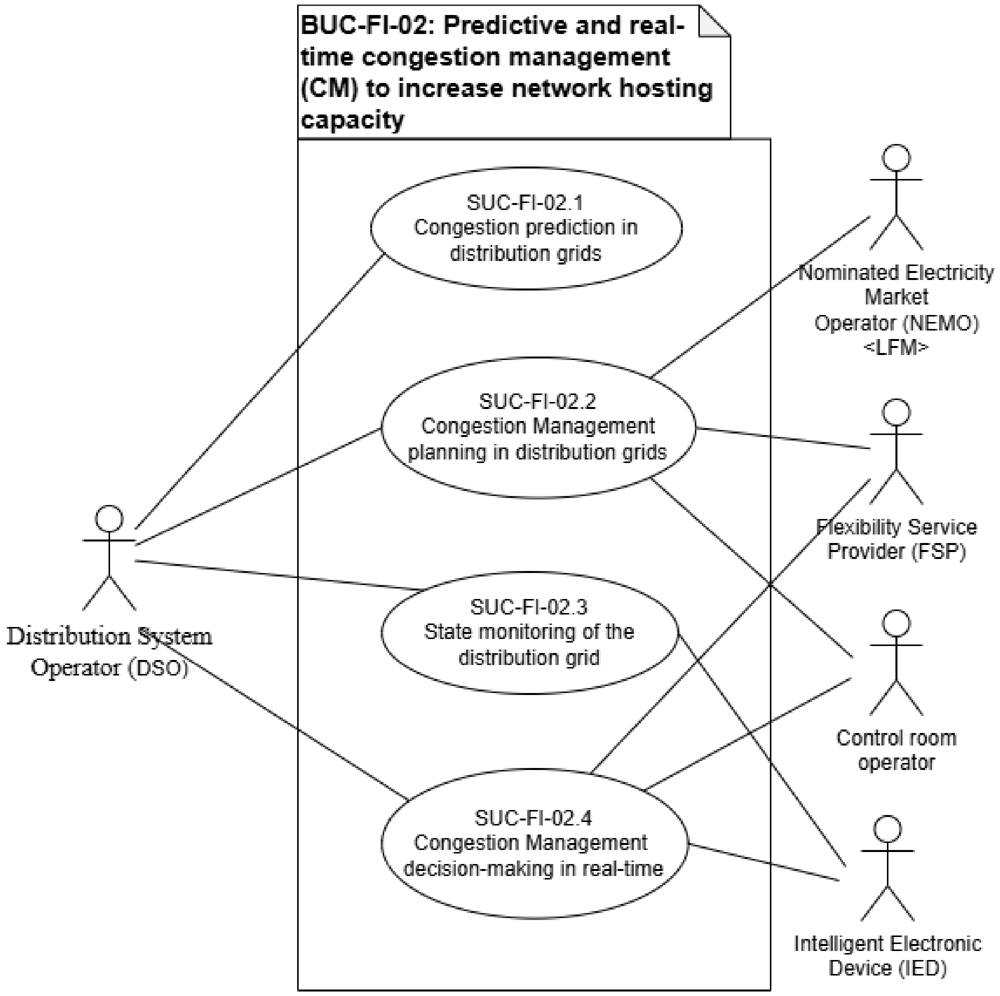

FIGURE 4: BUC-FI-02 UML USE CASE DIAGRAM

Greek Pilot

TABLE 3: GREEK PILOT SUCS

BUC ID & BUC name	SUC ID	SUC name
BUC-GR-01 Flexibility management through active prosumers/consumers engagement	SUC-GR-01.01	Optimization of Flexibility Distribution
	SUC-GR-01.02	Demand Forecasting
	SUC-GR-01.03	Production Forecasting
	SUC-GR-01.04	Edge Processing
	SUC-GR-01.05	User Interaction
BUC-GR-02 Leveraging data exchange and AI edge algorithms for energy forecasting and prevention of critical grid events	SUC-GR-02.01	Energy Grid Management using Forecasting Data
BUC-GR-03	SUC-GR-03.01	Registration & Prequalification on Local

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Flexibility trading platform for mitigating problems of the T&D networks		Flexibility Market
	SUC-GR-03.02	Flexibility Trading

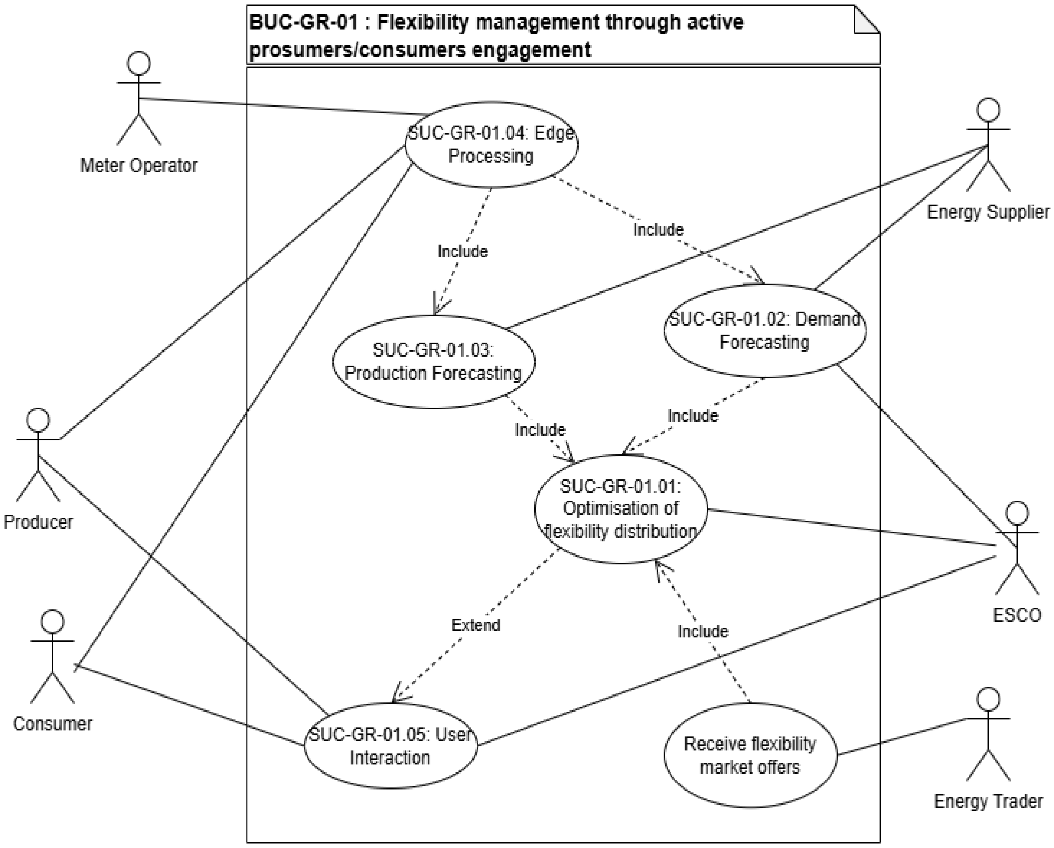

FIGURE 5: BUC-GR-01 UML USE CASE DIAGRAM

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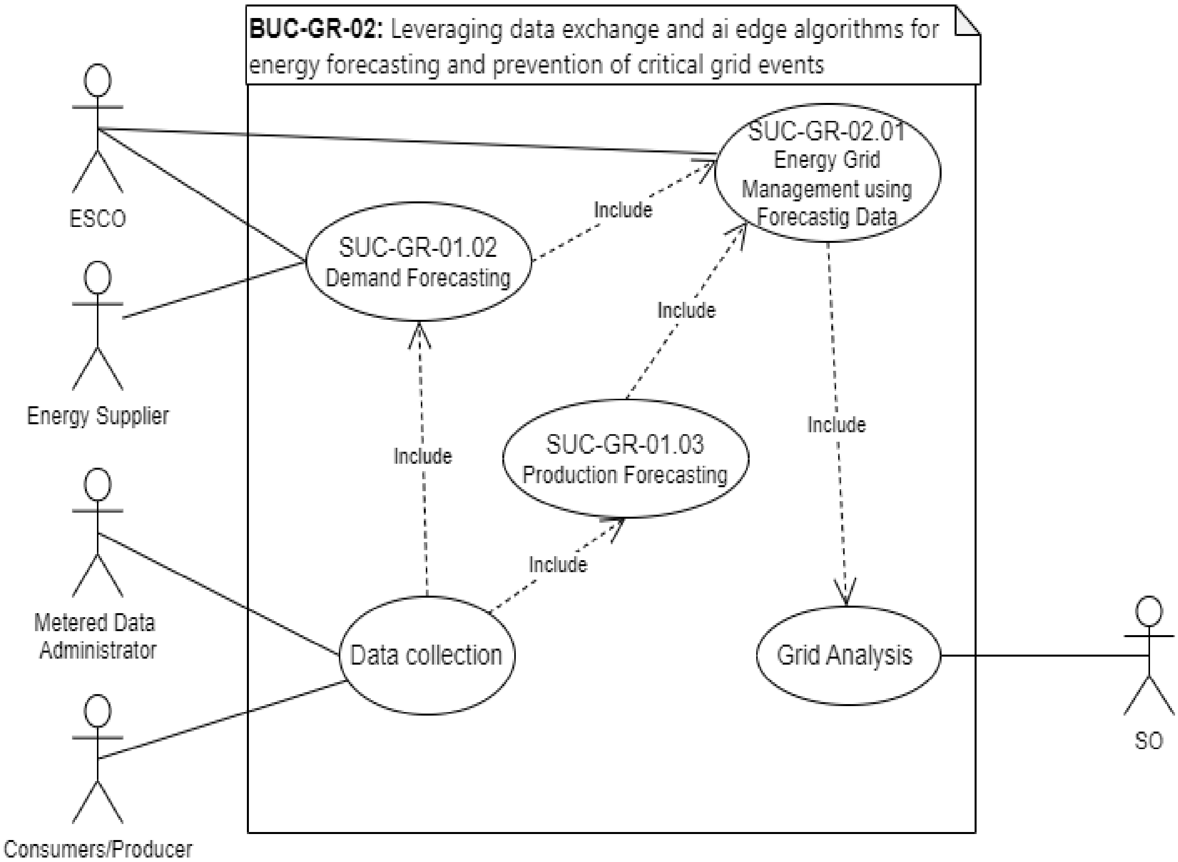

FIGURE 6: BUC-GR-02 UML USE CASE DIAGRAM

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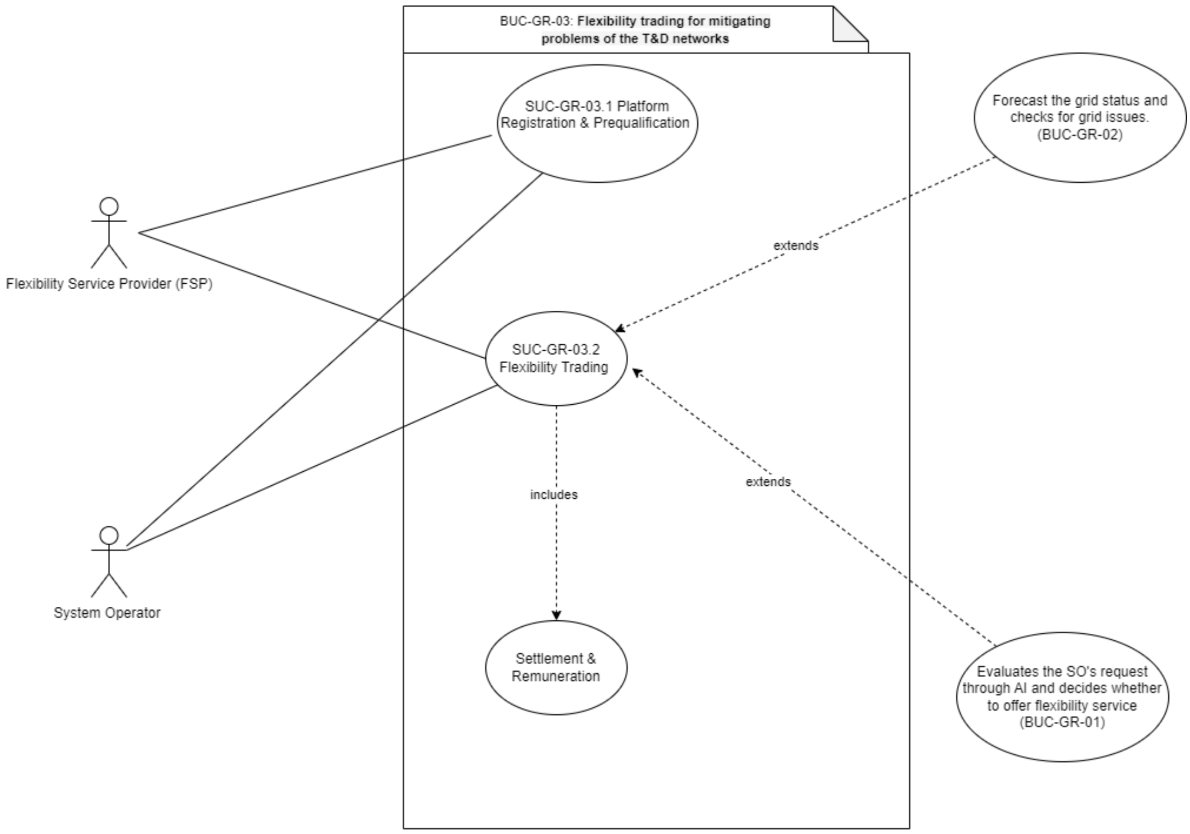

FIGURE 7: BUC-GR-03 UML USE CASE DIAGRAM

Italian Pilot

TABLE 4: ITALIAN PILOT SUCS

BUC ID & BUC name	**SUC ID**	**SUC name**
BUC-IT-01 Energy flow optimisation with dynamic grid limits	SUC-IT-01.1	Energy community power management
	SUC-IT-01.2	Energy community performance forecasting
BUC-IT-02 Flexibility provided by Energy Community to solve a local congestion	SUC-IT-02.1	Grid behaviour forecasting
	SUC-IT-02.2	Grid congestion computing
	SUC-IT-02.3	Localized weather forecast

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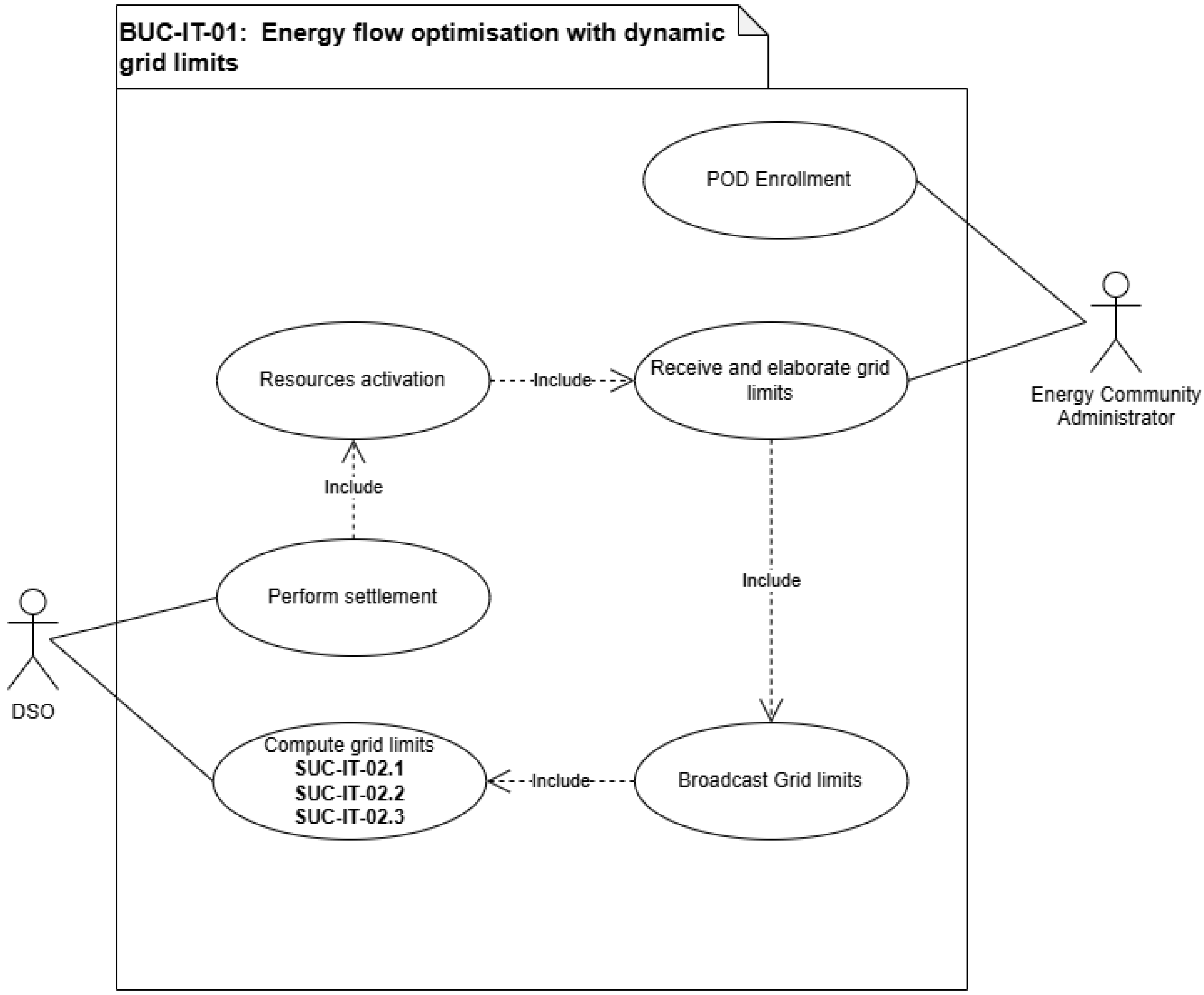

FIGURE 8: BUC-IT-01 UML USE CASE DIAGRAM

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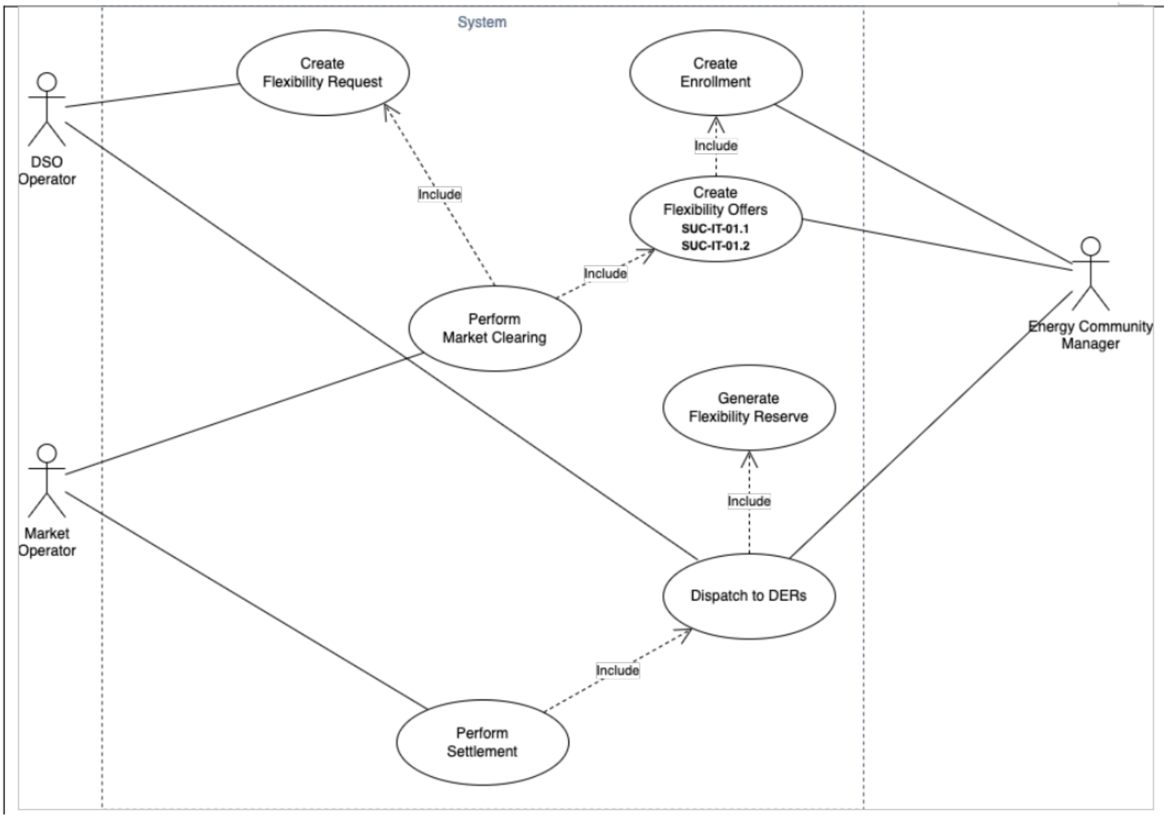

FIGURE 9: BUC-IT-02 UML USE CASE DIAGRAM

Dutch Pilot

TABLE 5: DUTCH PILOT SUCS

BUC ID & BUC name	SUC ID	SUC name
BUC-NL-01 Energy Flexibility at business park	SUC-NL-01.1	Monitor energy nodes and local grid & dashboard for data insights
	SUC-NL-01.2	Integrate energy nodes and EMS/BMS via semantics for control and explainability
	SUC-NL-01.3	Optimize energy production & consumption
	SUC-NL-01.4	Flexibility alignment
BUC-NL-02 Enhance local grid resilience through detection & prevention	SUC-NL-02.1	Anomaly and fault detection in the local grid
	SUC-NL-02.2	Predictive maintenance

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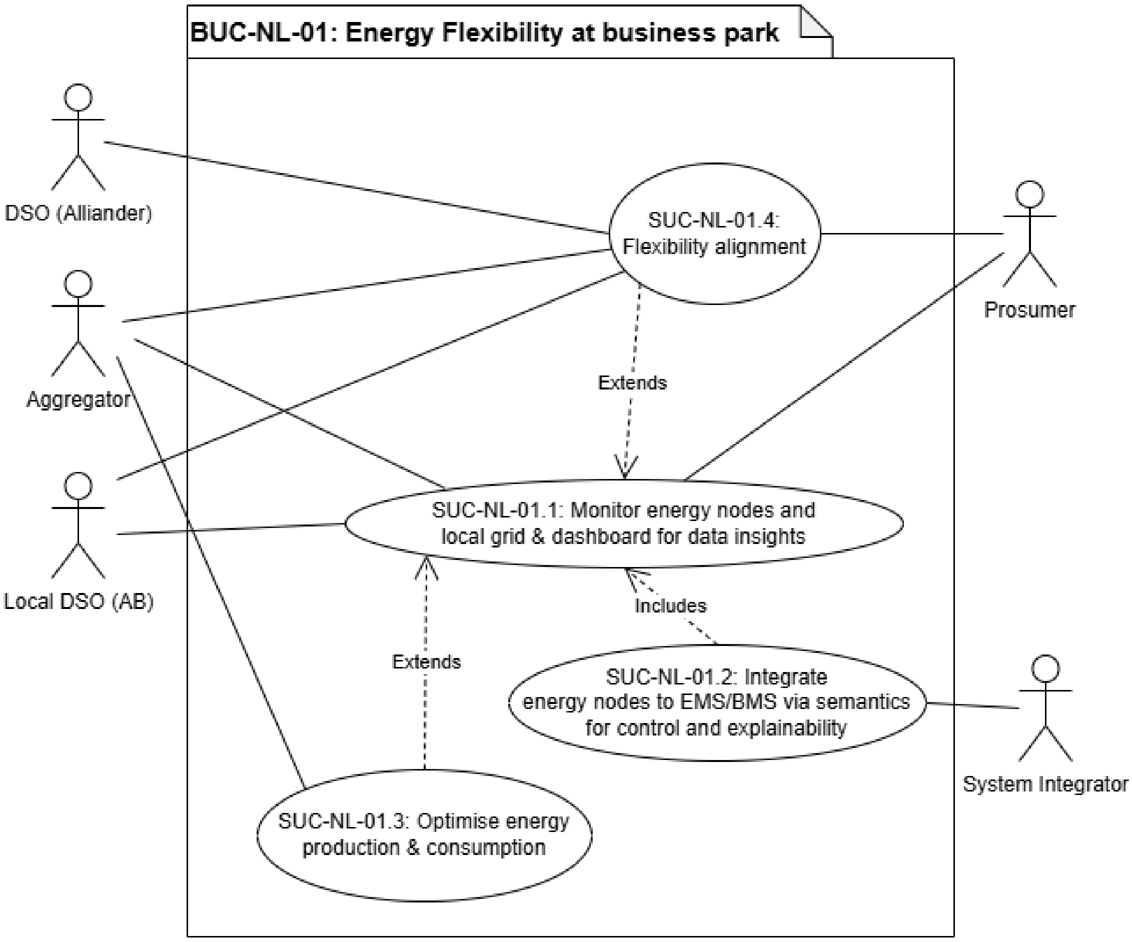

FIGURE 10: BUC-NL-01 UML USE CASE DIAGRAM

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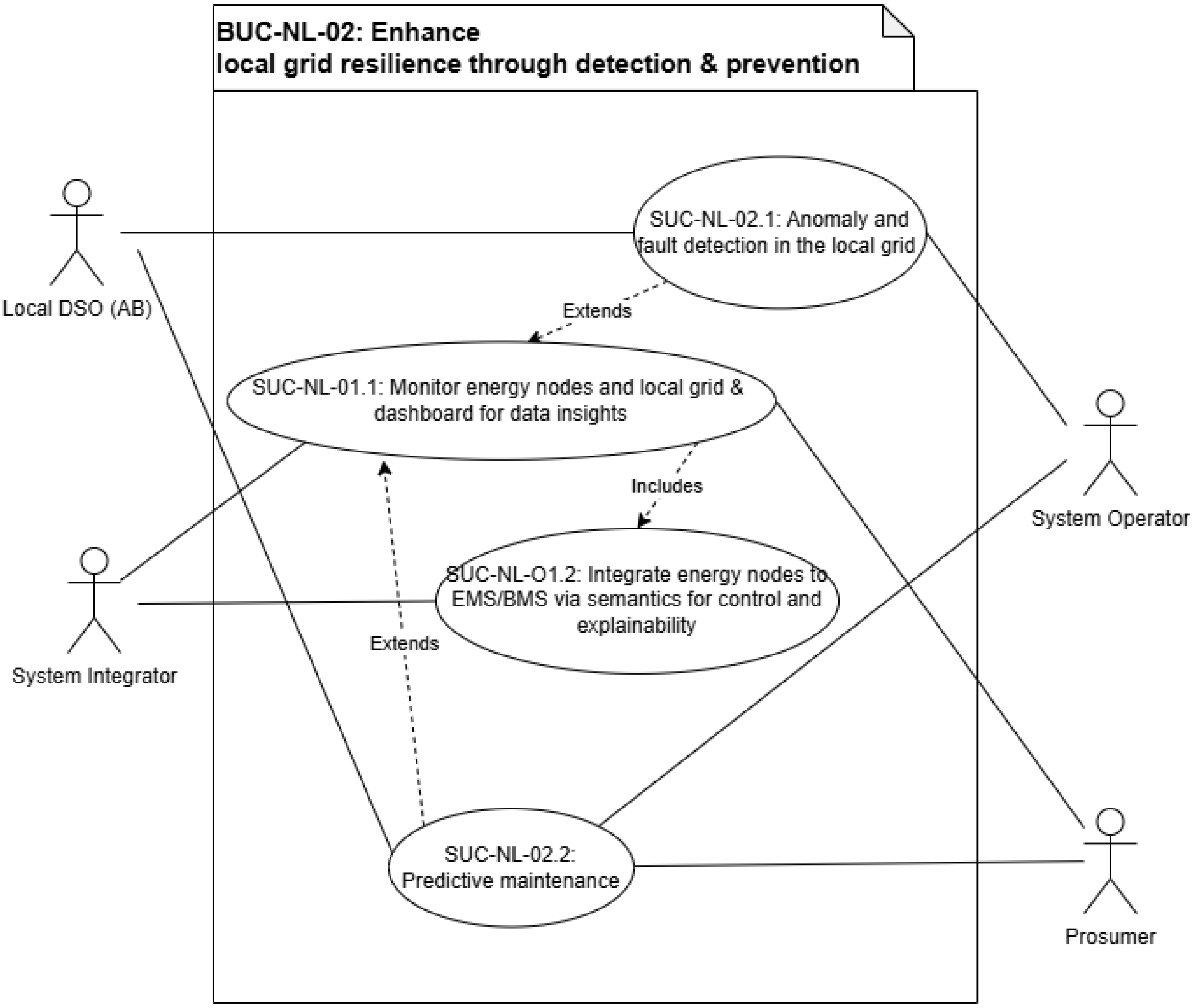

FIGURE 11: BUC-NL-02 UML USE CASE DIAGRAM

Portuguese Pilot

TABLE 6: PORTUGUESE PILOT SUCS

BUC ID & BUC name	SUC ID	SUC name
BUC-PT-01 GreenVale: Harnessing the potential of energy communities by leveraging Federated Learning strategies	SUC-PT-01.1	Connect flexibility providers across the DPP flexibility value chain
	SUC-PT-01.2	Enable Data Exchange via Data Spaces
	SUC-PT-01.3	Mobilizing Energy Flexibility
	SUC-PT-01.4	Activation of Energy Flexibility
BUC-PT-02 Participation of industrial and residential energy communities in ancillary services market for the TSO	SUC-PT-02.1	Bidding & Selection
	SUC-PT-02.2	aFRR/mFRR Activation
	SUC-PT-02.3	aFRR / mFRR Settlement

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BUC-PT-03 Flexibility aggregation at tertiary buildings	SUC-PT-03.1	Integrate flexible assets from commercial buildings
	SUC-PT-03.2	Default valorization scenario based on price hedging
	SUC-PT-03.3	TSO valorization scenario

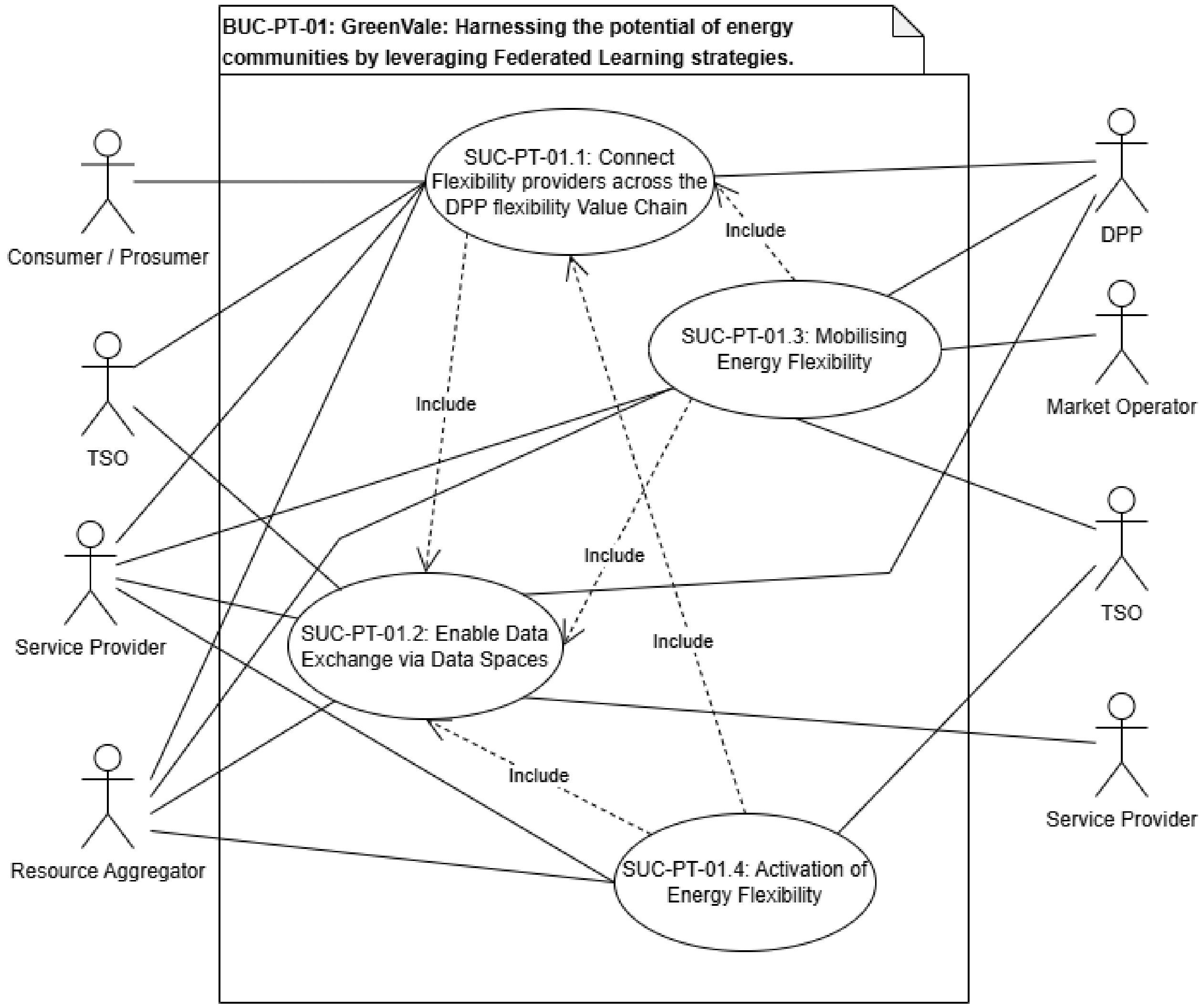

FIGURE 12: BUC-PT-01 UML USE CASE DIAGRAM

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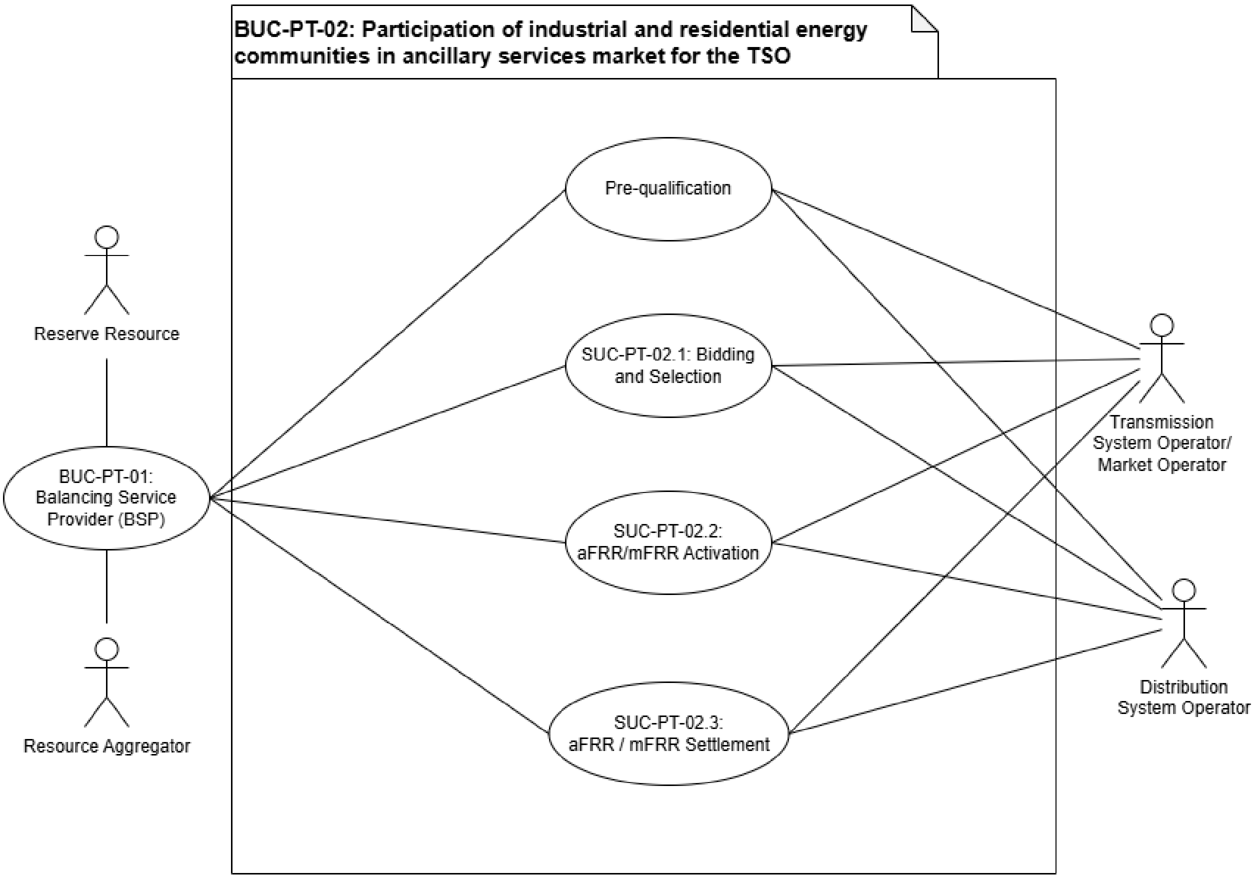

FIGURE 13: BUC-PT-02 UML USE CASE DIAGRAM

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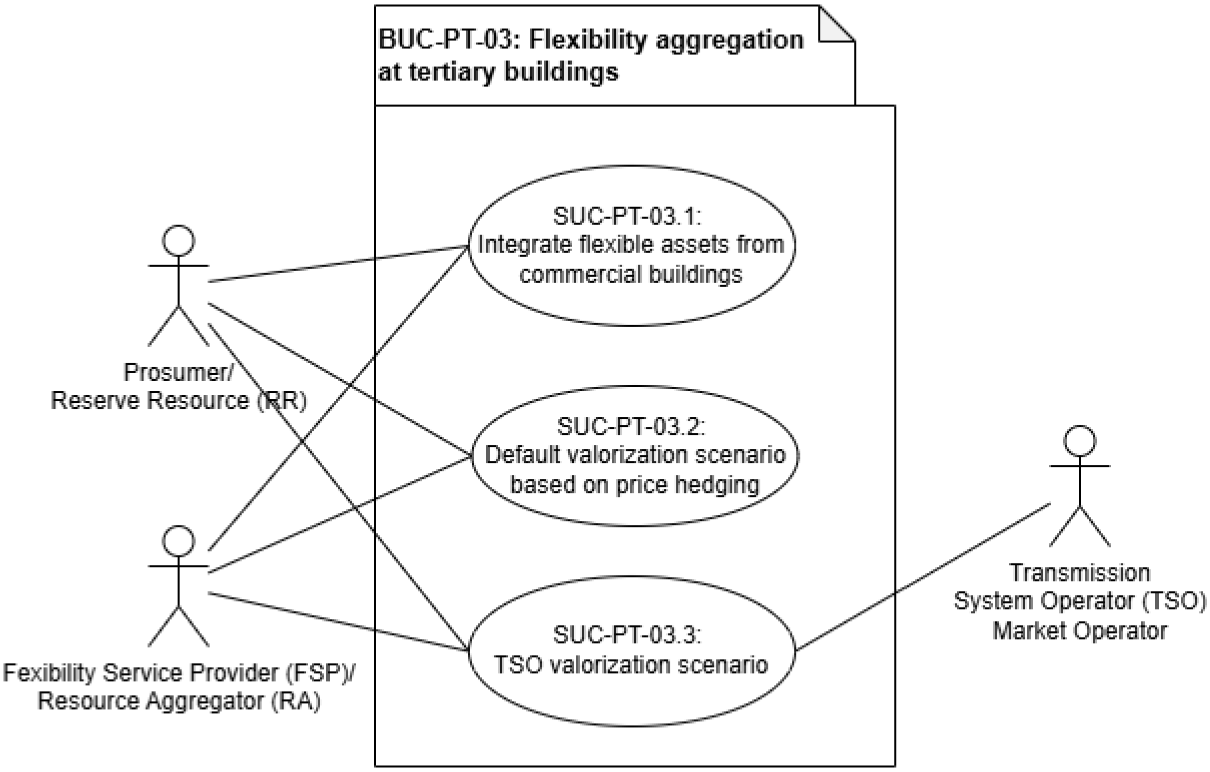

FIGURE 14: BUC-PT-03 UML USE CASE DIAGRAM

Slovenian Pilot

TABLE 7: SLOVENIAN PILOT SUCS

BUC ID & BUC name	SUC ID	SUC name
BUC-SI-01 Maximizing asset capacity for increased lifetime of DSO and TSO equipment	SUC-SI-01.1	Dynamic Thermal Rating (DTR) edge calculation
	SUC-SI-01.2	Dynamic Line Rating (DLR) edge calculation
BUC-SI-02 Enhanced Network Manageability and Observability	SUC-SI-02.1	Semantic model of the substation
	SUC-SI-02.2	ML algorithm for enhanced network management and planning

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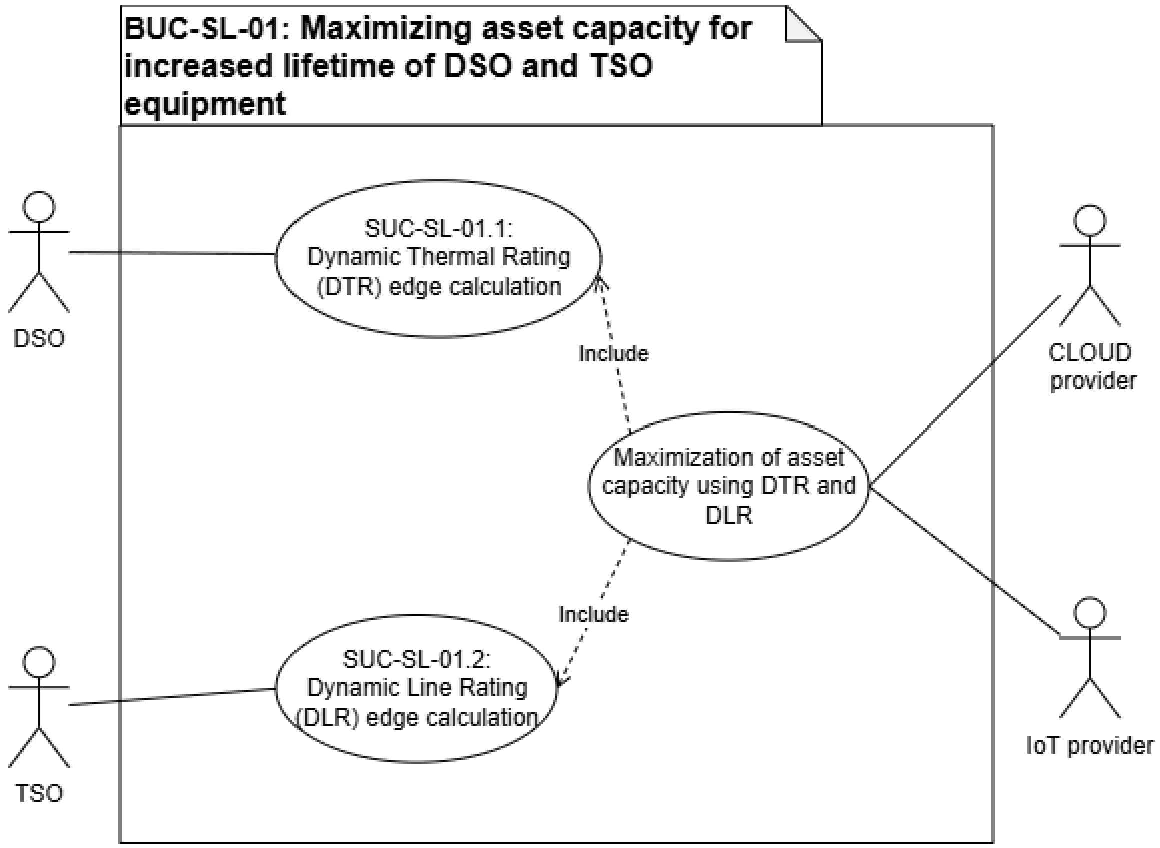

FIGURE 15: BUC-SI-01 UML USE CASE DIAGRAM

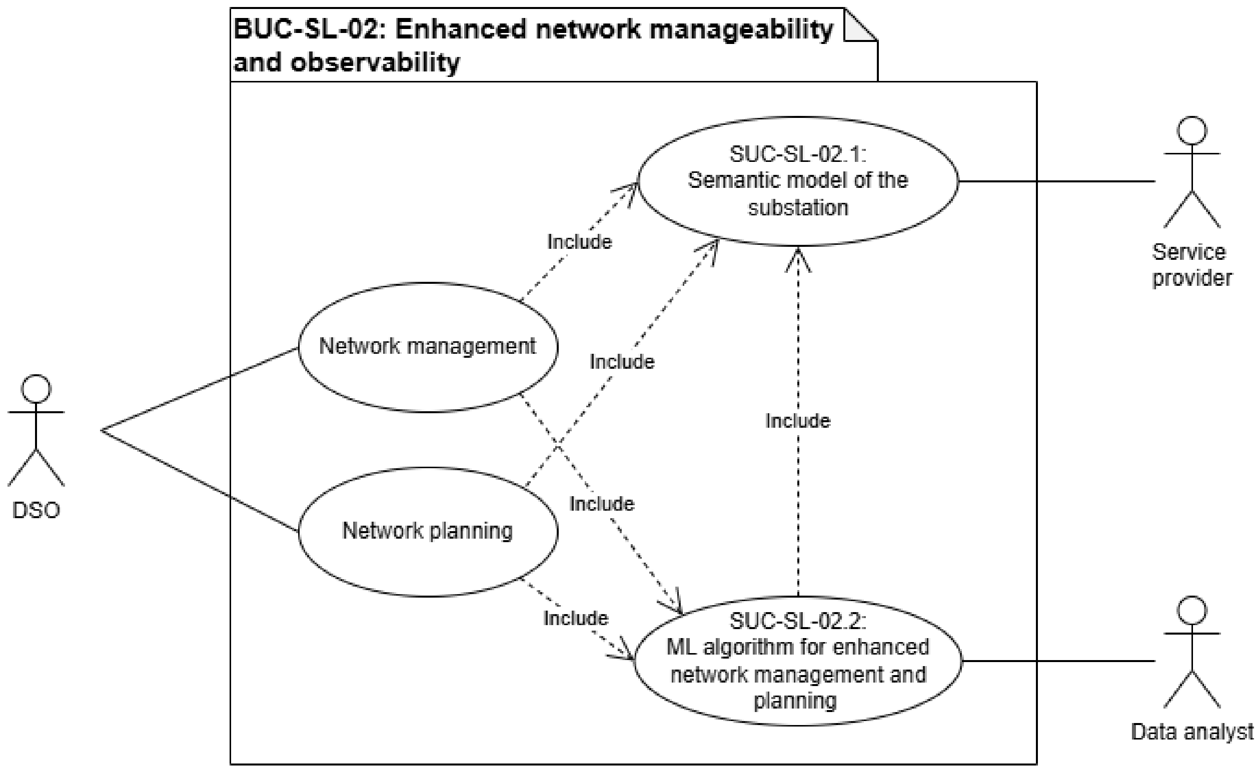

FIGURE 16: BUC-SI-02 UML USE CASE DIAGRAM

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2.3. HEDGE-IOT – PILOTS SYSTEM USE CASES SPECIFICATIONS

Given the substantial amount of information in producing the system use case specifications for all HEDGE-IoT pilots, each pilot's completed IEC 62559 template for their respective SUCs are provided in a separate document. These documents can be found as Annexes of this report as per Table 8.

TABLE 8: SUCS DOCUMENTS OF PILOTS

Pilot	**System Use Case Specifications document**
Finnish	Annex Document 1: Finnish Pilot SUCs
Greek	Annex Document 2: Greek Pilot SUCs
Italian	Annex Document 3: Italian Pilot SUCs
Dutch	Annex Document 4: Dutch Pilot SUCs
Portuguese	Annex Document 5: Portuguese Pilot SUCs
Slovenian	Annex Document 6: Slovenian Pilot SUCs

In the following subsections, an overview of the SUCs for each demonstrator is presented, including the SUC's scope and objectives and the UML use case diagram.

Finnish pilot

SUC–FI–01.1 DATA COLLECTION AND ANOMALY DETECTION

TABLE 9: SUC–FI–01.1

SUC ID	SUC-FI-01.1
SUC NAME	Data collection and anomaly detection
SCOPE	Processing of data stream from Intelligent Electronic Devices (IEDs), identification of abnormalities and storing indicator values
OBJECTIVES	1. To process and analyse the live data stream. 2. To pick all issues that seem abnormal. 3. To store their indicators into logs so that long-term evolving phenomena can also be identified in next phases.
UML USE CASE DIAGRAM	

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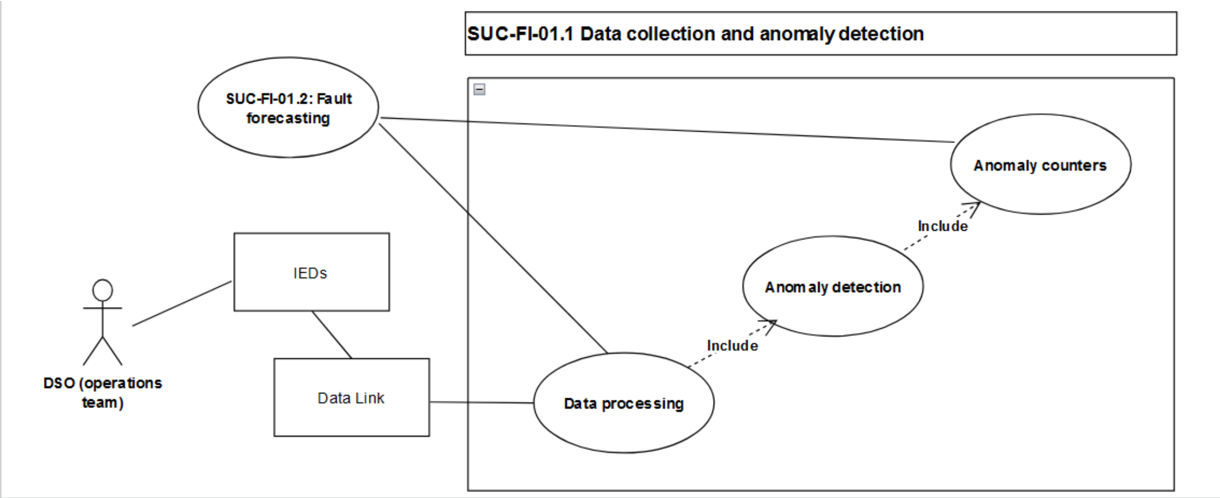
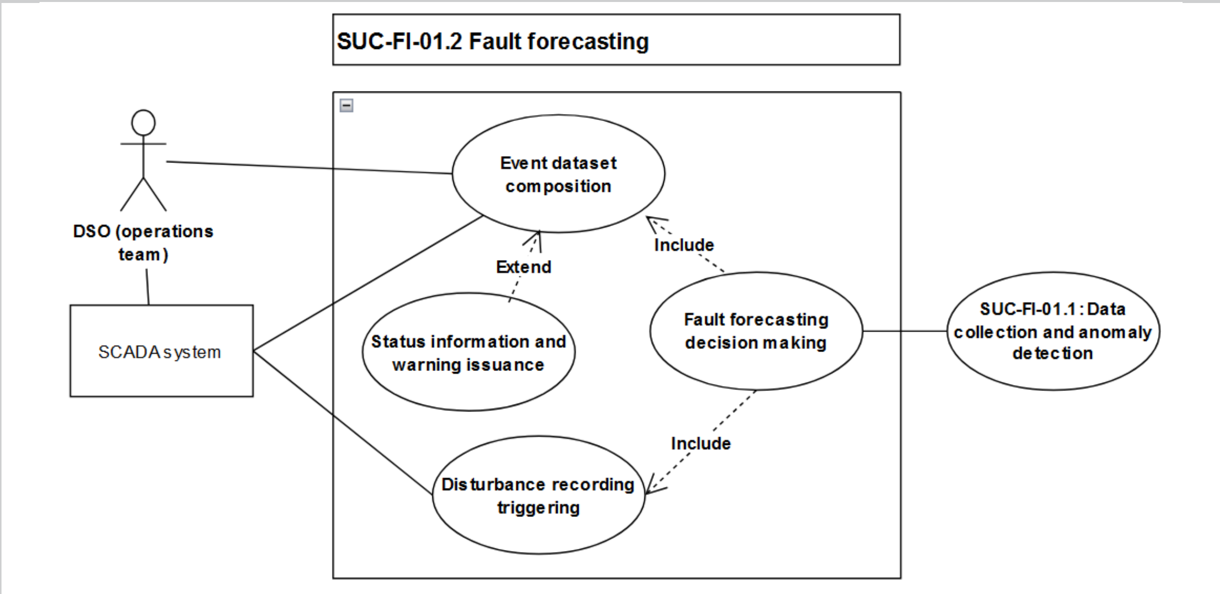


SUC-FI-01.2 FAULT FORECASTING

TABLE 10: SUC-FI-01.2

SUC ID	SUC-FI-01.2
SUC NAME	Fault forecasting
SCOPE	Methodology for decision-making based on identified anomalies
OBJECTIVES	1. Drawing decisions based on anomaly logs and data stream 2. Issuing status signals and warnings to the user 3. Triggering the fault recording process timely
UML USE CASE DIAGRAM	



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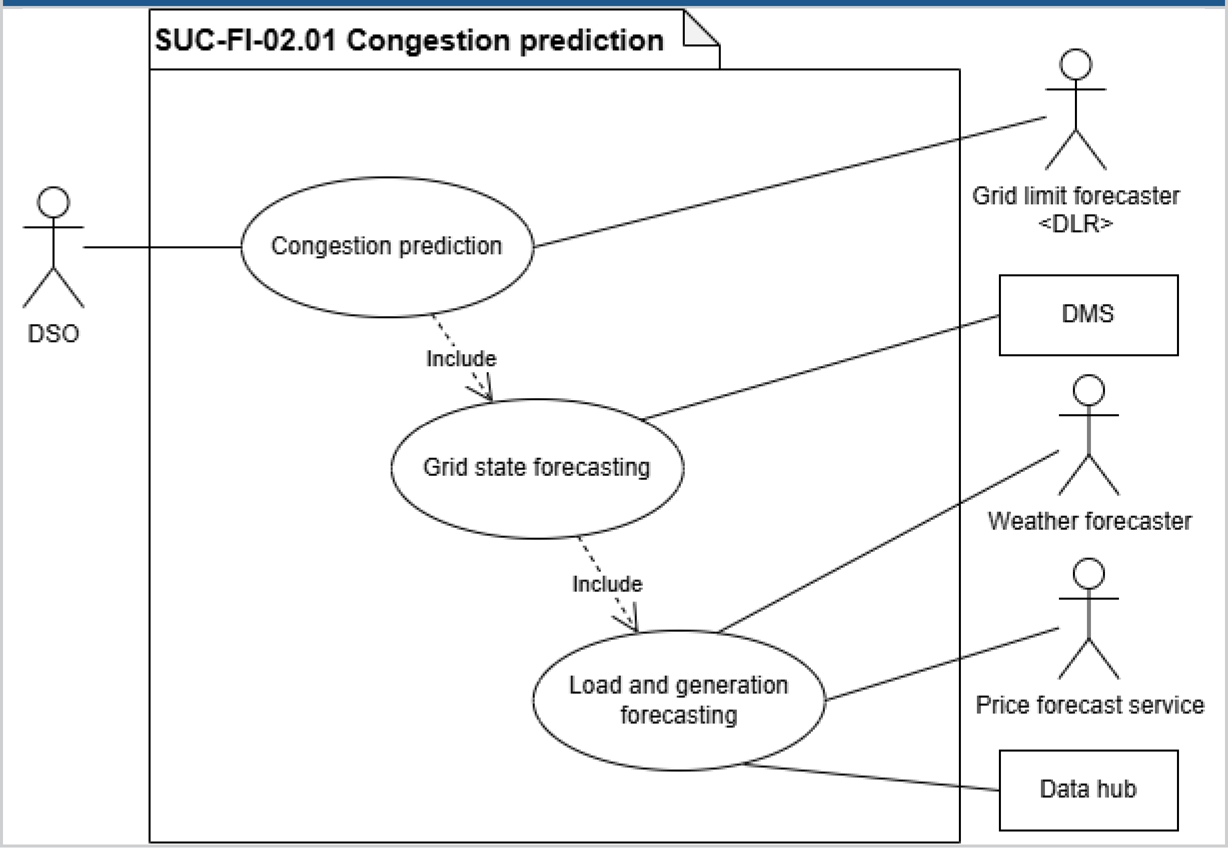
SUC-FI-02.1 CONGESTION PREDICTION IN DISTRIBUTION GRIDS

TABLE 11: SUC-FI-02.1

SUC ID	SUC-FI-02.1
SUC NAME	Congestion prediction in distribution grids
SCOPE	DSO's congestion prediction in the day ahead timeframe
OBJECTIVES	The use case objective from DSO's perspective is: 1. Predict the grid congestion for the coming day.
UML USE CASE DIAGRAM	



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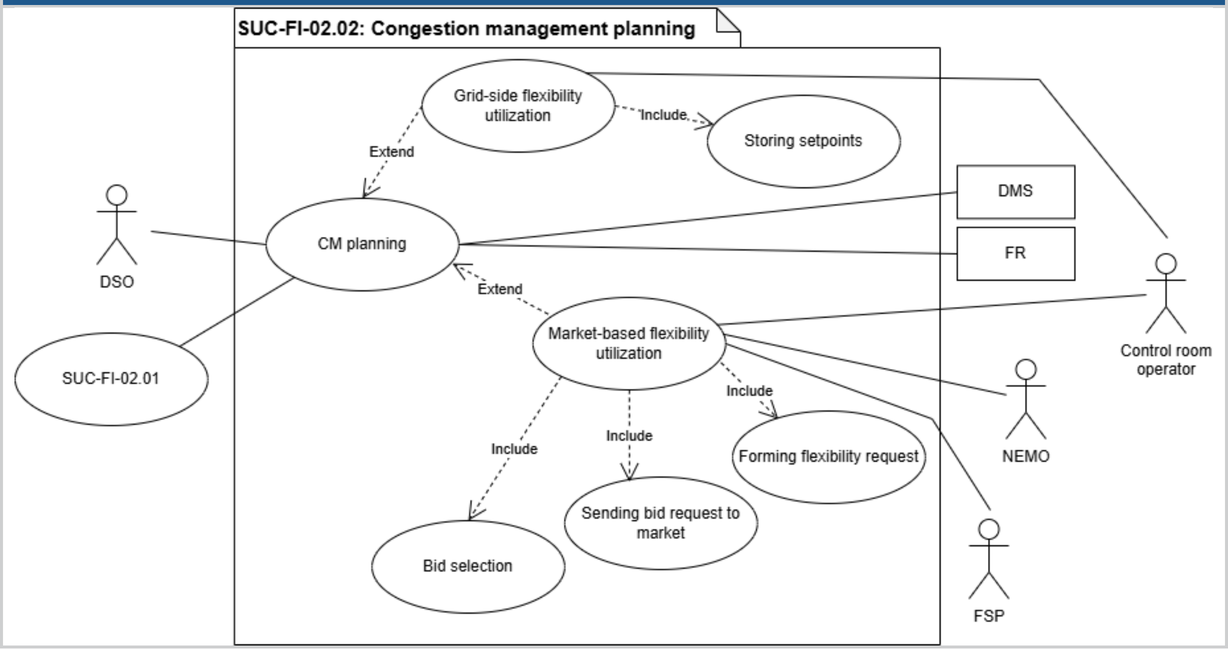
SUC-FI-02.2 CONGESTION MANAGEMENT PLANNING IN DISTRIBUTION GRIDS

TABLE 12: SUC-FI-02.2

SUC ID	SUC-FI-02.2
SUC NAME	Congestion management planning in distribution grids
SCOPE	DSO's Congestion management (CM) planning in the day-ahead timeframe
OBJECTIVES	The use case objective from DSO's perspective is: 1. Enhance the preparedness of the grid operation for the coming day.
UML USE CASE DIAGRAM	



SUC-FI-02.3 STATE MONITORING OF THE DISTRIBUTION GRID

TABLE 13: SUC-FI-02.03

SUC ID	SUC-FI-02.03
SUC NAME	State monitoring of the distribution grid
SCOPE	Distribution grid's state monitoring in real-time
OBJECTIVES	The use case objective from DSO's perspective is: 1. Enhance the observability of the grid congestion in real-time.

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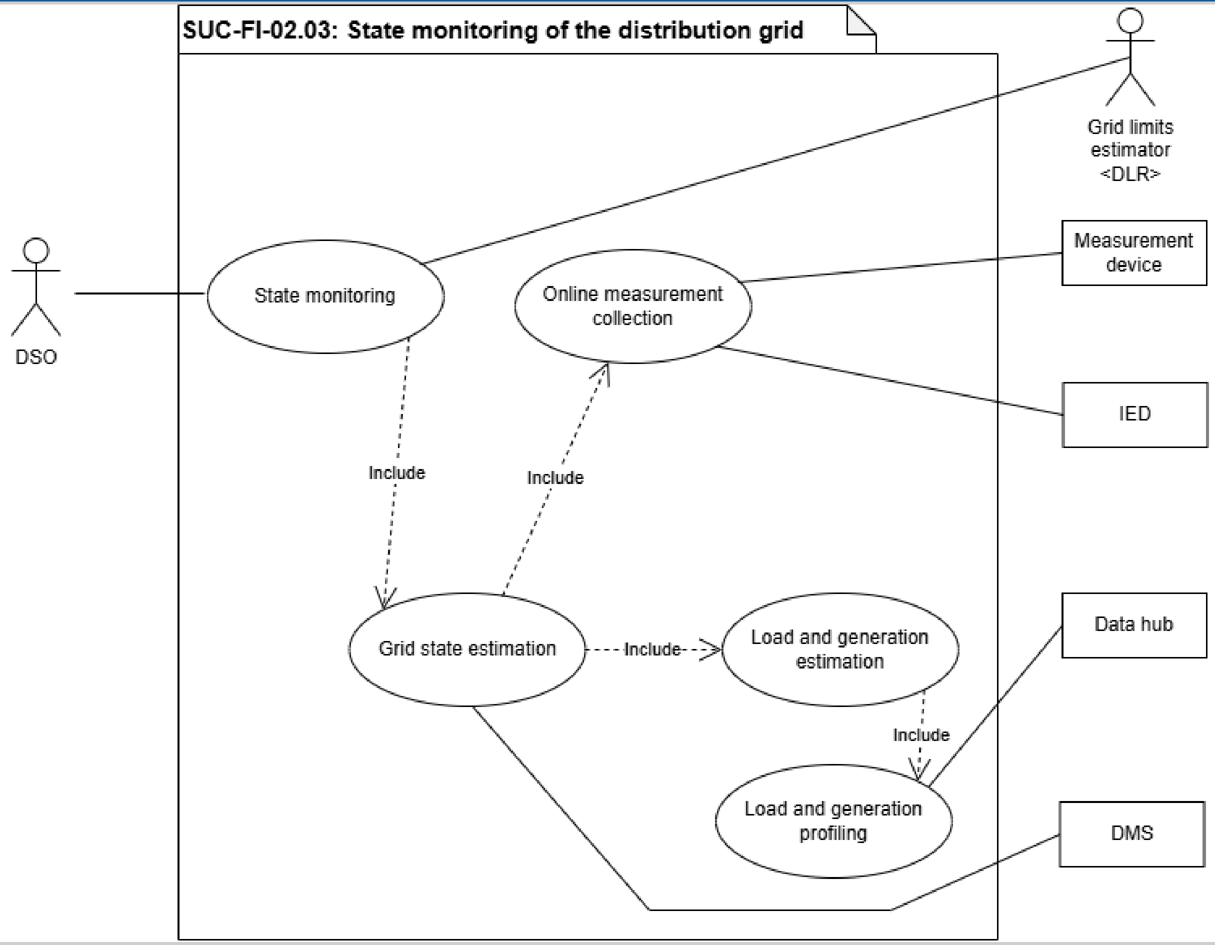
UML USE CASE DIAGRAM



SUC-FI-02.4 CONGESTION MANAGEMENT DECISION-MAKING IN REAL-TIME

TABLE 14: SUC-FI-02.4

SUC ID	SUC-FI-02.4
SUC NAME	Congestion management decision-making in real-time
SCOPE	DSO's Congestion management (CM) decision-making in the real-time timeframe
OBJECTIVES	The use case objective from DSO's perspective is: 1. Remove/alleviate congestion in the real-time operation of the grid.
UML USE CASE DIAGRAM	

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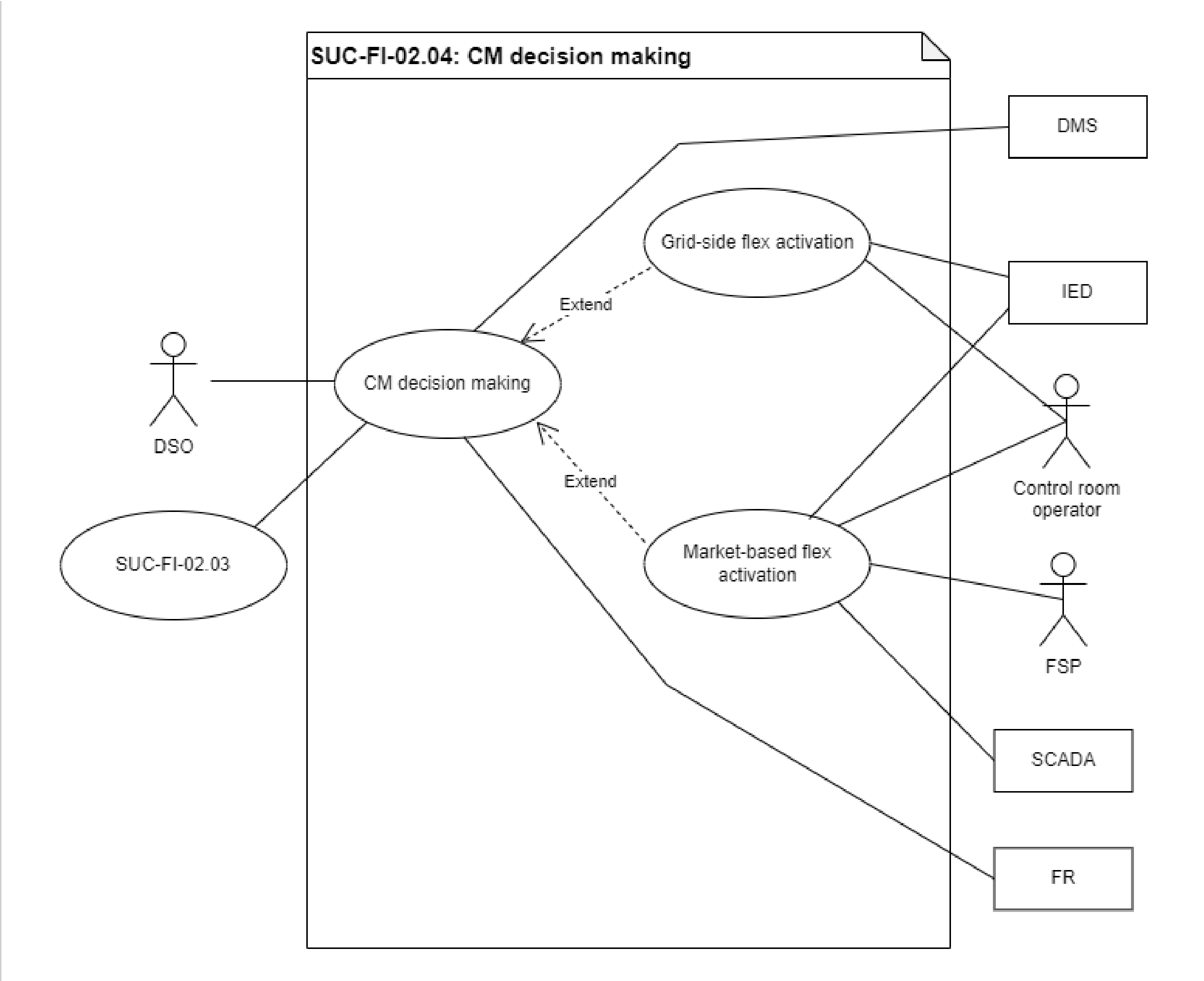

Greek pilot

SUC-GR-01.01 OPTIMIZATION OF FLEXIBILITY DISTRIBUTION

TABLE 15: SUC-GR-01.01

SUC ID	SUC-GR-01.01
SUC NAME	Optimization of flexibility distribution
SCOPE	To enable flexibility actions from residential consumers, responding to a signal from the aggregator. The aggregator will design an optimisation module to satisfy the flexibility signal coming from the Local Flexibility Market (LFM). The optimisation module focuses on identifying the optimal Demand Response (DR) scenarios to be able to bid in the LFM and to offer the relevant incentives to the consumers to perform the flexibility action.
OBJECTIVES	The main objectives are: 1. To identify if the aggregator will be able to bid in the LFM based on the available flexibility and consumers' behaviour. 2. To find the optimal DR strategies to be competitive under market conditions.

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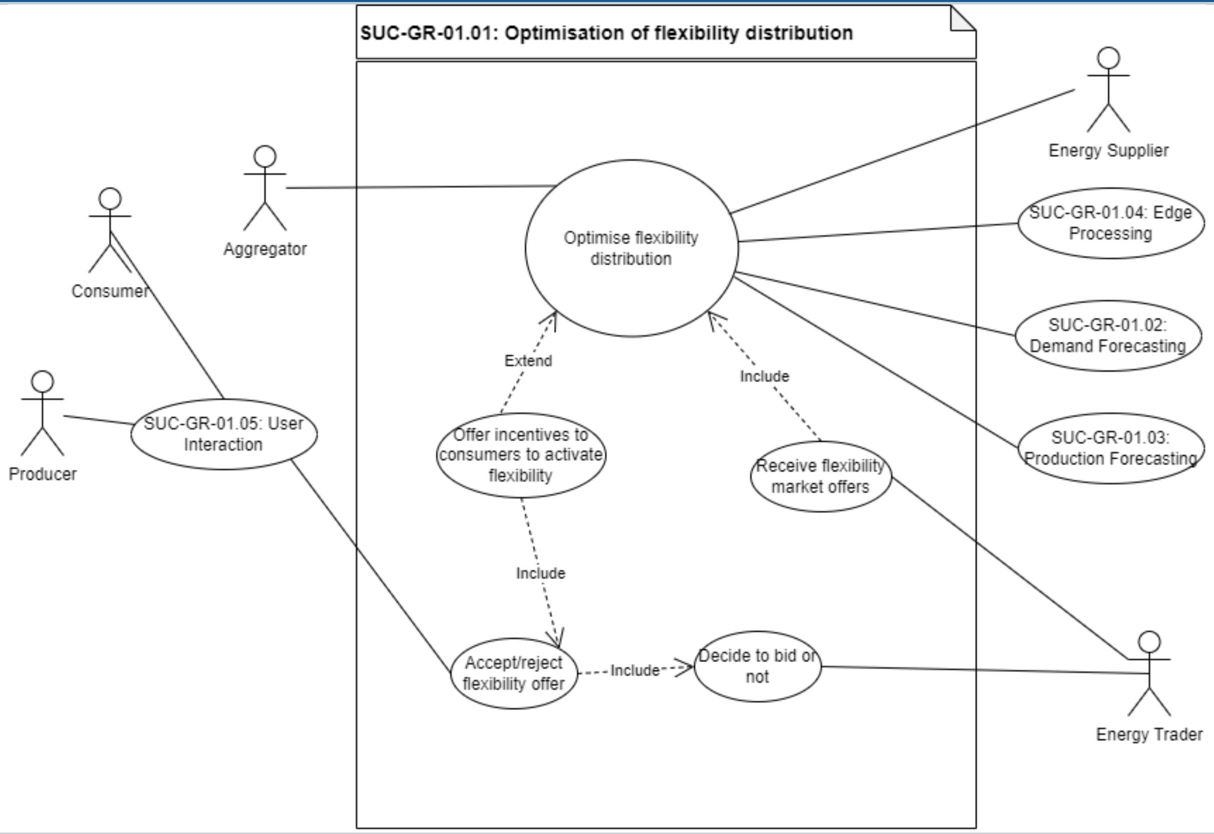
	3. To find the necessary incentives to offer to consumers.

UML USE CASE DIAGRAM



SUC-GR-01.02 DEMAND FORECASTING

TABLE 16: SUC-GR-01.02

SUC ID	SUC-GR-01.02
SUC NAME	Demand Forecasting
SCOPE	To forecast the demand of the customers to identify their ability to offer flexibility. The aggregator will use this information to run the optimization algorithm and decide if it can bid for a flexibility market product.
OBJECTIVES	The main objectives are: 1. To develop a robust system to accurately forecast the demand of customers. This involves collecting and analysing historical data, identifying patterns, and predicting future consumption trends. 2. To assess the ability of customers to offer flexibility in their energy usage. 3. To ensure the system can process and update data in real-time or near real-time to reflect the most current demand 4. To help the system operators to identify grid issues and request flexibility

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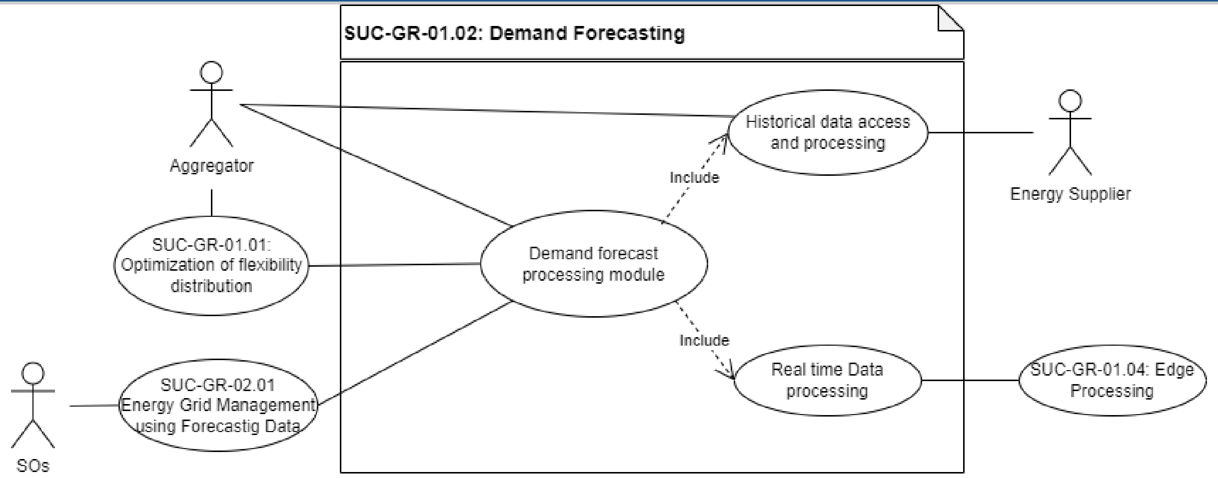
UML USE CASE DIAGRAM



SUC-GR-01.03 PRODUCTION FORECASTING

TABLE 17: SUC-GR-01.03

SUC ID	SUC-GR-01.03
SUC NAME	Production Forecasting
SCOPE	To forecast the production of the prosumers to identify their ability to offer flexibility. The aggregator will use this information to run the optimization algorithm and decide if it can bid for a flexibility market product.
OBJECTIVES	The main objectives are: 1. To predict the energy production of prosumers (households with PV systems) over a specified period. This involves collecting and analysing historical data, weather forecasts, and predicting future production trends. 2. To determine the ability of prosumers to offer flexibility based on their predicted production as well as identify the surplus energy that can be potentially used for flexibility services. 3. To provide the aggregator with timely and reliable production forecasts so it can use this information to run optimization algorithms effectively. 4. To help the system operators to identify grid issues and request flexibility
UML USE CASE DIAGRAM	

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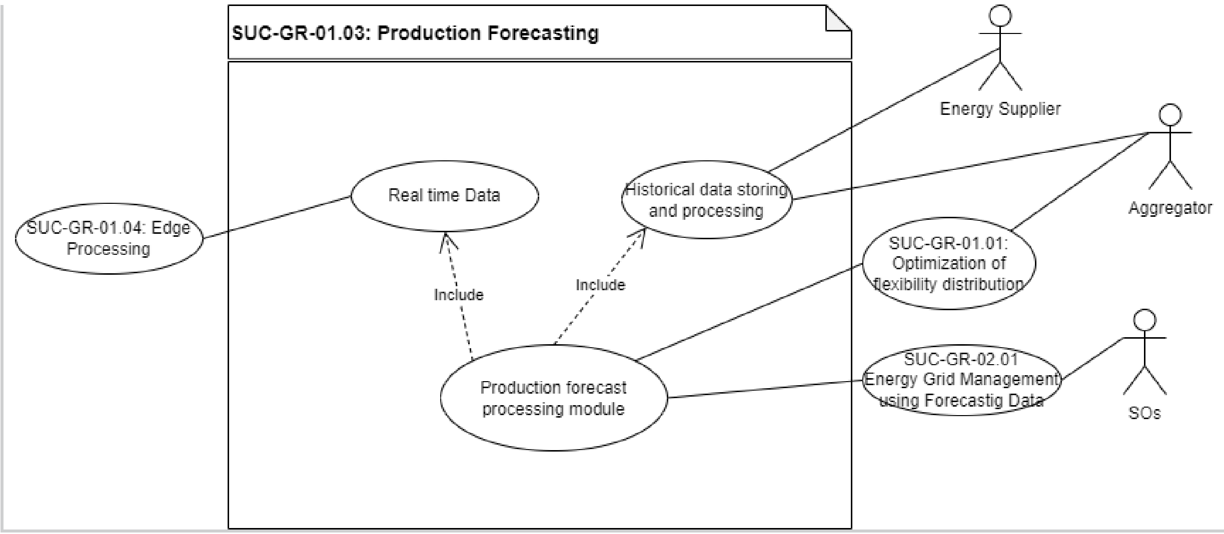

SUC-GR-01.04 EDGE PROCESSING

TABLE 18: SUC-GR-01.04

SUC ID	SUC-GR-01.04
SUC NAME	Edge Processing
SCOPE	The edge processing system will focus on real-time monitoring and analysis of residential energy consumption using IoT devices. It aims to provide actionable insights and facilitate efficient energy management to support consumer participation in the Local Flexibility Market (LFM).
OBJECTIVES	The main objectives are: 1. To continuously monitor and calculate key energy metrics such as average voltage, instant consumption, and total energy usage 2. To identify unusual patterns or potential issues in energy consumption to enable proactive management and maintenance 3. To provide detailed visualizations and customized insights on energy consumption patterns to help users optimize their energy usage 4. To enable the Aggregator to leverage real-time data and insights to make informed decisions about flexibility offers and incentivize consumer participation in the LFM
UML USE CASE DIAGRAM	

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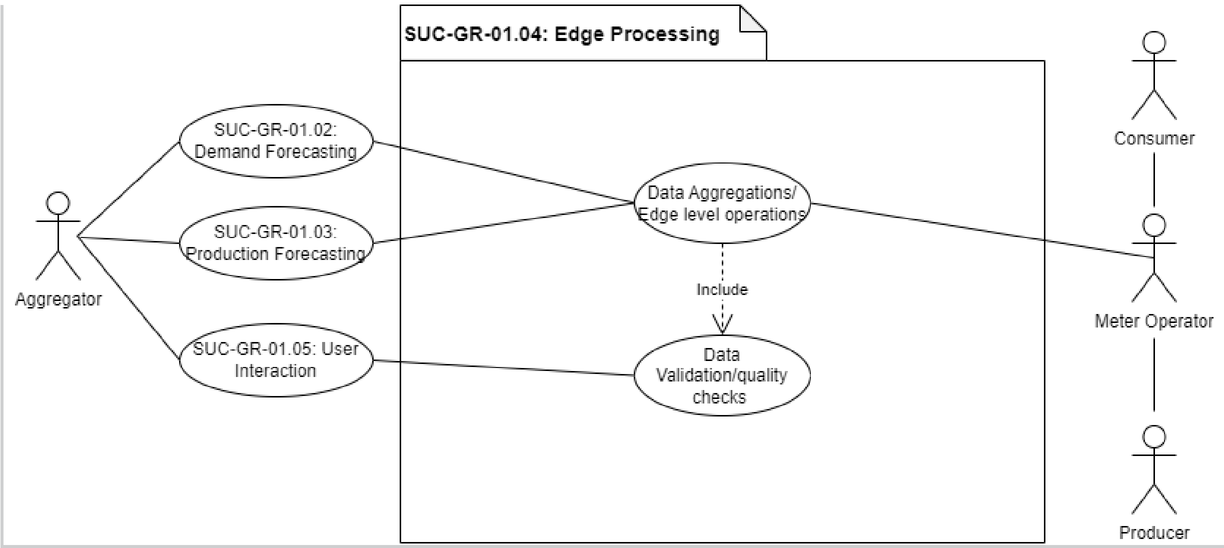

SUC-GR-01.05 USER INTERACTION

TABLE 19: SUC-GR-01.05

SUC ID	SUC-GR-01.05
SUC NAME	User Interaction
SCOPE	To enable active participation of consumers/prosumers in the flexibility market facilitated by an interactive user interface (UI) that includes functionalities for consumers/prosumers to receive, review, and respond to flexibility requests from the aggregator, while also providing insights into energy consumption patterns and offering economic incentives based on participation.
OBJECTIVES	The main objectives are: 1. To enable consumers/prosumers to actively engage in the flexibility market 2. To provide a user-friendly interface for reviewing and responding to flexibility requests from the aggregator 3. To offer insights into energy consumption patterns to optimize usage and maximize economic incentives.
UML USE CASE DIAGRAM	

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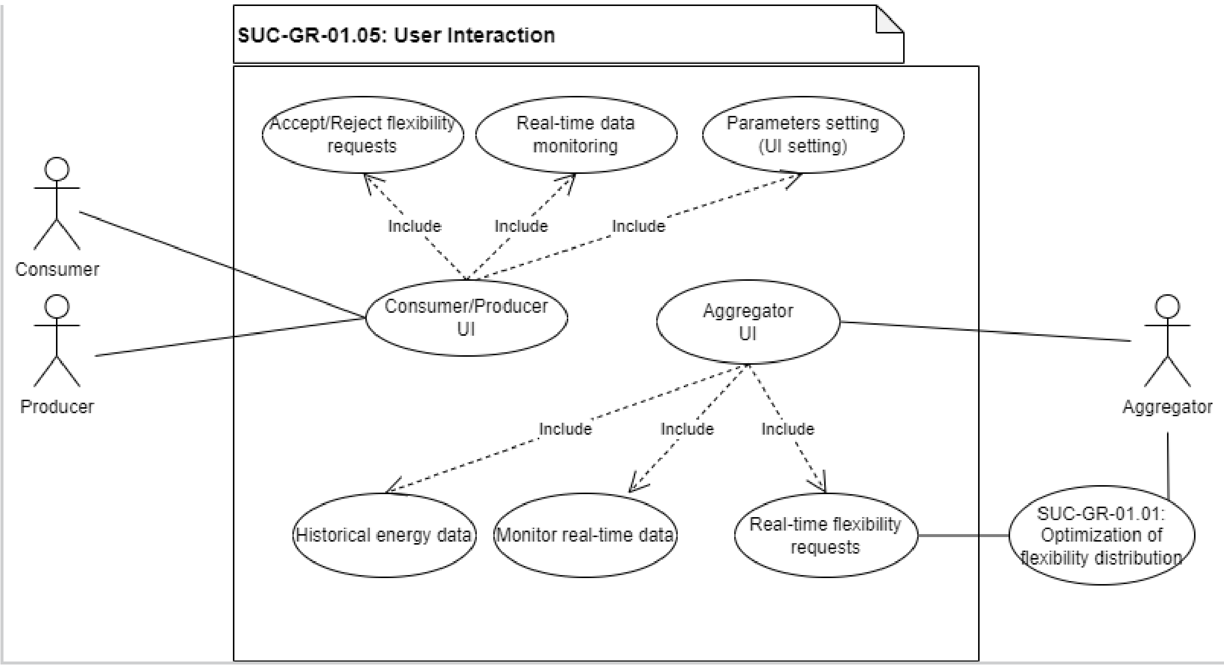

SUC-GR-02.01 ENERGY GRID MANAGEMENT USING FORECASTING DATA

TABLE 20: SUC-GR-02.01

SUC ID	SUC-GR-02.01
SUC NAME	Energy Grid Management using forecasting data
SCOPE	Strategically utilizing forecasting data, the System Operator (SO) and the Energy Service Company (ESCO) collaborate to leverage production and demand forecasts for proactive grid load management, issue identification, and flexibility calculation.
OBJECTIVES	The main objectives are: 1. To regularly analyse the current state of the energy grid and assess its performance and efficiency. 2. To proactively identify potential issues or inefficiencies within the grid using data-driven insights from production and demand forecasting, thereby enhancing grid management, decision-making, and operational responsiveness. 3. To determine the necessary flexibility in grid operations to accommodate variability in energy production and demand, ensuring stability and efficiency.
UML USE CASE DIAGRAM	

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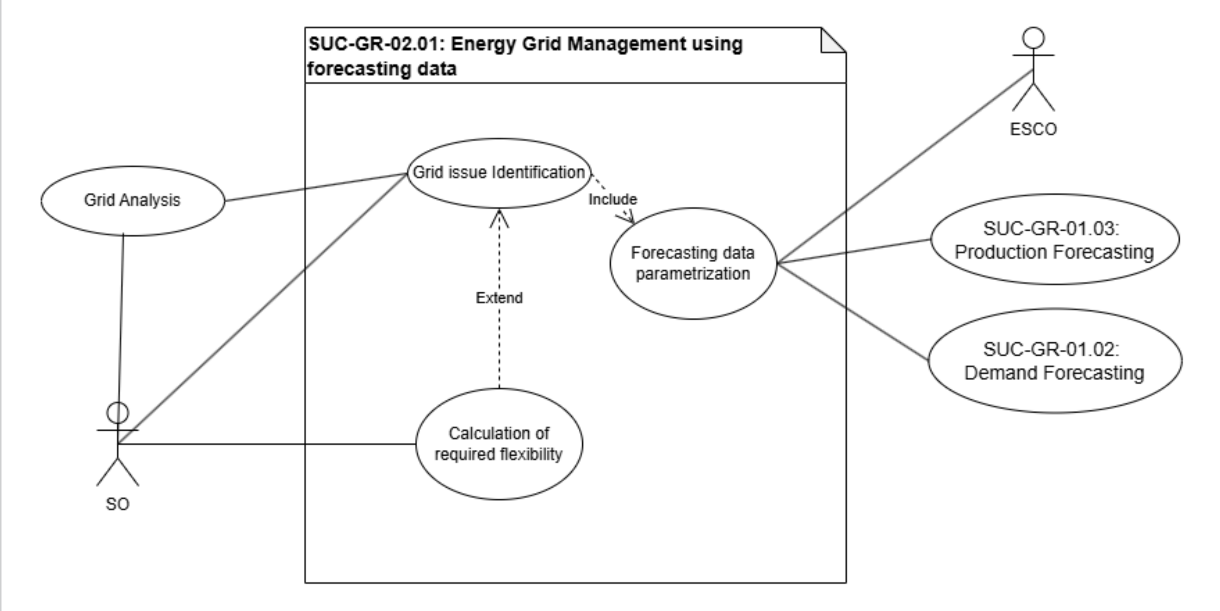

SUC-GR-03.01 REGISTRATION & PREQUALIFICATION ON LOCAL FLEXIBILITY MARKET

TABLE 21: SUC-GR-03.01

SUC ID	SUC-GR-03.01
SUC NAME	Registration & Prequalification on Local Flexibility Market
SCOPE	The scope of the SUC is to describe the authorization 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 personalized and efficient process for accessing the platform's features and opportunities.
OBJECTIVES	The objective of this use case is to outline the comprehensive authorization process for users accessing the LFM Platform. This process includes registration and prequalification steps designed to ensure that users are granted access to platform features and opportunities based on their specific roles. The authorization process aims to achieve the following: 1. **Ensure Secure Access**: Implement a robust and secure mechanism for user registration and authentication to protect sensitive information and prevent unauthorized access. 2. **Role-Specific Tailoring**: Provide distinct registration and prequalification procedures for different user roles, such as **SOs** and **FSPs**, to ensure that each user has appropriate access rights and capabilities. 3. **Streamlined User Experience**: Design an efficient and user-friendly process that minimizes the time and effort required for users to register and get prequalified, enhancing overall user satisfaction. 4. **Accurate Role Assignment**: Ensure that users are accurately categorized and assigned roles based on their submitted information and prequalification criteria, facilitating effective and appropriate use of the platform.

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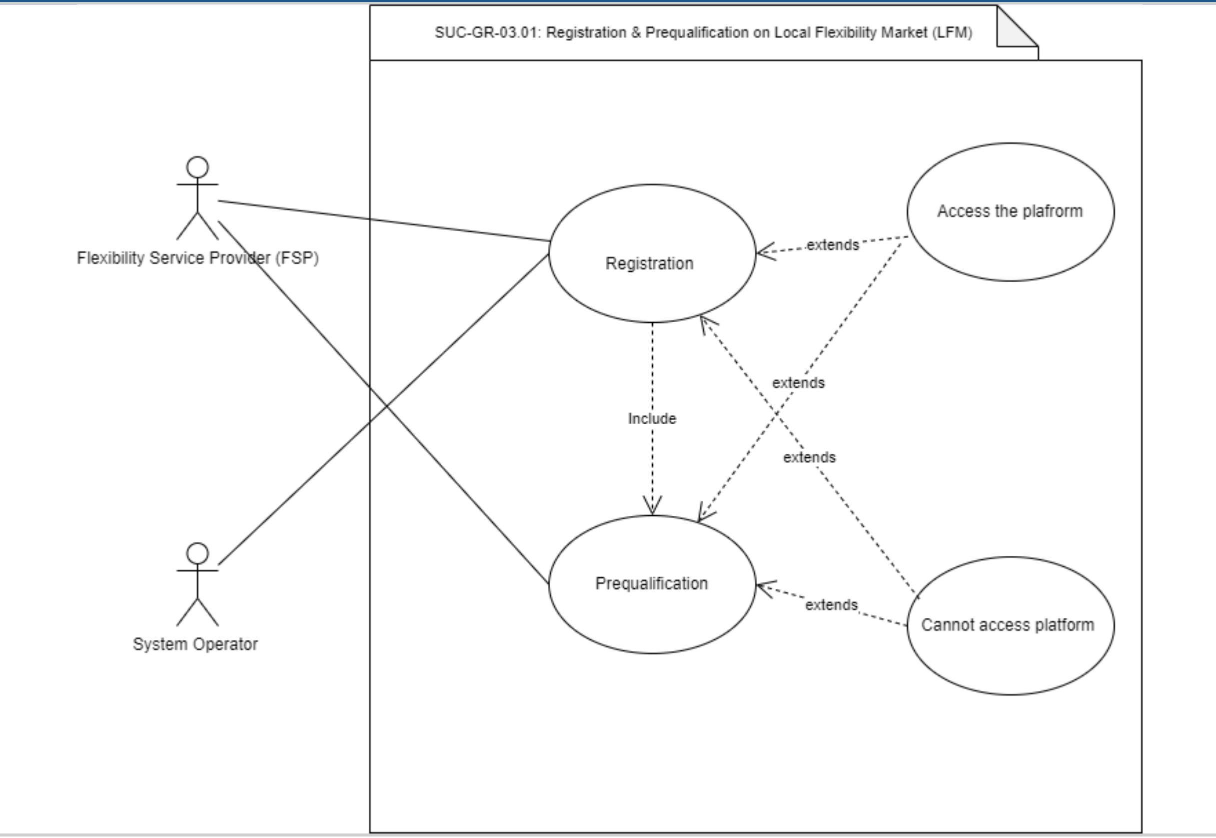
	5. **Effective Communication**: Provide clear and timely communication to users throughout the registration and prequalification process, including confirmation emails, status updates, and notifications of approval or requests for additional information. 6. **Transparent and Continuous Access:** Offer users continuous access to and a clear overview of the registration steps, ensuring they are fully informed of their progress. 7. **Synchronized Communication:** Ensure synchronized communication between the user and the platform, so users are always aware of their current status and any actions required to complete the registration and prequalification process. By achieving these objectives, the LFM Platform can maintain a secure, efficient, and user-centric environment that supports the diverse needs and roles of its users, fostering a productive and collaborative market ecosystem.
UML USE CASE DIAGRAM	



SUC-GR-03.02 FLEXIBILITY TRADING

TABLE 22: SUC-GR-03.02

SUC ID	SUC-GR-03.02

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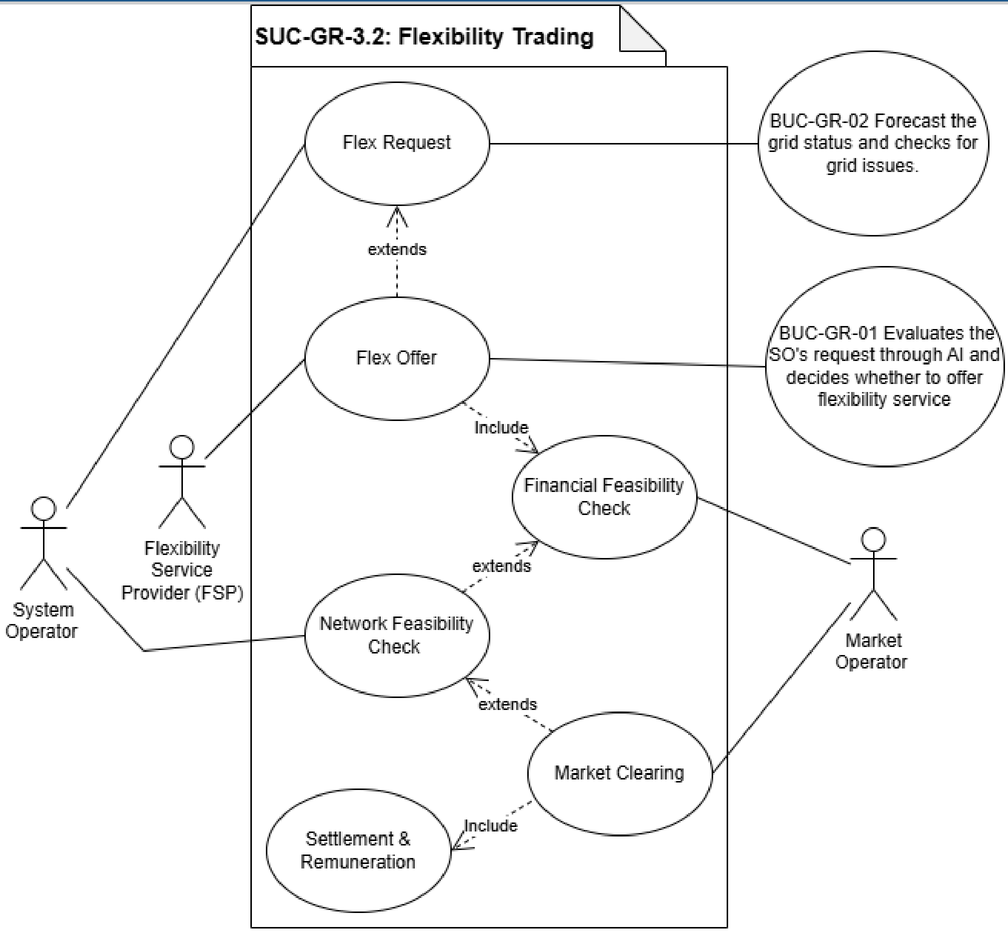
SUC NAME	Flexibility Trading
SCOPE	This use case encompasses the process of trading flexibility services to maintain grid stability and ensure efficient market operations. The primary focus is on the interactions between System Operators (SO), Market Operators (MO), and Flexibility Service Providers (FSP) within the context of a flexibility market. This includes a series of processes such as the submission of flexibility requests and offering assessment of feasibility of trades and market clearing – settlement of results. The above processes are based on information exchange and coordination mechanisms between the FSPs, MO, and SOs.
OBJECTIVES	The main objectives of this use case are: 1. Ensure grid stability and optimize market operations by effectively managing and trading flexibility services. 2. Facilitate seamless interactions between System Operators, Market Operators, and Flexibility Service Providers. 3. Promote real-time data sharing and execute financially and technically viable flexibility offers. 4. Leverage advanced IoT and AI technologies to improve grid performance and provide economic benefits to end-users.

UML USE CASE DIAGRAM



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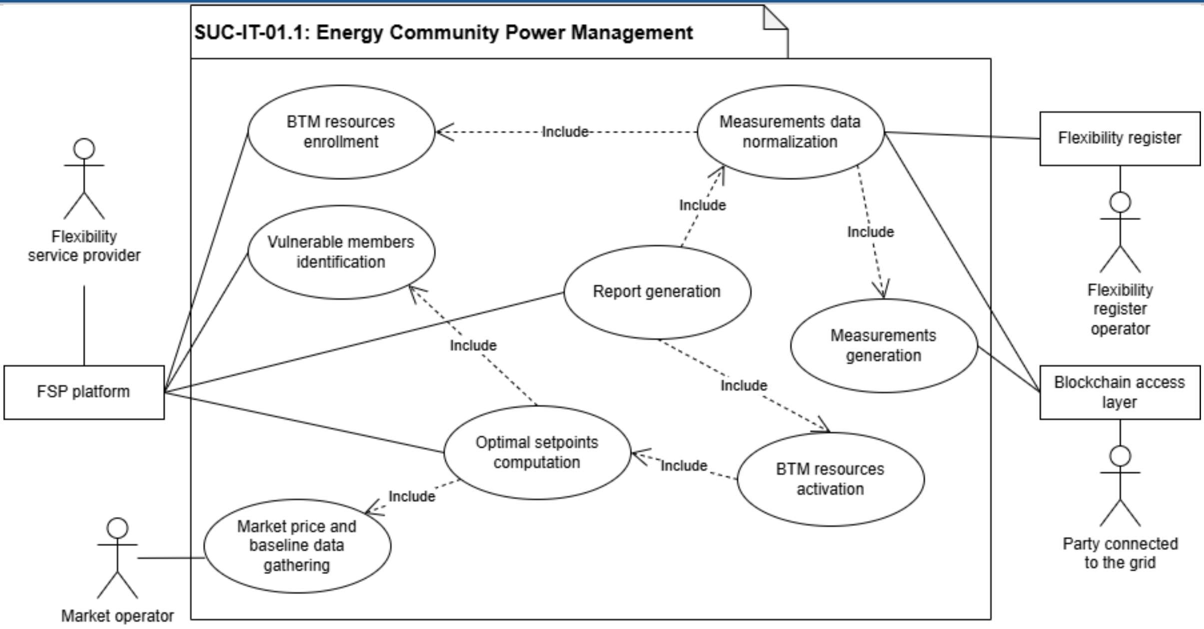
Italian pilot

SUC-IT-01.1 ENERGY COMMUNITY POWER MANAGEMENT

TABLE 23: SUC-IT-01.1

SUC ID	SUC-IT-01.1
SUC NAME	Energy community power management
SCOPE	Optimizing Energy Community's power management through BTM, EMS, Baseline and market data.
OBJECTIVES	1. Provide more accurate power management to energy community administrators 2. Include social and market parameters in power management
UML USE CASE DIAGRAM	



SUC-IT-01.2 ENERGY COMMUNITY PERFORMANCE FORECASTING

TABLE 24: SUC-IT-01.2

SUC ID	SUC-IT-01.2
SUC NAME	Energy community performance forecasting

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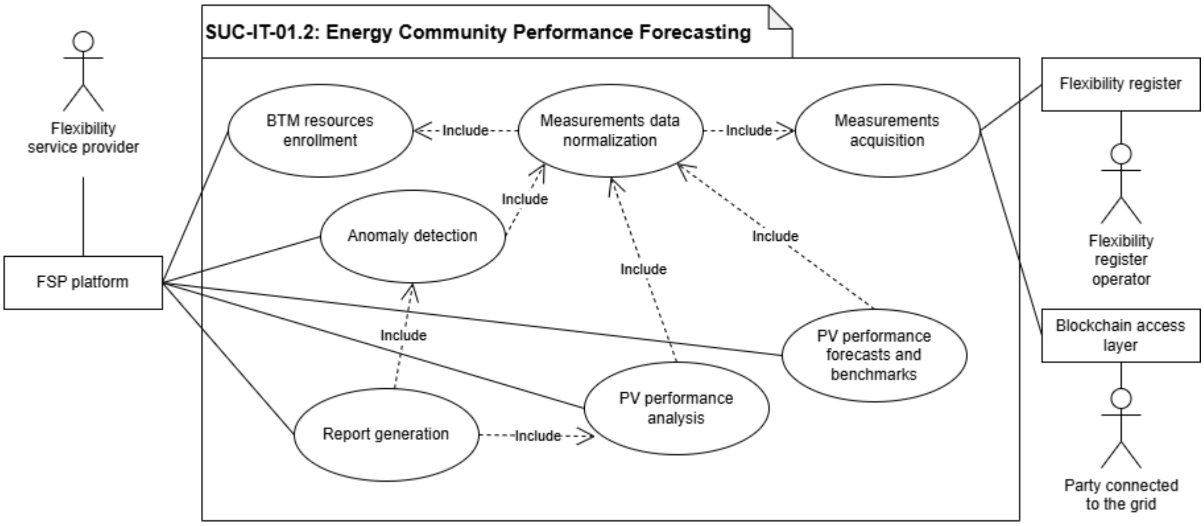
SCOPE	Improving Energy Community performances by performing continuous performance analysis and forecasting of the BTM resources' output
OBJECTIVES	1. Improve EC performance
UML USE CASE DIAGRAM	



SUC-IT-02.1 GRID BEHAVIOUR FORECASTING

TABLE 25: SUC-IT-02.1

SUC ID	SUC-IT-02.1
SUC NAME	Grid behaviour forecasting
SCOPE	Combine readings from DSO, EC and consumers to increase the grid behaviour model's accuracy
OBJECTIVES	1. Enhanced behaviour prediction for both energy production and consumption based on near-real-time data
UML USE CASE DIAGRAM	

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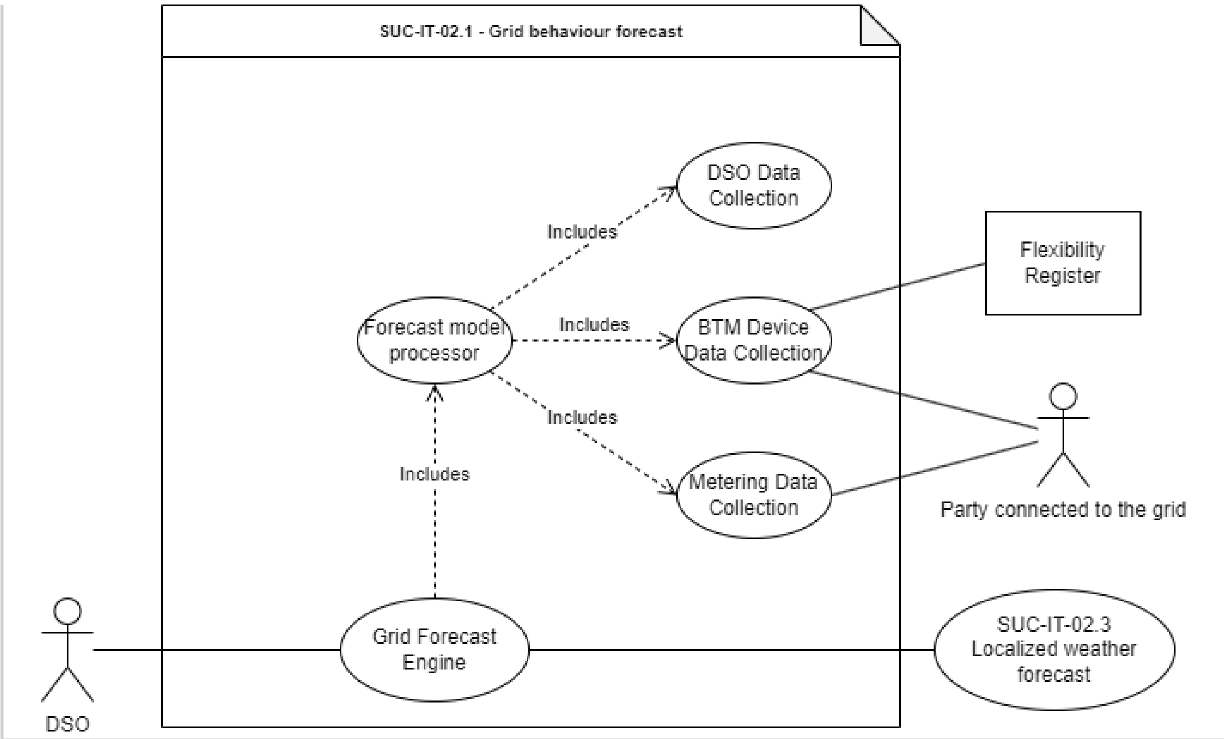

SUC-IT-02.2 GRID CONGESTION COMPUTING

TABLE 26: SUC-IT-02.2

SUC ID	SUC-IT-02.2
SUC NAME	Grid congestion computing
SCOPE	Demonstrate effectiveness and appropriateness to forecast the grid congestion defining the distribution grid component and resources involved.
OBJECTIVES	1. Deferral of grid reinforcement investments (defer or avoid MV feeder or secondary substation replacements). 2. Improve security of supply enabling a demand response mechanism to prevent congestion in the distribution grid.
UML USE CASE DIAGRAM	

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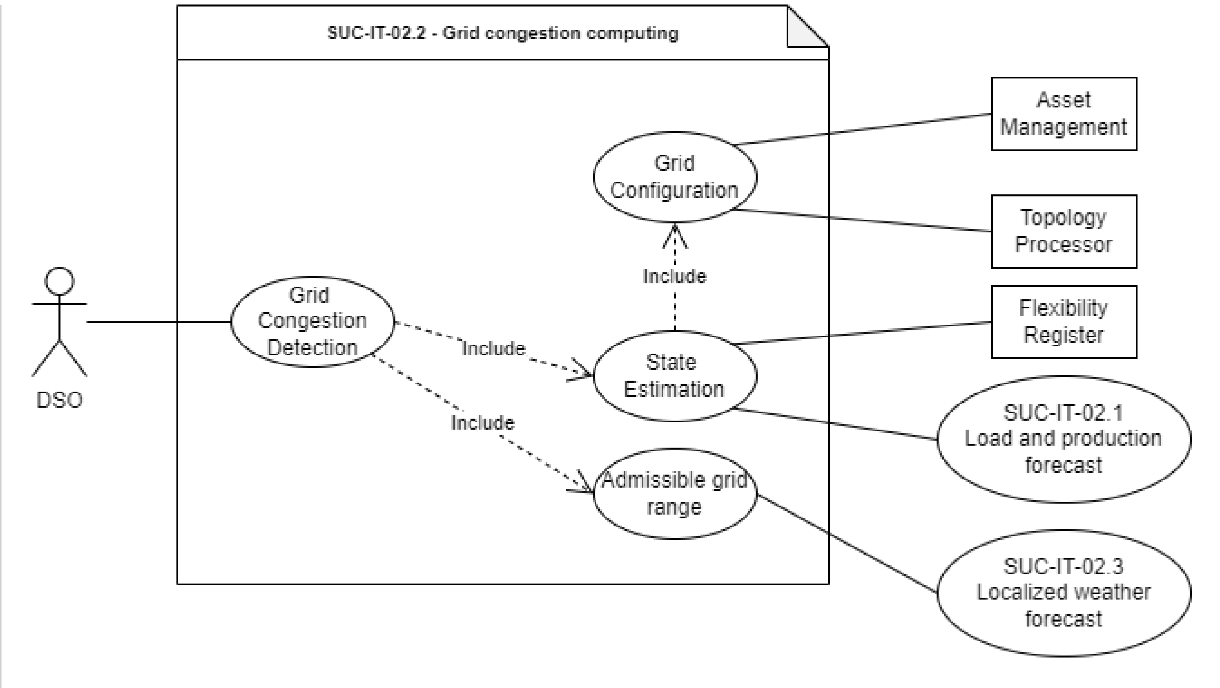

SUC-IT-02.3 LOCALIZED WEATHER FORECAST

TABLE 27: SUC-IT-02.3

SUC ID	SUC-IT-02.3
SUC NAME	Localized weather forecast
SCOPE	City-wide weather forecasts can be combined with local IoT weather station to achieve finer predictions, accurate to the single renewal production plant and/or city block.
OBJECTIVES	1. Enable a better prediction of renewable sources energy production based on localized weather forecasts.
UML USE CASE DIAGRAM	

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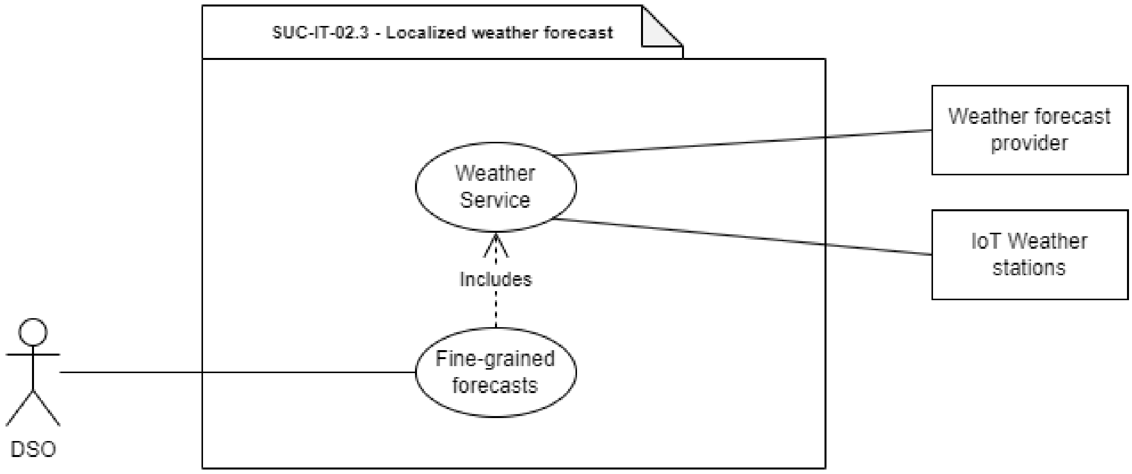

Dutch pilot

SUC-NL-01.1 MONITOR ENERGY NODES AND LOCAL GRID & DASHBOARD FOR DATA INSIGHTS

TABLE 28: SUC-NL-01.1

SUC ID	SUC-NL-01.1
SUC NAME	Monitor energy nodes and local grid & dashboard for data insights [Monitoring & Dashboards]
SCOPE	Grid monitoring and HMI
OBJECTIVES	1. Real-Time Data Collection: Capture and aggregate data from diverse energy nodes in (near) real-time. 2. Actionable Insights: Develop dashboards that provide clear insights and improve explainability of energy consumption and technical functions.
UML USE CASE DIAGRAM	

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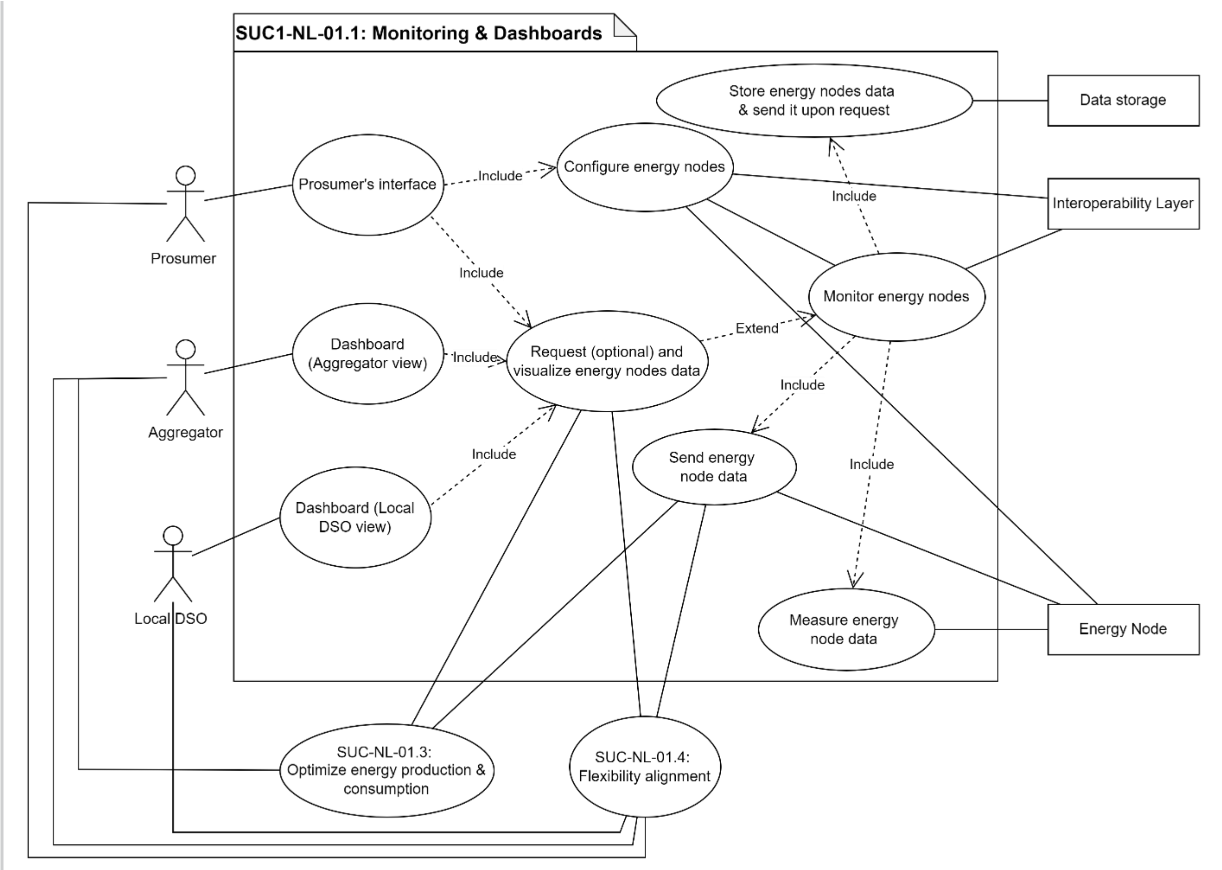

SUC-NL-01.2 INTEGRATE ENERGY NODES AND EMS/BMS VIA SEMANTICS FOR CONTROL AND EXPLAINABILITY

TABLE 29: SUC-NL-01.2

SUC ID	SUC-NL-01.2
SUC NAME	Integrate energy nodes and EMS/BMS via semantics for control and explainability [Semantic integration energy nodes]
SCOPE	Implement semantic interoperability to integrate energy nodes at the Electricity Campus Arnhems Buiten.
OBJECTIVES	1. Detection of (new) energy nodes 2. Creating semantic adapters 3. Explainability via semantics
UML USE CASE DIAGRAM	

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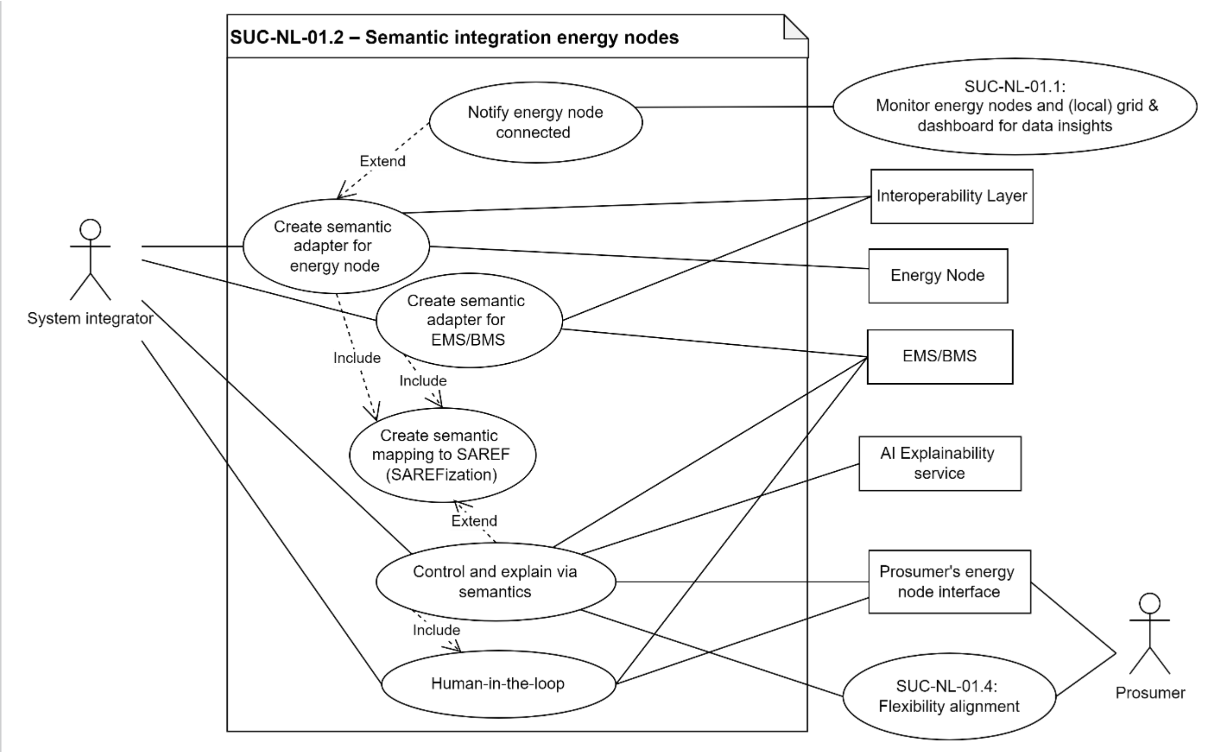

SUC-NL-01.3 OPTIMIZE ENERGY PRODUCTION & CONSUMPTION

TABLE 30: SUC-NL-01.3

SUC ID	SUC-NL-01.3
SUC NAME	Optimize energy production & consumption
SCOPE	Implement an energy optimization module of the production and consumption at the Electricity Campus Arnhems Buiten
OBJECTIVES	1. Enhance grid stability: Optimize energy production and consumption to maintain a balanced grid and prevent power outages or voltage fluctuations. 2. Reduce energy costs: Minimize energy losses and optimize resource allocation to reduce overall energy costs for both consumers and grid operators. 3. Promote sustainable energy practices: Encourage the adoption of renewable energy sources and optimize their integration into the grid to reduce carbon emissions and promote environmental sustainability.
UML USE CASE DIAGRAM	

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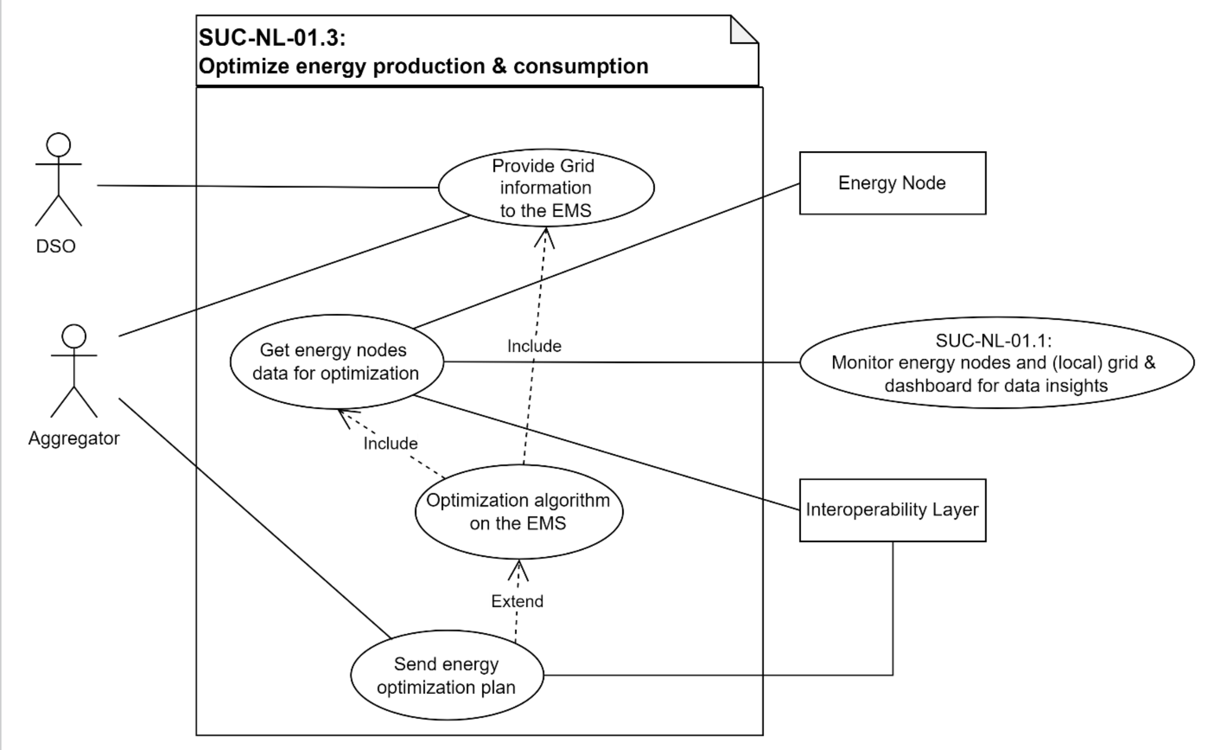

SUC-NL-01.4 FLEXIBILITY ALIGNMENT

TABLE 31: SUC-NL-01.4

SUC ID	SUC-NL-01.4
SUC NAME	Flexibility alignment
SCOPE	Implement a flexibility alignment system at the Electricity Campus Arnhems Buiten, enabling prosumers and aggregators to exchange and execute energy optimization plans, utilizing smart grid technologies to optimize energy use and demonstrate flexibility benefits.
OBJECTIVES	1. Implement a functional flexibility exchange system 2. Optimize energy use and reduce costs 3. Mitigate grid congestion
UML USE CASE DIAGRAM	

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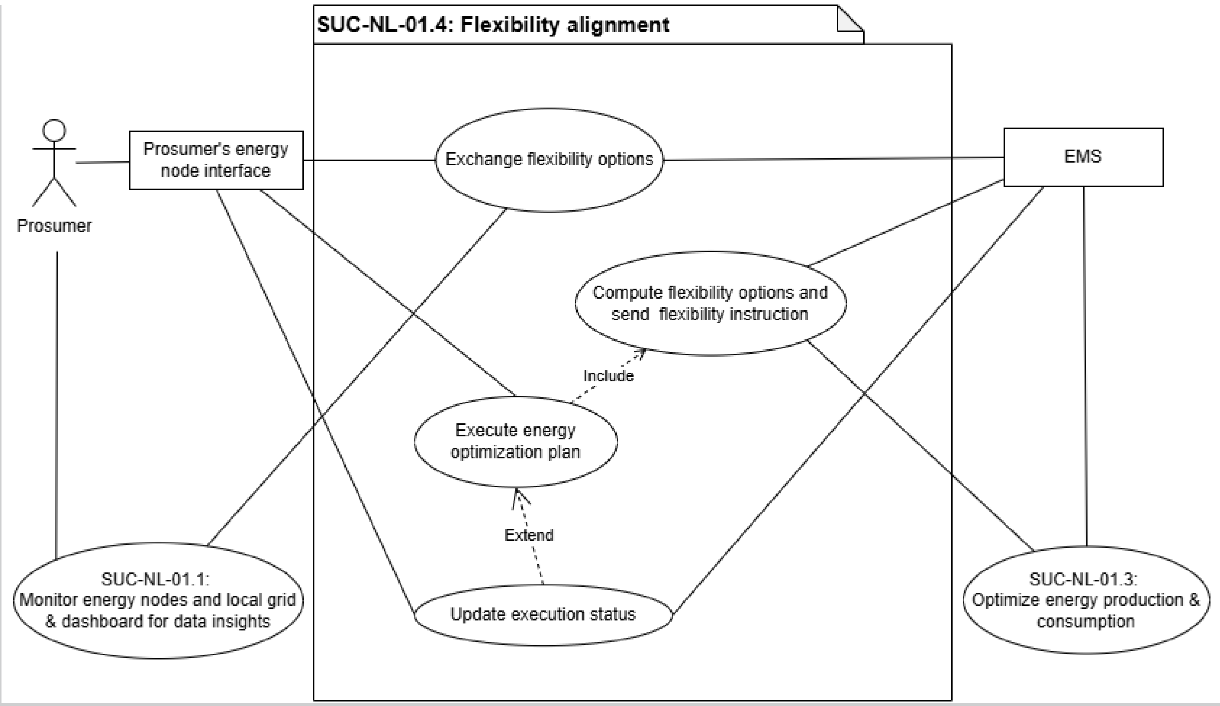

SUC-NL-02.1 ANOMALY AND FAULT DETECTION IN THE (LOCAL) GRID

TABLE 32: SUC-NL-02.1

SUC ID	SUC-NL-02.1
SUC NAME	Anomaly and fault detection in the local grid
SCOPE	Implement a system to detect anomalies and faults in the local grid at the Electricity Campus Arnhems Buiten and inform stakeholders about these anomalies such that they can be resolved thereby improving the resilience of the local grid.
OBJECTIVES	1. Implement a system for detecting anomalies 2. Assess the severity and potential impact of anomalies and faults. 3. Update the status of anomalies and faults. 4. Resolve anomalies and faults.
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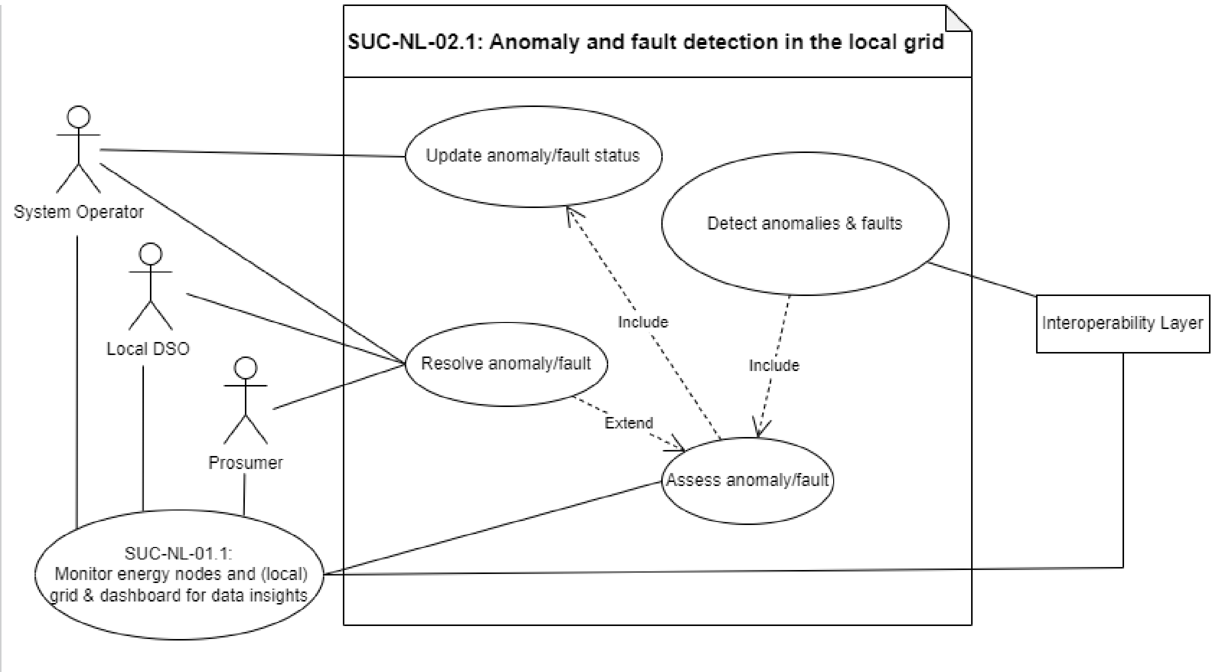

SUC-NL-02.2 PREDICTIVE MAINTENANCE

TABLE 33: SUC-NL-02.2

SUC ID	SUC-NL-02.2
SUC NAME	Predictive maintenance
SCOPE	This use case describes the process of utilizing predictive maintenance techniques to identify potential faults or failures in the grid infrastructure, enabling proactive maintenance actions to be taken.
OBJECTIVES	1. Predict Maintenance needs for the end user and local DSO 2. Inform local DSO and/or service provider to coordinate maintenance activities
UML USE CASE DIAGRAM	

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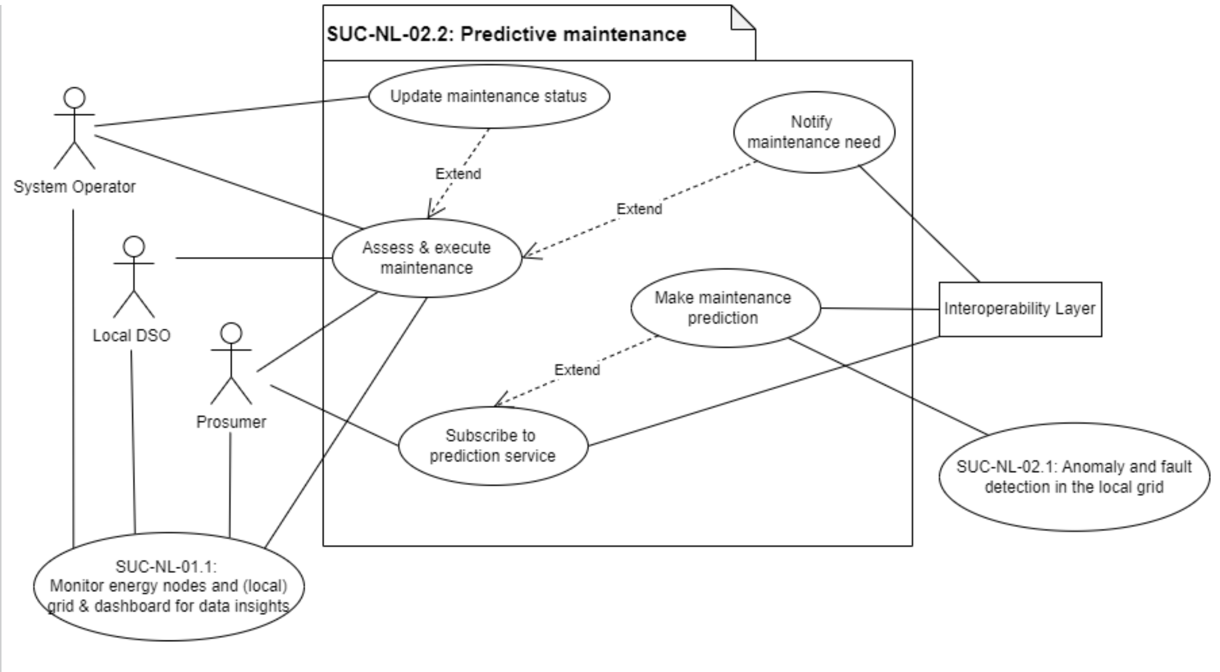

Portuguese pilot

SUC-PT-01.1 CONNECT FLEXIBILITY PROVIDERS ACROSS THE DPP FLEXIBILITY VALUE CHAIN

TABLE 34: SUC-PT-01.1

SUC ID	SUC-PT-01.1
SUC NAME	Connect flexibility providers across the DPP flexibility value chain
SCOPE	Exploitation of the energy flexibility of citizen's energy communities. Advances towards the creation of energy and non-energy services.
OBJECTIVES	Link consumers with suppliers/installers/O&M service providers of flexible DER to participate in the value chain and exploit flexibility business models.
UML USE CASE DIAGRAM	

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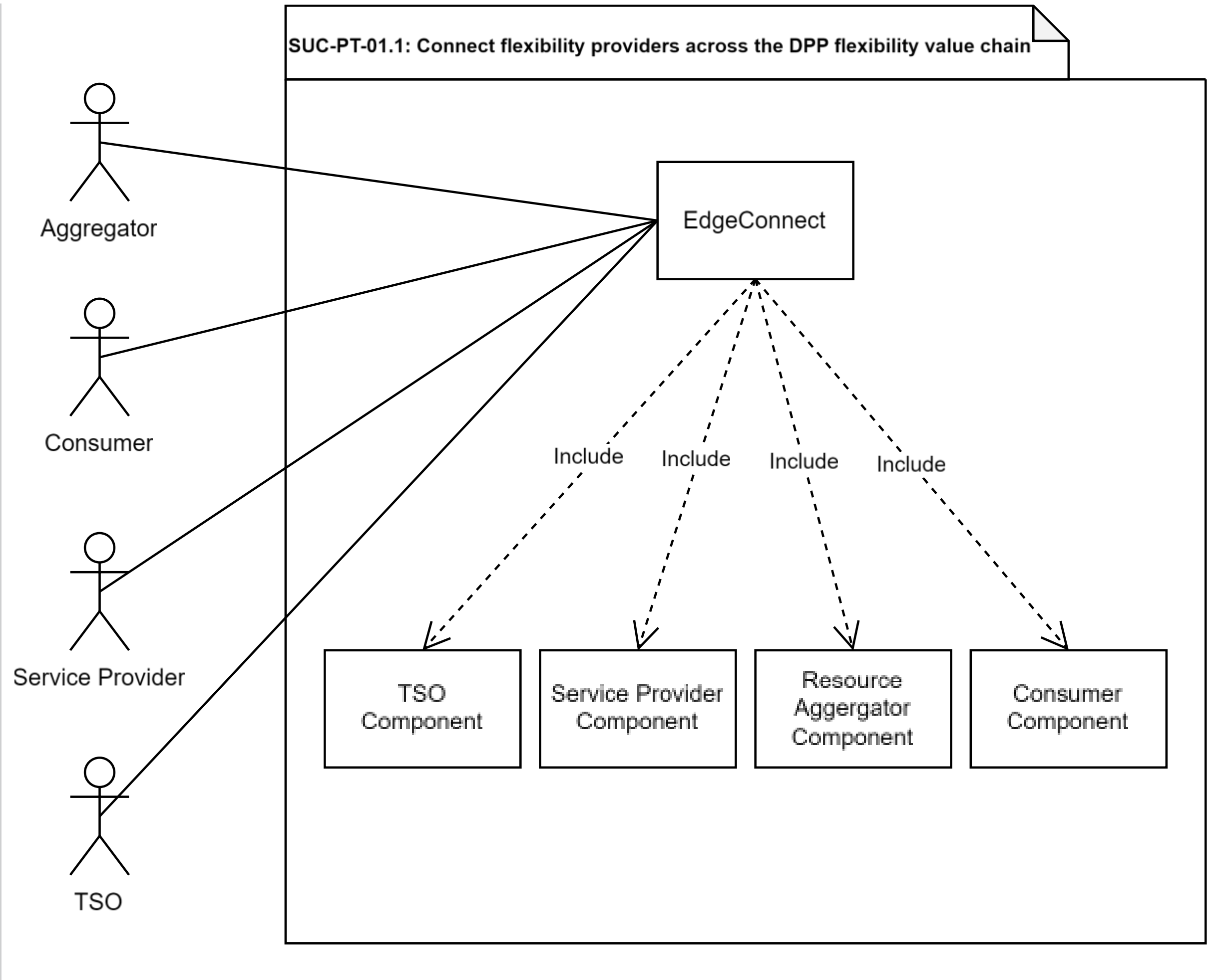

SUC-PT-01.2 ENABLE DATA EXCHANGE VIA DATA SPACES

TABLE 35: SUC-PT-01.2

SUC ID	SUC - PT-01.2
SUC NAME	Enable Data Exchange via Data Spaces
SCOPE	Exploitation of energy flexibility in energy communities enabled in an interoperable way. Need for a clear and unambiguous communication and data models between all the actors involved in the energy flexibility market.
OBJECTIVES	The system use case unfolds the following objectives: 1. All systems adhere to exchange set-up and operational data with data sovereignty and trust. 2. Identify and publish the data assets' descriptions as data producers. 3. Model data assets to interoperable standards. 4. Establish data usage contracts, and scoping permissions to consume data as data consumers. 5. Exchange the required data assets

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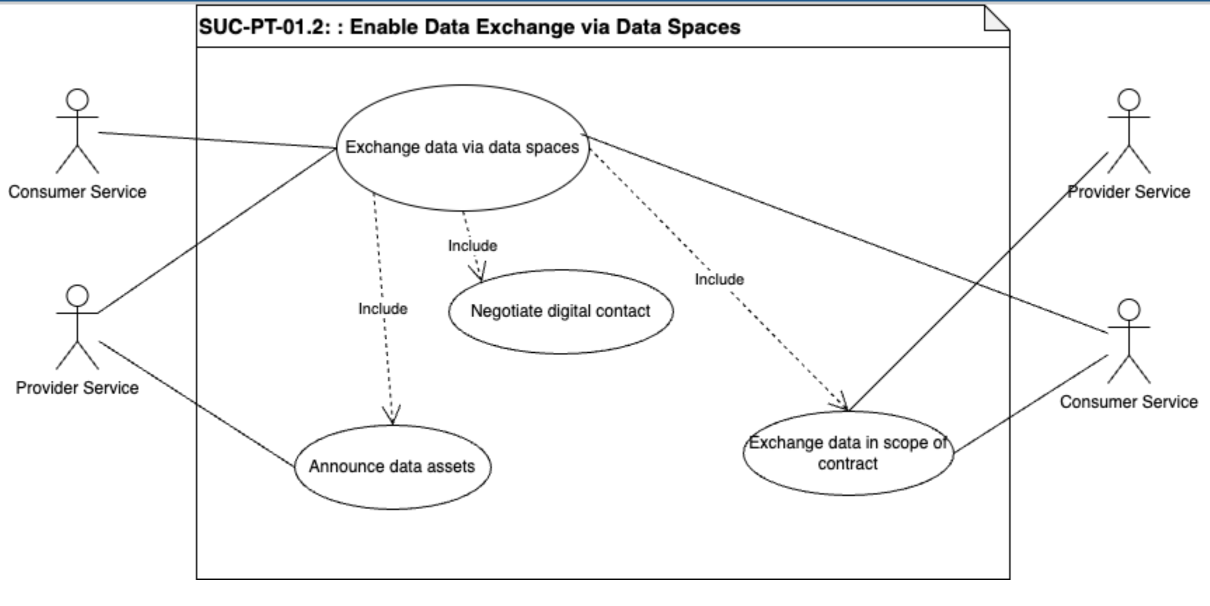

SUC-PT-01.3 MOBILIZING ENERGY FLEXIBILITY

TABLE 36: SUC-PT-01.3

SUC ID	SUC - PT-01.3
SUC NAME	Mobilizing Energy Flexibility
SCOPE	The mobilization of energy flexibility is a fundamental step carried out by service providers to explore their participation in energy markets. The purpose of the use-case is to implement strategies to allow the different residential and non-residential participants to elect the assets that will be made available to take part on energy flexibility services within the energy community. The context surrounding this use case encompasses the need to exploit the energy flexibility of citizen energy communities toward the creation of energy and non-energy services.
OBJECTIVES	This system use case will fulfil the following objectives: 1. Enable the participation of consumers in flexibility services. 2. Determine the types of energy assets that can take part in flexibility services (i.e., heating water storage, electric vehicles, induction hobs, electric ovens, well pumps, HVAC). 3. Set the minimum connectivity and controllability requirements of each device and system participating in flexibility operation. 4. Define the connectivity needs with the digital platform provider. 5. Establish the access to incentives to participate in the flexibility services. 6. Register the participation of flexibility assets in an energy management system.

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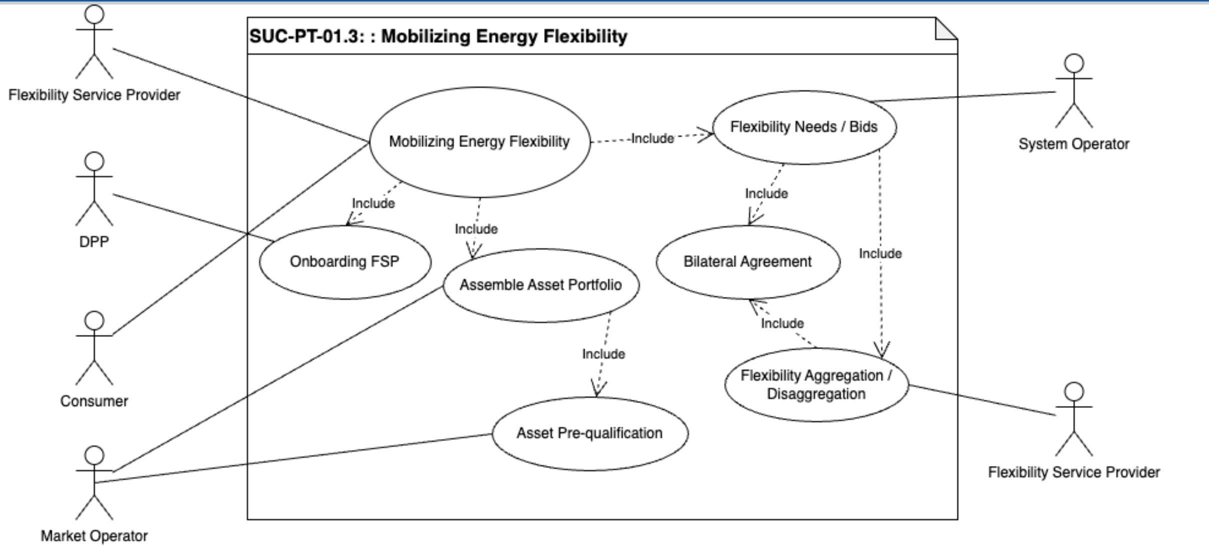

SUC-PT-01.4 ACTIVATION OF ENERGY FLEXIBILITY

TABLE 37: SUC-PT-01.4

SUC ID	SUC - PT-01.4
SUC NAME	Activation of Energy Flexibility
SCOPE	Exploitation of the energy flexibility of citizen's energy communities. Advances towards the creation of energy and non-energy services focusing on the activation part of the process.
OBJECTIVES	The system use case unfolds the following objectives: 1. Market platform or system clears the winning bids according to those that have been issued in scope of SUC-PT-01.3. 2. Cleared flexibilities bids are communicated to the System Operator through the EdgeConnect platform, which selected the bids to be activate. 3. The EdgeConnect platform forwards the selected bids for activation to the aggregators/FSP that have issued them (including aggregators that run hold a bilateral agreement with another aggregator. 4. The Aggregators in case of having any bilateral agreements with other aggregators or FSPs communicate/validate they were notified to mobilize their contracted loads.
UML USE CASE DIAGRAM	

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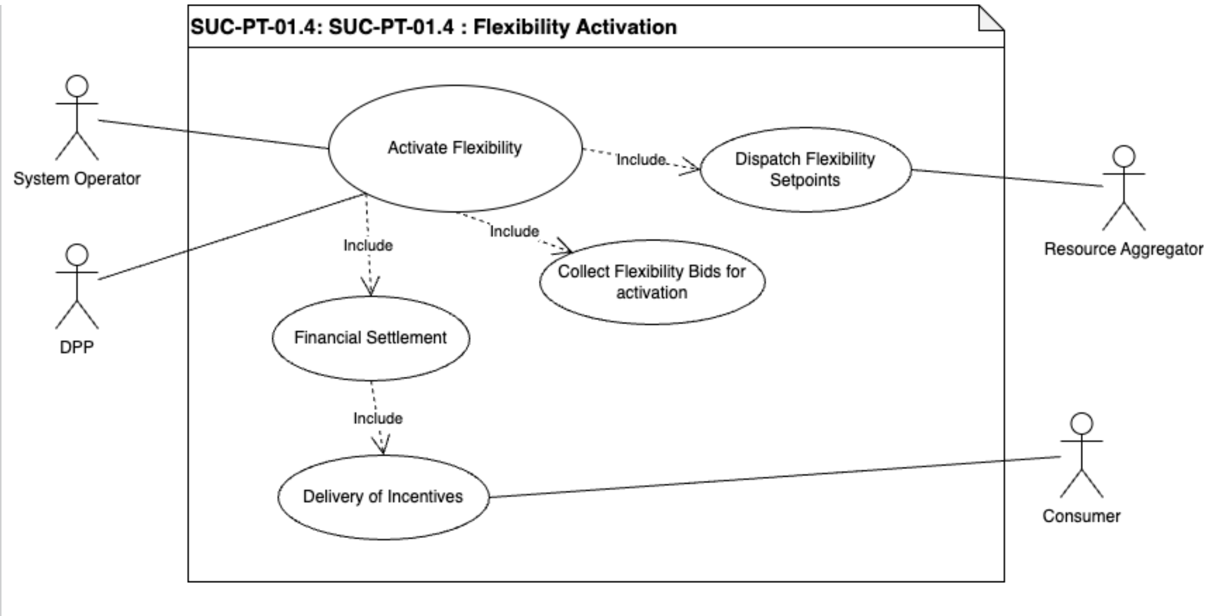

SUC-PT-02.1 BIDDING & SELECTION

TABLE 38: SUC-PT-02.1

SUC ID	SUC-PT-02.1
SUC NAME	Bidding & Selection
SCOPE	The scope of this use case encompasses the processes involved in soliciting bids from reserve capacity providers and selecting the most appropriate bid to maintain network stability and frequency regulation. This includes the initiation of the bidding process, the submission of bids by the reserve capacity providers, the review of the bids and the selection by the system operator.
OBJECTIVES	1. Streamline the process of soliciting flexibility offers and selecting the most suitable bids to ensure efficient procurement of flexibility services. 2. Select bids that offer the best combination of capacity, response time, and pricing to effectively address grid stability and frequency regulation requirements. 3. Ensure compliance with established market rules and regulations governing the bidding and selection process to maintain market integrity and fairness.
UML USE CASE DIAGRAM	

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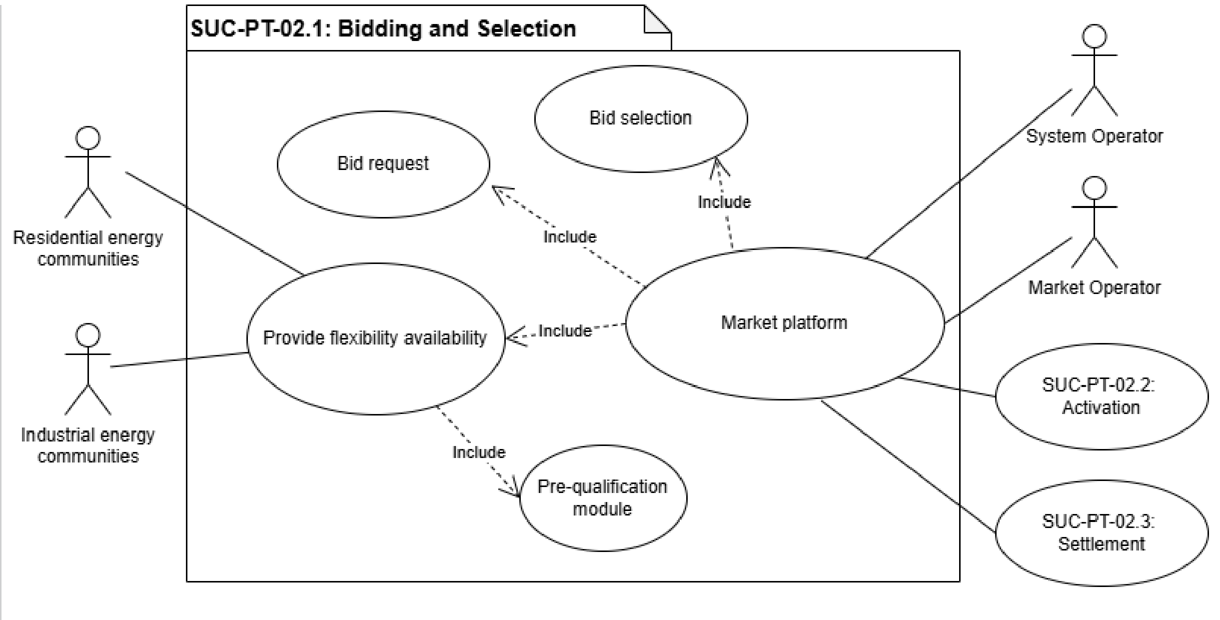

SUC-PT-02.2 AFRR/MFRR ACTIVATION

TABLE 39: SUC-PT-02.2

SUC ID	SUC-PT-02.2
SUC NAME	aFRR/mFRR Activation
SCOPE	The scope of this system use case involves the activation of the automatic Frequency Restoration Reserves (aFRR) and manual Frequency Restoration Reserves (mFRR) services provided by industrial and residential energy communities (ECs).
OBJECTIVES	1. Identify, at the systems' functionality level, what is necessary to activate aFRR and mFRR. 2. Develop a coordinated mechanism among the actors for the issuing of activation signals. 3. Communicate and confirm reception of activation signals to the corresponding actors.
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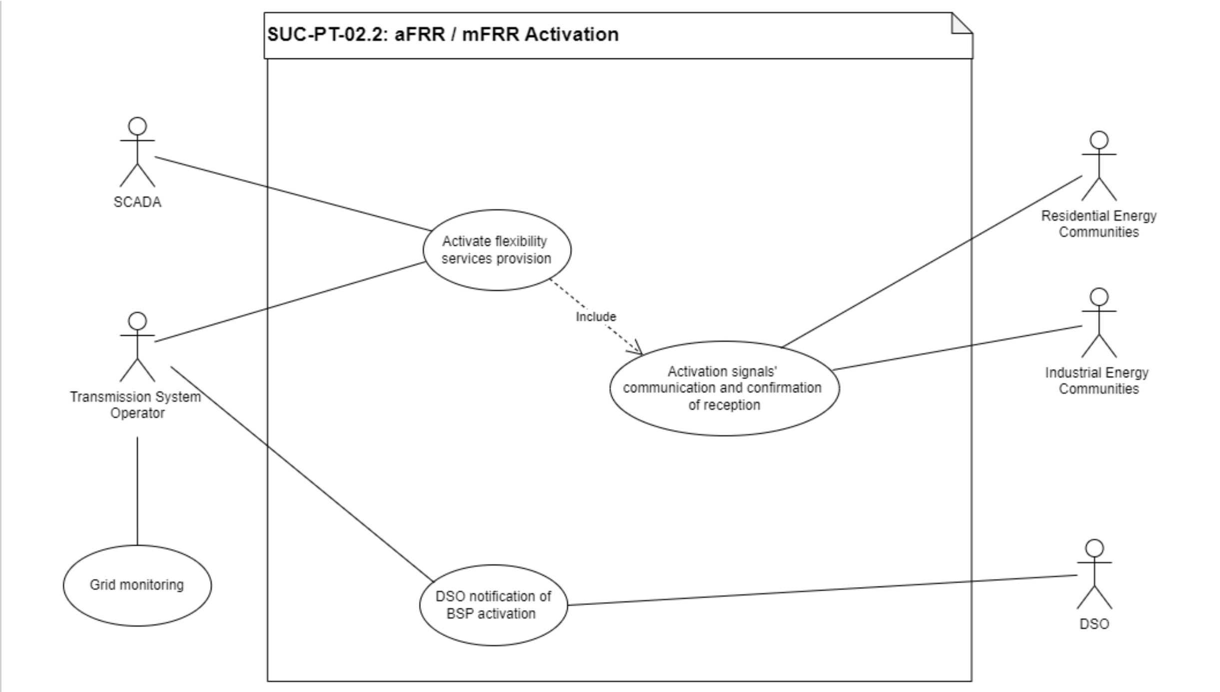

SUC-PT-02.3 AFRR / MFRR SETTLEMENT

TABLE 40: SUC-PT-02.3

SUC ID	SUC-PT-02.3
SUC NAME	aFRR / mFRR Settlement
SCOPE	Verification and Settlement of the automatic frequency restoration reserve (aFRR)/ manual frequency restoration reserve (mFRR) flexibilities actually delivered by Balancing Service Providers (BSPs)
OBJECTIVES	1. Calculate actually delivered flexibility as response to activation requests. 2. Verify that delivered flexibility matches the flexibility requested. 3. Calculate the payments and penalty if the delivered flexibility is less than the requested flexibility
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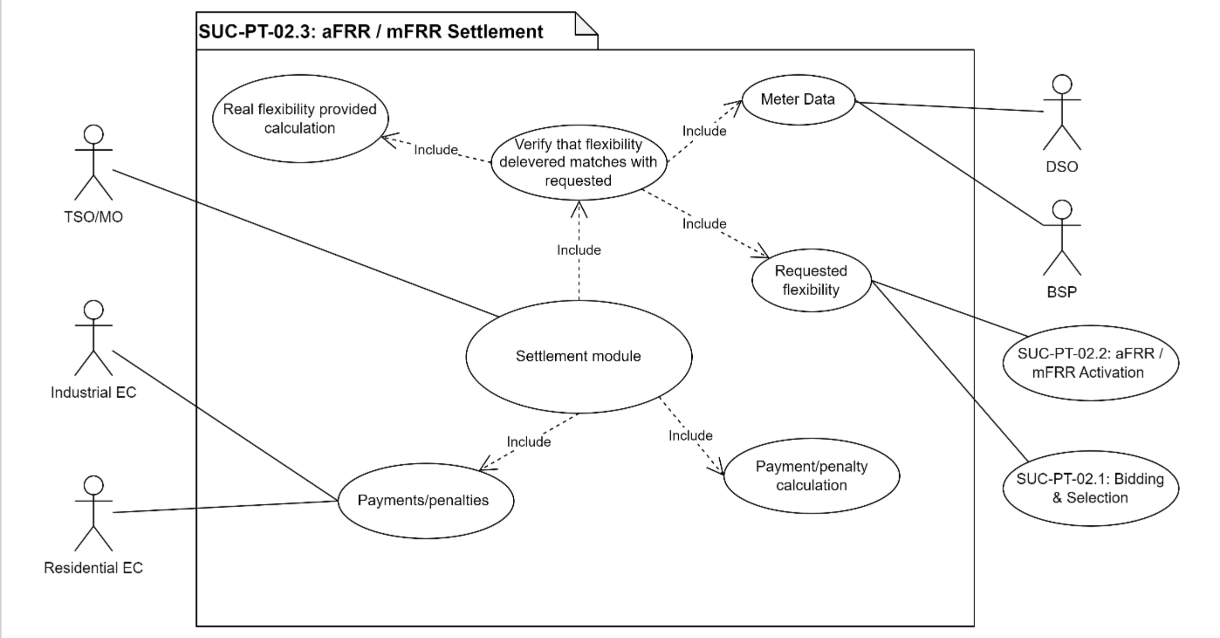

SUC-PT-03.1 INTEGRATE FLEXIBLE ASSETS FROM COMMERCIAL BUILDINGS

TABLE 41: SUC-PT-03.1

SUC ID	SUC-PT-03.1
SUC NAME	Integrate flexible assets from commercial buildings
SCOPE	Flexibility aggregation for commercial applications
OBJECTIVES	1. Integrate selected Reserve Resources in the energybox 2. Control selected Reserve Resources through the energybox 3. Enrolment of Reserve Resources within the Platform Provider
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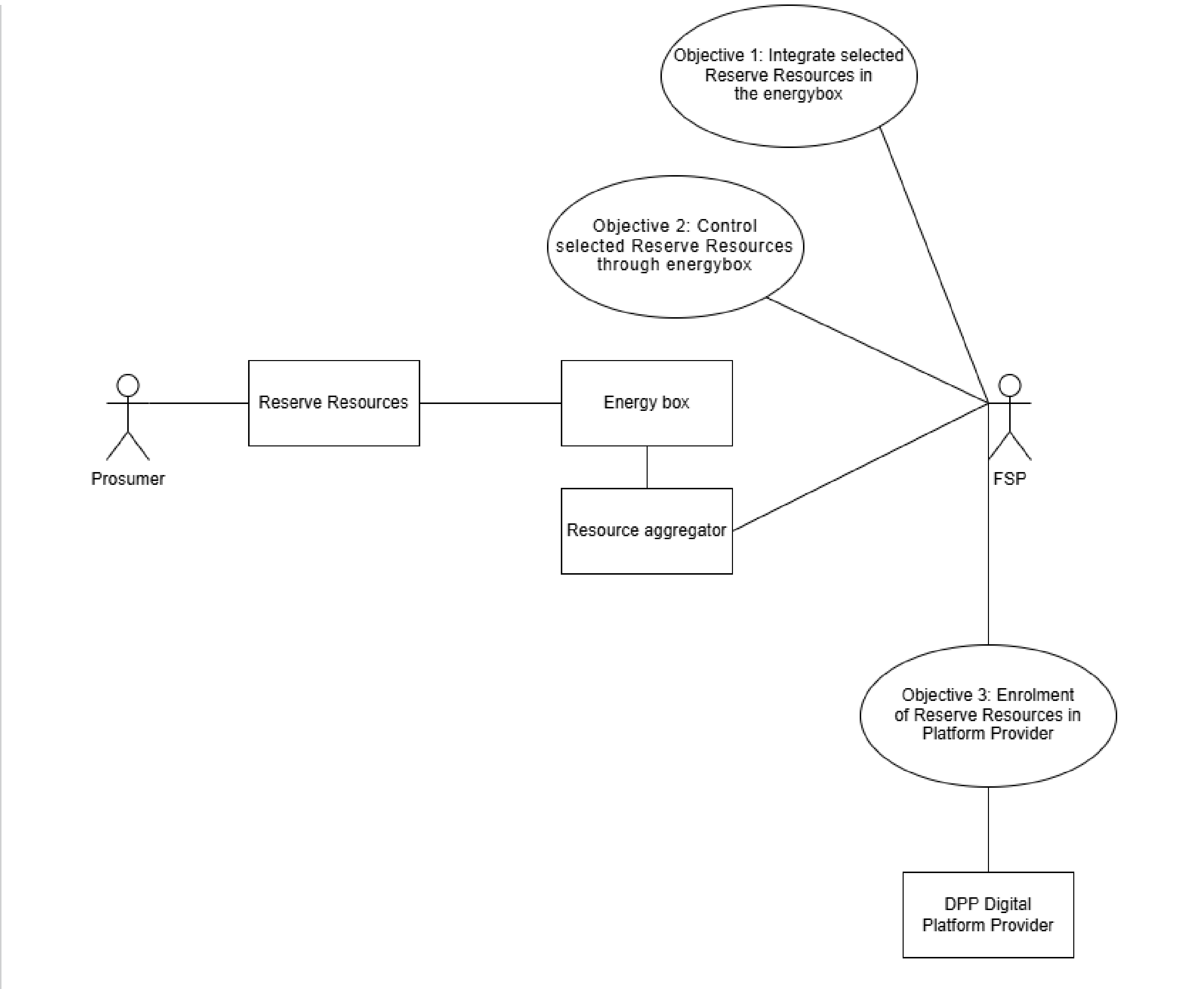

SUC-PT-03.2 DEFAULT VALORIZATION SCENARIO BASED ON PRICE HEDGING

TABLE 42: SUC-PT-03.2

SUC ID	SUC-PT-03.2
SUC NAME	Default valorisation scenario based on price hedging
SCOPE	Flexibility aggregation for commercial applications
OBJECTIVES	1. Optimize default scenario based on cost savings through forecast tools 2. Upload schedule, based on default scenarios, for each reserve resources
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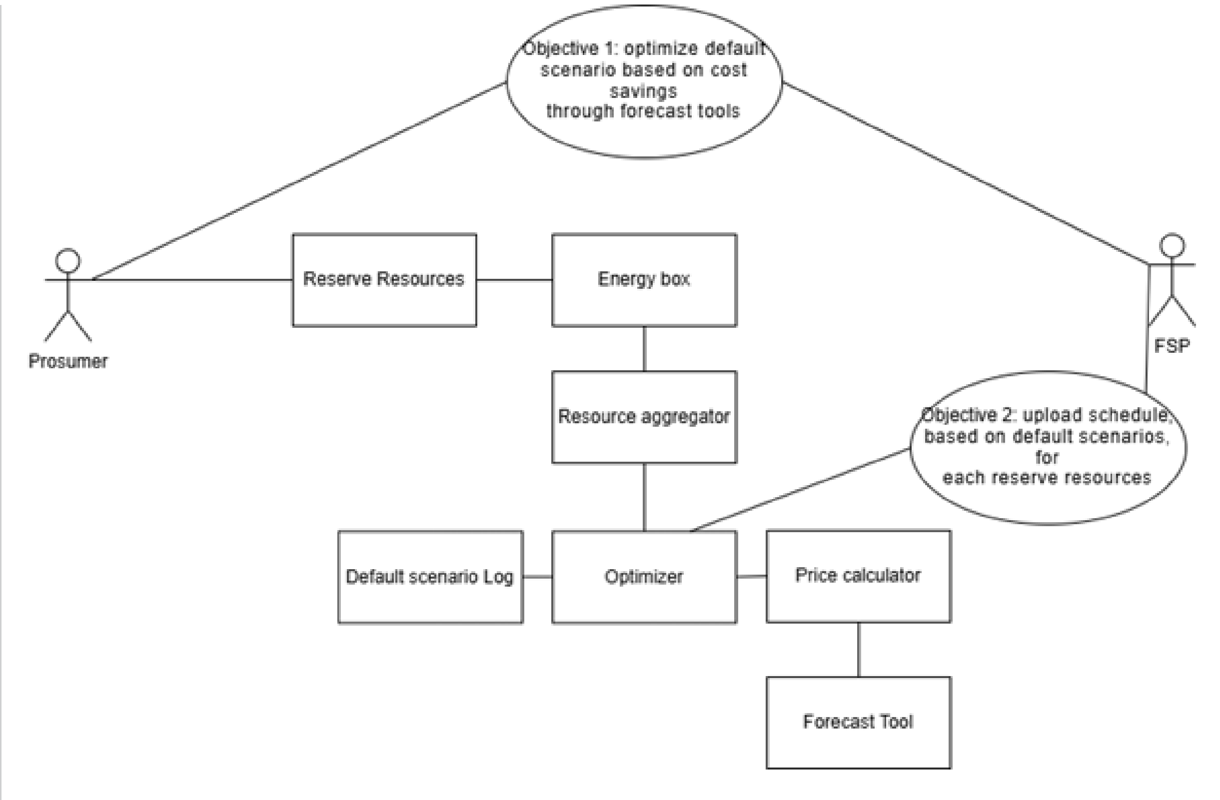

SUC-PT-03.3 TSO VALORIZATION SCENARIO

TABLE 43: SUC-PT-03.3

SUC ID	SUC-PT-03.3
SUC NAME	TSO valorisation scenario
SCOPE	Flexibility aggregation for commercial applications
OBJECTIVES	1. Compare default and market-based scenarios 2. Creation and submission of bids to the flexibility market 3. Upload schedule, based on TSO request, for each reserve resources
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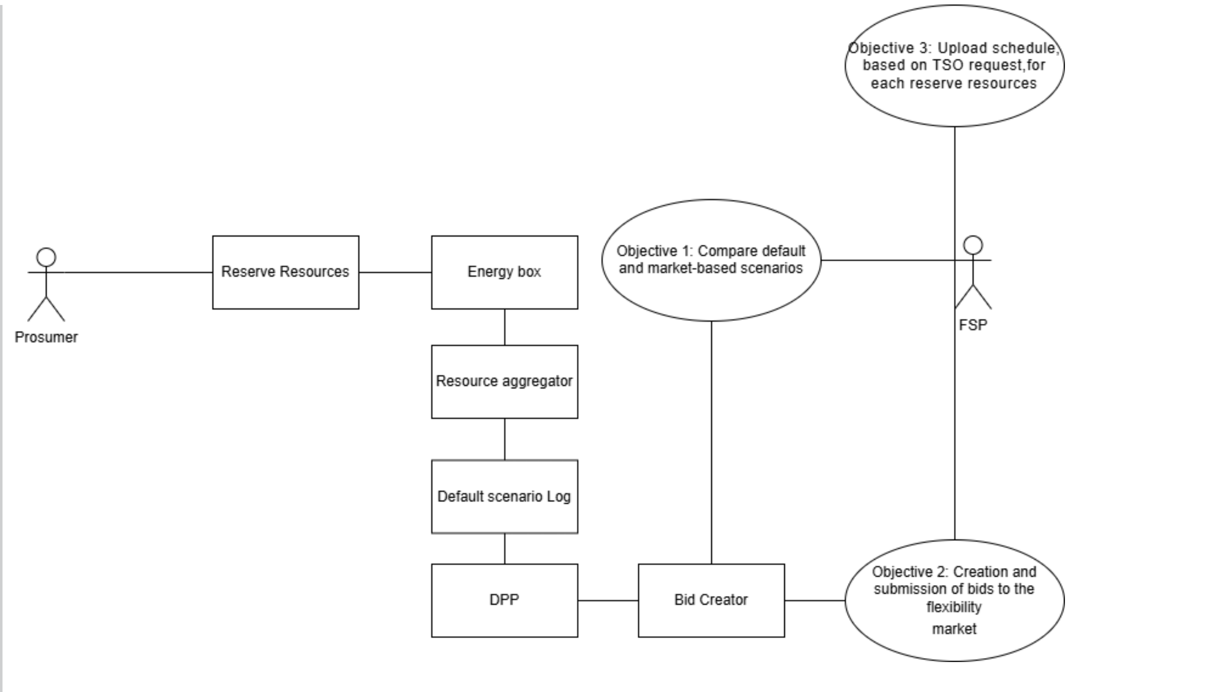

Slovenian pilot

SUC-SL-01.1 DYNAMIC THERMAL RATING EDGE CALCULATION

TABLE 44: SUC-SI-01.1

SUC ID	SUC-SL-01.1
SUC NAME	Dynamic Thermal Rating edge calculation
SCOPE	The scope of this SUC is the edge calculation of Dynamic thermal rating that is taking place on IoT devices located on secondary transformer substations
OBJECTIVES	1. Perform the edge DTR calculation. Calculation will occur on edge IoT devices located on secondary transformers substations in DSO grid. The DTR calculation is adapted for edge calculation with all the necessary input parameters and additional sensors for the validation of DTR
UML USE CASE DIAGRAM	

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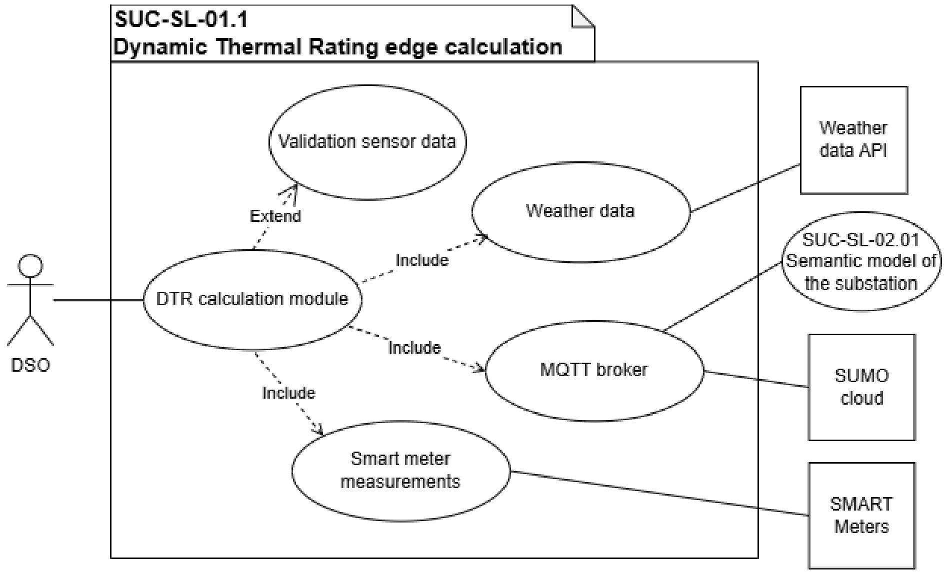

SUC-SL-01.2 DYNAMIC LINE RATING CALCULATION

TABLE 45: SUC-SL-01.2

SUC ID	SUC-SL-01.2
SUC NAME	Dynamic Line Rating calculation
SCOPE	Calculation of the Dynamic Line Rating on a transformer substation and power line
OBJECTIVES	1. Evaluate the SUMO cloud-edge solution's integration with security measures and to determine its suitability for use in a transmission network
UML USE CASE DIAGRAM	

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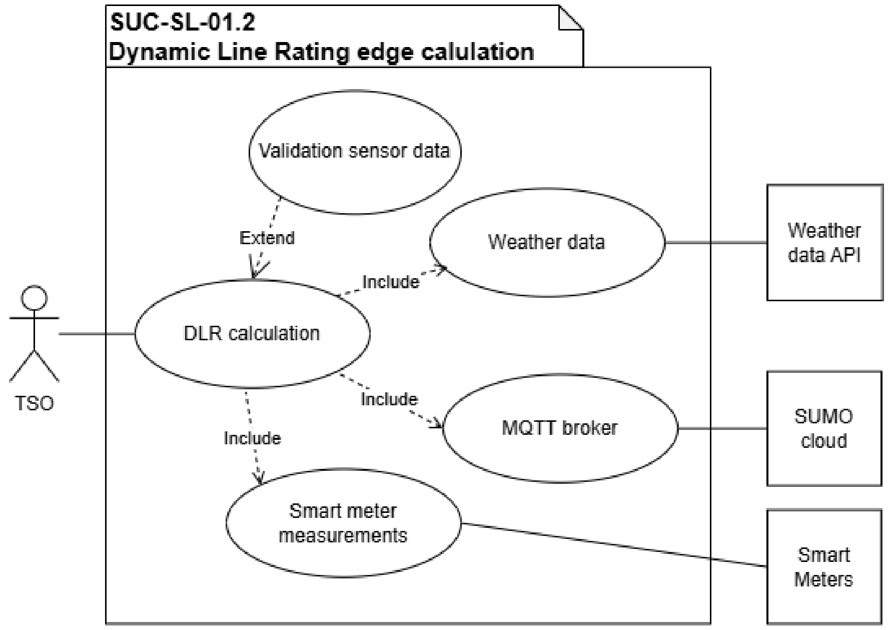

SUC-SL-02.1 SEMANTIC MODEL OF THE SUBSTATION

TABLE 46: SUC-SL-02.1

SUC ID	SUC-SL-02.1
SUC NAME	Semantic model of the substation
SCOPE	Definition of a semantically unified model for power grid stakeholders.
OBJECTIVES	1. Collecting and merging models from separate systems. 2. Providing a standardized model to different system stakeholders.
UML USE CASE DIAGRAM	

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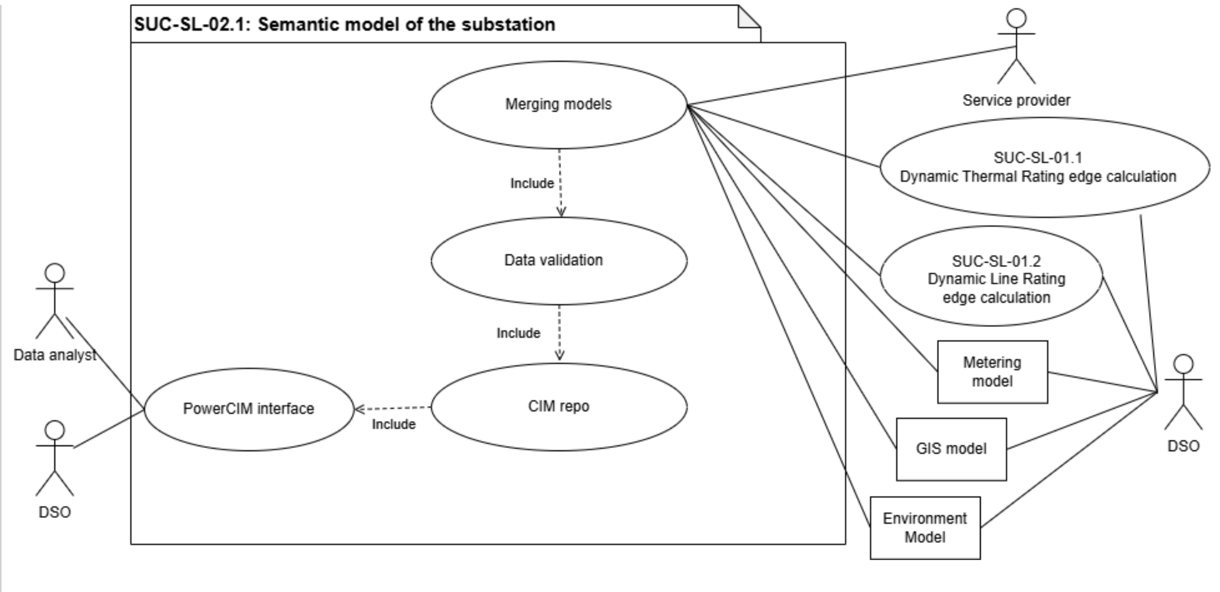

SUC-SL-02.2 ML ALGORITHM FOR ENHANCED NETWORK MANAGEMENT AND PLANNING

TABLE 47: SUC-SL-02.2

SUC ID	SUC-SL-02.2
SUC NAME	ML algorithm for enhanced network management and planning
SCOPE	Helping DSOs to enhance planning and operation of smart distribution networks by relying on IoT devices and advanced ML algorithms.
OBJECTIVES	1. Data analysis, detection of errors in measurements and development of methods for errors removing 2. Identification of DERs in secondary distribution networks 3. Forecast of technical parameters measured at secondary substations
UML USE CASE DIAGRAM	

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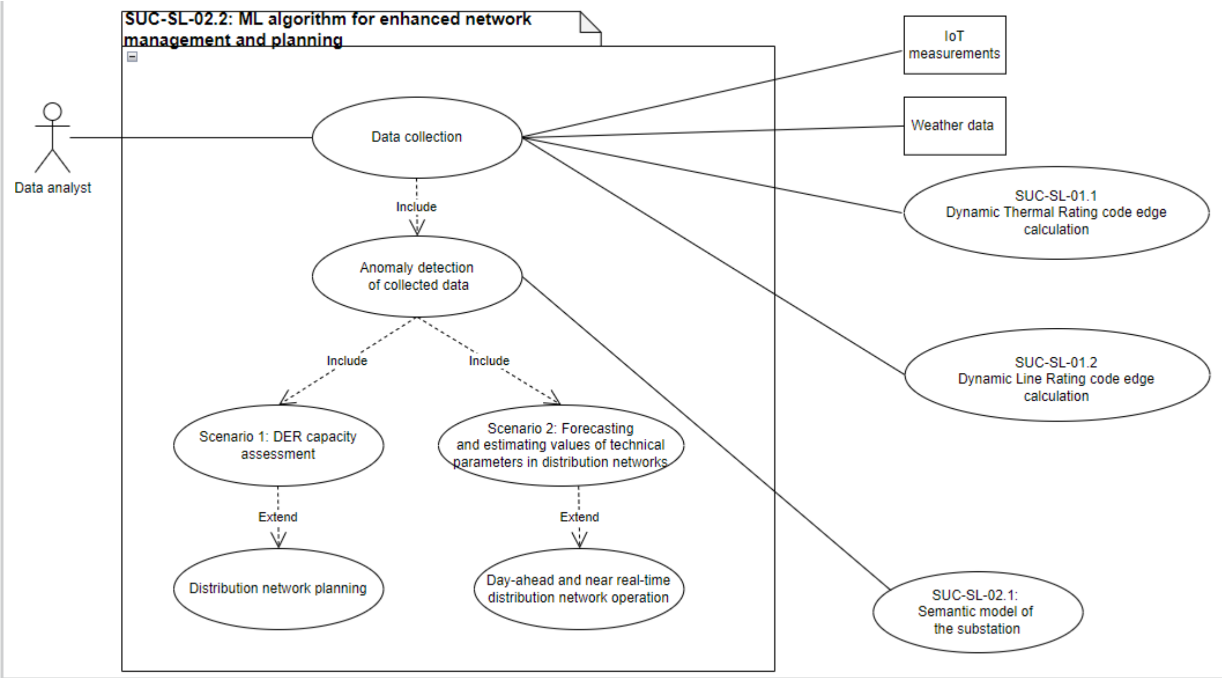

2.4. HEDGE-IOT FUNCTIONAL REQUIREMENTS

This section presents the results of a complementary study performed based on all the SUCs of the project pilots. This analysis was conducted to identify the first list of HEDGE-IoT functional requirements. The analysis was done purely based on quantitative terms. It is based on the intentions explicitly declared in the SUCs' documents by each pilot, without going into the details of their solutions.

Methodology

To prepare the architecture design and complete the SUCs with more generic HEDGE-IoT functional requirements, normalized functions and high-level technical capabilities representing every function from every pilot are needed. These functions were extracted from the SUCs provided by the pilots using the IEC 62559-2 template.

The diagram summarizing the analysis is available in the section Appendix B: Overview of the identification of the main functions through a SUCs analysis

Functions, which can be defined as solutions implemented to achieve the scenario's objectives, were extracted and then regrouped into uniform technical capabilities covering every pilot's needs.

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The HEDGE-IoT technical capabilities section was split into 8 categories:

- Data management
- Optimization and forecasting
- Flexibility management
- User interfaces
- Grid monitoring and control
- Interoperability and data exchanges
- Artificial intelligence
- Main external data.

HEDGE-IoT technical capabilities

The following list defines the high-level technical capabilities required for HEDGE-IoT.

It is important to keep in consideration that HEDGE-IoT pilots have different objectives, developments and constraints. Not all the functions and technical capabilities listed below are relevant for all pilots.

DATA MANAGEMENT

- IoT data collection: Collect and monitor real-time data from IoT devices, IEDs, and energy nodes.
- Real-time data processing and aggregation: Process and aggregate real-time data (e.g., DTR, DLR, DER). The data could be located in the cloud or at the edge level depending on each pilot.
- Data storage and access: Store and access data. Data recording could be set up with a trigger.
- Data validation and quality check: Ensure data accuracy with quality checks.

OPTIMIZATION AND FORECASTING

- Optimization: Manage and optimize consumption, flexibility, congestion and energy management system (EMS) with real-time adjustments.
- Forecasting: Predict production, consumption, grid limits, demand, weather, PV production, etc.
- Anomaly/fault detection and prediction: Identify and forecast faults or anomalies in the grid.
- Anomaly/fault assessment and resolution: Analyse and make decisions to solve or minimize anomaly/fault quickly to maintain operational continuity.
- Congestion prediction and management planning: Anticipate and prevent grid congestion.
- Performance analysis: Analyse system performance (e.g., photovoltaic (PV) production).
- Maintenance prediction: Predict and manage maintenance to ensure grid reliability.

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FLEXIBILITY MANAGEMENT

- Registration, prequalification and resources enrolment: Register and prequalify organisation and flexibility resources for integration.
- Flexibility offer handling: Send, receive, accept, or reject flexibility offers; check feasibility and propose incentives.
- Market price tracking and forecasting: Track and predict energy and flexibility market prices.
- Activation & planning: Execute and plan flexibility actions at both grid and market levels.
- Flexibility estimation: Estimate and calculate the required flexibility
- Real flexibility provided calculation: Calculation of required/agreed flexibility and provided flexibility.
- Settlement & payments: Manage flexibility settlements, payments, and penalties.
- Vulnerable user identification: Identify users who have major constraints related to their infrastructures' power supply.

USER INTERFACES

- User interfaces: Provide user interfaces for DSOs, producers, consumers, and aggregators.
- User interface configuration: Configuration of user interfaces such as preferences and parameter settings.
- Alerting, reporting & visualization: Generate security alerts, notifications, reports and visualize relevant information.
- Dynamic tariffs: Display dynamic tariffs for customer engagement and flexibility pricing.
- User registration and contract information: Implement a user registration system that securely captures and stores user details and contract information, allowing for account creation, verification, and management.

GRID MONITORING AND CONTROL

- Grid state monitoring: Monitor and estimate grid status in real time.
- Grid and energy node configuration: Configure energy nodes and integrate new ones.

INTEROPERABILITY AND DATA EXCHANGES

- Interoperability among systems: Ensure interoperability for communication among systems and grid components with a semantic interoperability layer.
- Semantic adapters: Provide semantic adapters to new systems/components to allow them to be part of the interoperable ecosystem.

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- Data exchanges: Provide a means of data exchanges among a pilot such as a gateway, an API or a data space connector.
- Data space: Provide a data space to allow communications among project systems and pilots.
- Data space connectors: Provide data space connectors to allow systems to access and exchange data between actors systems and tools, within the data space.

ARTIFICIAL INTELLIGENCE

- AI explainability: Provide transparent AI-driven decisions for trust.
- AI maintenance: Provide an AI maintenance system that continuously monitors model performance, and facilitates updates and further developments.
- AI trustworthiness: Provide the assurance that AI systems used are trustable, including aspects like security, reliability, safety, ethics, integrity and accuracy.

MAIN EXTERNAL DATA

- Grid historical data: Access grid historical data as one major input to the system.
- Weather data: Incorporate weather forecasts to enhance grid operation decisions.
- Geographic information system (GIS) model: Access geographic information systems for environmental data.

3 REFERENCE ARCHITECTURE METHODOLOGY

3.1. SCOPE

As a reminder, HEDGE-IoT aims to implement a novel Digital Framework which will use different IoT assets (from behind-the-meter, up to the TSO level), to add intelligence to the edge and cloud layers through advanced AI/ML tools and to bridge the cloud/edge continuum introducing federated applications governed by advanced computational orchestration solutions. It will also attempt to upgrade the RES-hosting capacity of energy systems to leverage a previously untapped flexibility potential. The multi-dimensional framework of HEDGE-IoT comprises the following pillars: (a) the Technology Facilitator Pillar will exploit the computational sharing by offloading applications on the grid edge, towards providing a set of AI/ML federated learning and swarm computing applications; (b) the Interoperability Pillar, which leverages on leading-edge interoperable architectures, such as the Data Space architectures; (c) the Standardization Pillar will enable all involved platforms, systems, tools and actors to seamlessly communicate and exchange data in standardized formats using widely used standards, such as SAREF, etc.; (d) the Digital Energy Ecosystem Enabling Pillar will ensure the creation of an ecosystem facilitating the increased integration of RES and characterized by resilience.

To achieve the outlined objectives and foster the desired technological, business, adoption, and socio-economic impacts, the HEDGE-IoT Reference Architecture (RA) plays a crucial role. It will guide the development of technologies aimed at reaching these ambitious goals. This chapter

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presents the methodological approach for the design of the HEDGE-IoT Reference Architecture, reflecting the envisioned framework. Also, it presents a summarized description of current design methodologies along with an efficient time plan of the most crucial activities which will take place during RA design.

3.2. REFERENCE ARCHITECTURE APPROACH

The HEDGE-IoT Reference Architecture (RA), aims to create a functional, interconnected environment that supports the dynamic cloud-edge ecosystem. The key objectives include leveraging Data Space principles to manage data sovereignty and ensure compliance with EU regulations and initiatives, and promoting the decentralization of operational services, to improve system scalability. The RA will support interoperable and integrated solutions while ensuring regulatory-preserving data sharing and secure control over data. To ensure the RA aligns with ongoing EU efforts and global standards, the design process will integrate concepts and outcomes from several initiatives and projects, as detailed in Table 48. These efforts provide a foundation for the architectural framework, ensuring that the RA follows the latest regulatory, technological, and operational best practices (e.g., BRIDGE and AIOTI focus on interoperability and smart energy systems, while IDSA addresses data sovereignty). Similarly, related projects such as OneNet, Enershare, and Platone contribute to the understanding of distributed energy systems, data integration, and advanced market participation. By referencing these initiatives, the RA design remains at the forefront of technological advancements, ensuring seamless integration across platforms and regulatory compliance. As mentioned above, Table 48 lists the full set of EU initiatives and projects relevant to the design of the HEDGE-IoT RA, which will be further analyzed in D2.3.

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TABLE 48: GLOBAL & EU INITIATIVES AND RELATED PROJECTS

GLOBAL & EU INITATIVES	RELATED PROJECTS
BRIDGE	OneNet
	Enershare
AIOTI	Bright
	BD4NRG
IDSA	MATRYCS
	I-NERGY
FIWARE	Platone
	Resonance
IoT-EPI	Synergy
	Attest
The European AII Alliance	Exploit4Innomat

The approach to the HEDGE-IoT RA design will focus on establishing a cost-effective and easy-to-install middleware layer that integrates IoT/edge devices and fog/cloud platforms. As illustrated in Figure 17 that presents a first high-level conceptual Reference Architecture, the HEDGE-IoT Interoperability Middleware will be central to this design, as it enables communication between IoT Edge Services, data sources, and the HEDGE-IoT stakeholders via HEDGE-IoT Data Connectors. Core concepts like semantic interoperability, data access policies, identity management, and a Context Broker will ensure secure, regulatory-compliant data flows in line with EU regulations. Tools such as the Data Catalogue and App Store will manage data and service access, supporting interoperability across diverse platforms. The HEDGE-IoT Services Layer will provide essential services such as Federated Learning Services, User-centric Services, and Horizontal Services. These services are supported by the middleware layer and are integrated in a Service Catalogue. Federated learning will emphasize the decentralized nature of the system, allowing distributed nodes to collaborate while maintaining data privacy and security, crucial for regulatory compliance. This layer ensures smooth interaction between stakeholders and services, contributing to the system's overall scalability and modularity.

The HEDGE-IoT Monitoring & Computational Orchestration Layer at the top of Figure 17 will be critical for system administration, computational orchestration, and infrastructure planning. This layer will manage and monitor the entire ecosystem, ensuring efficient operation, planning, and scaling of resources. The Cybersecurity & Data Privacy considerations will run parallel across the

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entire architecture, reflecting the importance of maintaining secure operations and regulatory-preserving data sharing.

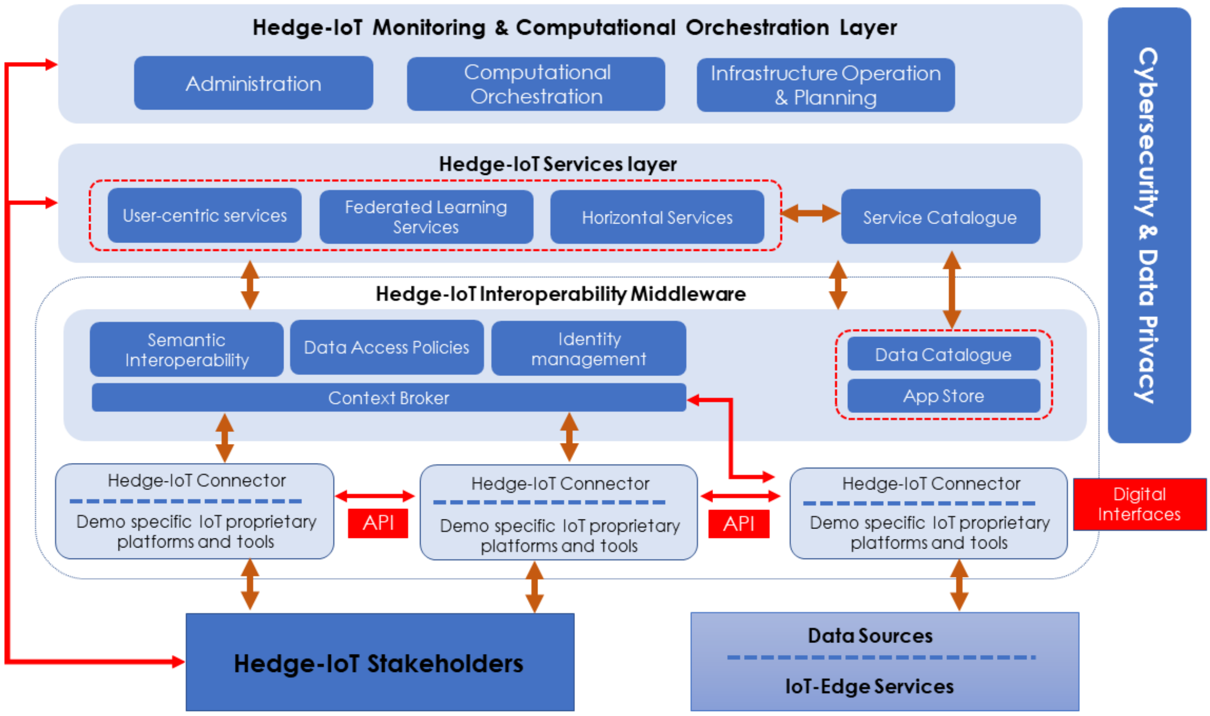

FIGURE 17: HEDGE-IOT RA CONCEPT MODEL

Figure 18 illustrates the key inputs in the methodology for the design of the HEDGE-IoT RA as necessary steps towards the design of the RA. To ensure that the design process aligns with real-world scenarios, the functional specifications derived from business use cases in WP2 must integrate with the RA to support seamless operation. This alignment ensures that the RA is not only compliant with external regulations but also takes into consideration the semantic ontologies and use cases of the project to maintain interoperability across different technical implementations. The methodology behind the RA will emphasize technical convergence between functional specifications and software architecture. This ensures that the system's technical elements, such as services and system use cases, align with the overarching RA, contributing to overall performance and reliability.

Quality of Service (QoS) is also central to the RA design, ensuring smooth interaction between system components. QoS will monitor system performance to ensure it meets the required standards for service delivery, dictating how actors, services, and technical specifications interact with the broader architecture. This is particularly critical during the alignment and convergence phases, ensuring reliable and efficient operation.

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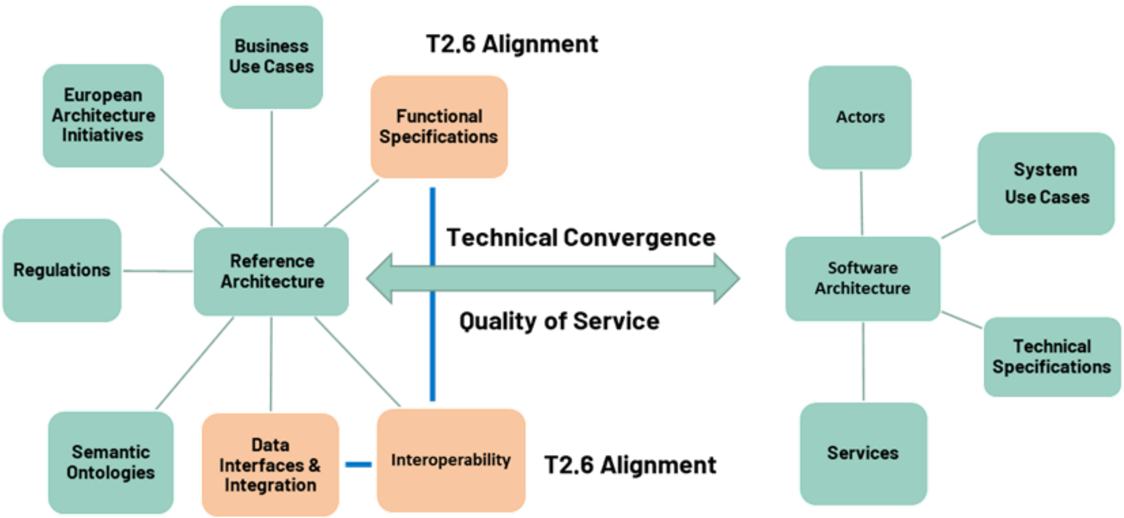

FIGURE 18: HEDGE-IOT RA METHODOLOGY CONSIDERATIONS

The use of ISO 42010 and the 4+1 Architecture Model will structure and describe the RA within the HEDGE-IoT ecosystem. ISO 42010 provides a standardized approach to describing the architecture of complex systems, addressing stakeholder concerns and viewpoints. The 4+1 Architecture Model will be applied to organize the RA into logical, process, physical, and deployment views, ensuring that all system components are clearly documented and aligned with the RA objectives.

Finally, the development of the RA will follow an iterative approach, ensuring continuous refinement and alignment with stakeholder concerns and project requirements. This will include gathering and analysing system use cases, developing a comprehensive integration plan and gathering feedback, particularly around functional requirements, and refining the architecture to address interoperability. Multiple review cycles will be conducted to validate and adjust the RA, with functional requirements being finalized through this iterative process.

3.3. ISO42010:2022 MODEL

The ISO 42010:2022 [4] is an international standard which provides a standardized framework for creating and managing architecture descriptions of complex systems. It is based upon a conceptual model – or "meta model" – of the terms and concepts affecting architecture descriptions. The standard defines the key elements involved in system architecture and specifies how they relate to the different stakeholder concerns. It distinguishes between the architecture (system fundamental organization) and the architecture description (the documentation for the architecture), by defining its three critical components:

1. Architecture Description Frameworks (ADFs): Structure how the architecture is described.
2. Architecture Description Languages (ADLs): Provide the language for expressing the architecture.
3. Architecture Viewpoints and Views: Organize stakeholder concerns during the architecture design process.

The HEDGE-IoT ecosystem is a complex system, which operates within multiple layers of the energy

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system, and thus introduces complexity that the ISO 42010 standard can manage. The standard's emphasis on stakeholder driven architecture aligns well with the HEDGE-IoT project, which has both diverse actors and a variety of technological systems. The different technologies which are integrated in the project (e.g. IoT devices, edge computing and cloud systems, AI/ML tools, etc.), can be structured through the ISO42010 to address the stakeholder concerns in the architecture of the project. Stakeholder concerns like interoperability and scalability, will be managed effectively through well-defined viewpoints and views, which can ensure that the design of the architecture is aligned with the expectations of stakeholders, from grid operators to IoT experts. As such, the architecture description will be used to provide a detailed view of how the system components interact to ensure coherence across the project's layers.

Within the context of HEDGE-IoT, the ADFs (wherever they apply) will structure the architectural description in a consistent and reusable way, making it easier to manage the complexity of the project. By providing proposed predefined structures like viewpoints, perspective and aspects to manage the design of the HEDGE-IoT system, the standard provides important tools for organizing the different elements in the system involved in the project, like AI/ML tools and cloud-edge integration. This will help address the multi-dimensional nature of the HEDGE-IoT framework by having consistency across various technological pillars. This approach will ensure scalability and adaptability of the system architecture to accommodate the evolving needs across the lifecycle of the project.

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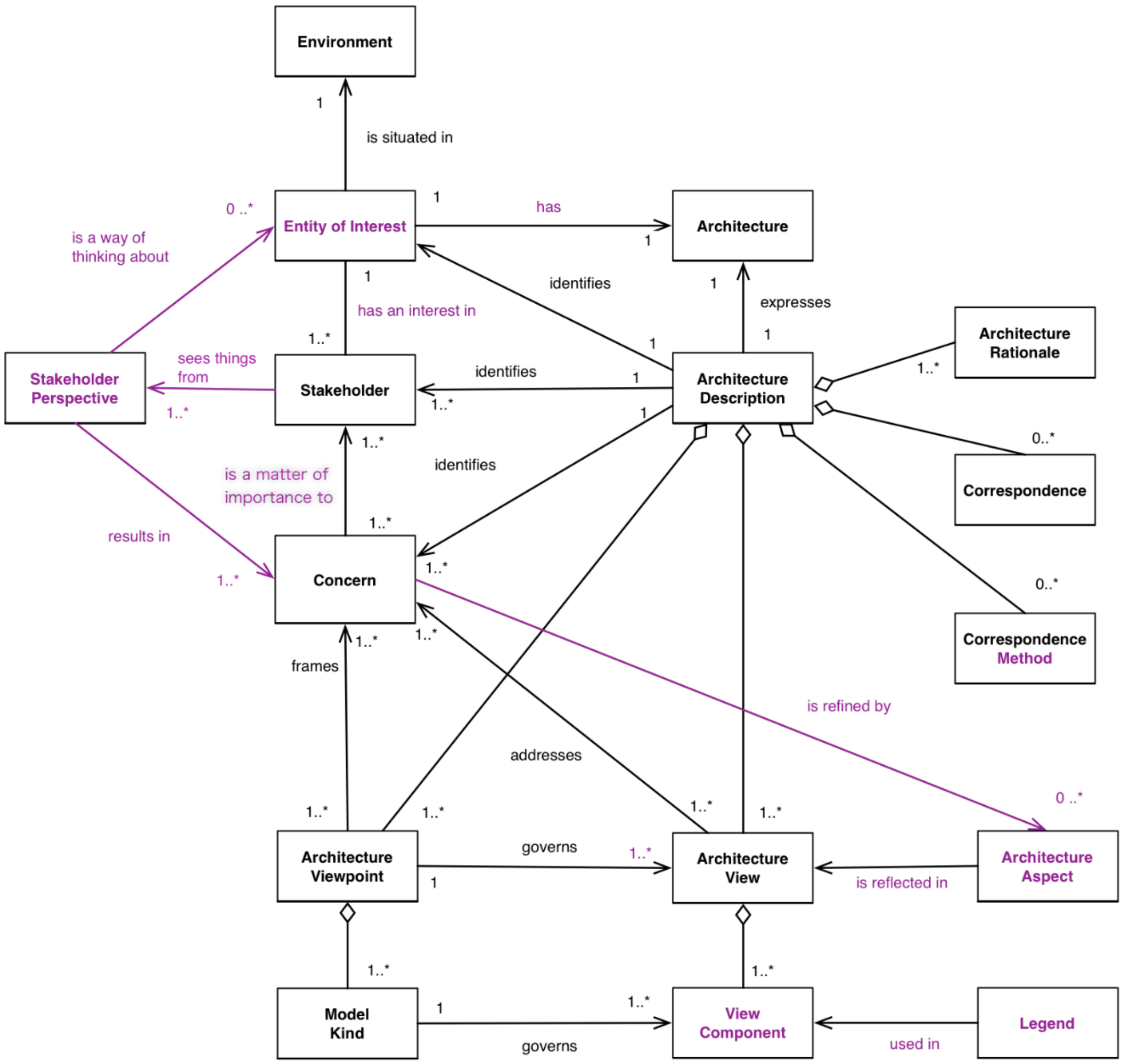

FIGURE 19: UML CLASS DIAGRAM OF THE ISO 42010:2022 (SECOND EDITION)

Correspondence is a concept in the ISO 42010 standard and is useful in the context of the HEDGE-IoT project, because it can help define key relationships between the different elements of an architecture description. They can help ensure that the different components of the architecture are consistent and aligned with each other to promote interoperability. In HEDGE-IoT, correspondences can be used to manage the complex relationships between grid systems and the different technologies that will interact with it, which are crucial for the operation of the HEDGE-IoT system. ISO 42010 specifies the use of ADLs, which provide the formal languages needed to describe complex systems such as HEDGE-IoT. They ensure clear communication between system components, making it easier to integrate diverse tools, devices and technologies across the architecture. They also help ensure that the architecture's components are described in a way that is unambiguous and standardized. In the context of HEDGE-IoT, ADLs will be used to formalize the interactions between different technologies that exist within the scope of the project.

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3.4. 4+1 ARCHITECTURAL VIEW MODEL

The 4+1 Architecture View Model, introduced by Philippe Kruchten [5], proposes a method to describe a system's architecture using five distinct views. These views address different aspects of the system and allow for better communication of design decisions to various stakeholders, such as developers, operators, and users. The model emphasizes that no single view can capture all architectural concerns, so multiple views are used to express different parts of the architecture while maintaining a coherent overall structure.

The five views are:

1. **Logical View:** Focuses on the system's functionality, showing how it is decomposed into components or objects. This view captures the system's object model and interactions, often represented through class diagrams and relationships.
2. **Process View:** Handles non-functional requirements, especially those related to concurrency, synchronization, and distribution. This view shows how system processes or threads interact, often with a focus on performance and fault tolerance.
3. **Development View:** Describes the system's organization in the development environment, including source code organization, modules, libraries, and subsystems. It supports the management of the development process and team collaboration.
4. **Physical View:** Maps the software onto the hardware infrastructure, showing how components are deployed across physical nodes. This view handles concerns like performance, scalability, reliability, and fault tolerance.
5. **Scenarios (Use Case View):** The "plus one" view ties the four other views together by demonstrating how they collaborate to support key use cases or scenarios. This view validates the architecture and ensures it meets the system's requirements.

By combining these five views, the 4+1 model (Figure 20) provides a comprehensive description of the system's architecture, allowing different stakeholders to focus on the aspects that are most relevant to them. Within the context of the HEDGE-IoT project, the 4+1 Architecture model can be utilized to organize the RA into clear and interrelated views, providing a comprehensive understanding of the system's structure and functionality, across logical, process, development, physical, and scenario views. The key objective is to ensure each of these views supports scalability, interoperability of IoT and decentralized services within the HEDGE-IoT ecosystem and being aligned with Dataspace principles.

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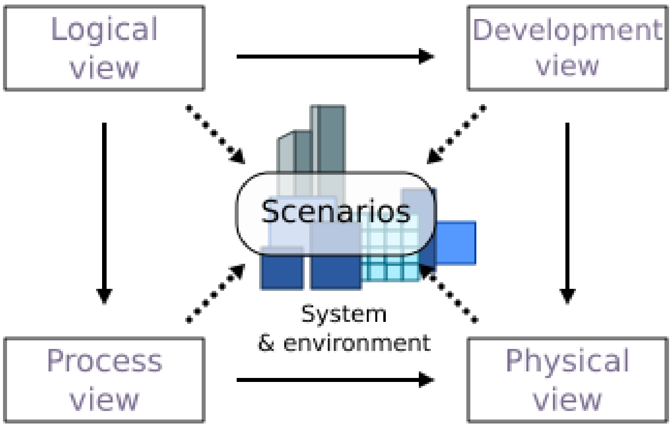

FIGURE 20: THE 4+1 ARCHITECTURE VIEW MODEL

- The Logical view will focus on defining the key HEDGE-IoT system components and their core functionality, which includes the interactions between IoT devices, edge nodes, technical platforms, and the middleware layer. The focus of this view will be on the logical relationship between these components to ensure modularity and flexibility, and to ensure that the concept of interoperability is built in the RA, to enable interconnectivity between layers.
- The Process View will address how the system behaves in terms of performance, scalability, and resilience. It will capture the dynamic behavior of the HEDGE-IoT system during its operation. This means defining the key processes involved in the RA, such as dataflows, decision making protocols and service orchestration. The focus of this view will be on how the operation processes can manage the scalability and have efficient resource use, and to ensure the system can handle high volume data processing in decentralized environments.
- The Development View will provide an architectural framework for the design and development of the software systems within HEDGE-IoT, focusing on the middleware, data interfaces, and integration components. The focus of this view will be to guide the development of interoperable building blocks and ensure that software components are aligned with data sovereignty, trust and regulatory compliance.
- The Physical View will describe how the HEDGE-IoT system is deployed across physical infrastructure and hardware components. Its focus is to align the physical infrastructure with EU standards and ensure that the physical layout supports efficient data flow and interoperability.
- The Scenarios View will focus on extracting stakeholder concerns and validating the RA. This view ensures that the architecture supports real-world operational scenarios which are defined in the scope of this project. The key focus is to ensure that the RA meets the functional and non-functional requirements of the system and to address stakeholder concerns.

In the 4+1 Architecture Model, the five views are interrelated, and correspondence between them ensures consistency. In the HEDGE-IoT system, IoT devices represented in the Logical View

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correspond to processes that manage data collection and processing across cloud and edge layers. The Process View then connects to the Physical View, where these processes are deployed onto physical hardware, ensuring that tasks, like data ingestion and analysis are efficiently distributed across nodes to enhance scalability and performance. The Development View aligns software components with the logical and physical structures, ensuring that the developed modules are modular, scalable, and deployable across the system's physical infrastructure. This view supports the practical organization of the software and facilitates its deployment. Finally, the Scenarios View ties all other views together, validating the architecture by demonstrating how it supports operational use cases, to satisfy the functional and non-functional requirements of the system.

3.5. TIME PLAN

The Gantt chart in Figure 21 outlines the timeline and key activities leading to the finalization of the D2.3 deliverable (scheduled for submission in M17) and the Reference Architecture design. The timeline is divided into two main phases, the first focusing on the finalization of deliverable D2.2, and the second on the development and finalization of deliverable D2.3.

		2024					2025						
		JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY
		M6	M7	M8	M9	M10	M11	M12	M13	M14	M15	M16	M17
	T2.7 Activities [leading up to D2.3]												
1	Develop Comprehensive Time Plan for Activities Leading to D2.3 Submission												
2	Complete Initial Draft of EU Initiatives (v1)												
3	Draft and Finalize D2.3 ToC (v1): Structure, Headings, and Deadlines												
4	Assign Task Responsibilities and Secure Partner Contributions for D2.3												
5	Collect and Conduct Preliminary Review of Relevant Projects (v1)												
6	Define Reference Architecture Methodology and Contribute to D2.2 Draft												
7	Finalize Contributions to D2.2 and Prepare for Submission												
D2.2	Submit Final Version					D2.2							
8	Integrate Inputs from D2.2 into the Development of D2.3												
9	Gather and Analyze Technical System Use Cases (SUCs)												
10	Develop a Detailed Plan for Task 2.7 Leading Up to the D2.3 Deliverable (M17)												
11	Develop a General Integration Plan within HEDGE IoT RA												
12	Develop Reference Architecture v1												
13	Integrate Data Space Principles into the Reference Architecture												
14	Extract and Define Functional Requirements (v1)												
15	Begin Initial Review of D2.3 (v1)												
16	Finalize the Reference Architecture (RA Final Version)												
17	Begin Second Review of D2.3 (v2)												
18	Finalize Functional Requirements for the Reference Architecture												
19	Conduct Final Review of D2.3 for Submission												
D2.3	Submit Final Version												D2.3

FIGURE 21: HEDGE-IOT T2.7 GANTT CHART LEADING UP TO D2.3

The **first phase**, which covers activities leading up to the submission of D2.2, consists of seven tasks. These tasks include creating a time plan in the initial stages of the activities during M6-M7 to guide all subsequent activities related to D2.3, ensuring that roles are allocated efficiently, and tasks are managed effectively. Following this, efforts will be placed on drafting the initial version of EU initiatives during M6-M9, which has an important role in shaping the structure of the RA, due to its

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need of being aligned with these initiatives. An important step is the drafting and finalization of the Table of Contents for deliverable D2.3 during M9-M10, which will provide the framework for the document's structure and deadlines. At the same time, responsibilities are assigned to partners, securing their contributions to ensure a collaborative effort towards deliverable D2.3. In parallel, an initial collection and review of the relevant and most recent projects will be conducted during M8-M10, which will inform the development of D2.3 to ensure alignment with the most recent technological and architectural efforts in this space. The methodology for the RA will be developed during M9-M10, which contributes to the deliverable D2.2. The first phase concludes with the finalization and submission of the RA Methodology for deliverable D2.2 in M10, a milestone that sets the foundation for the work that will be carried on for deliverable D2.3.

The **second phase** focuses on the development and submission of the work for deliverable D2.3. The first task in this phase is the integration of inputs from D2.2 into D2.3 (M10-M11), ensuring continuity between the two deliverables. In parallel, a detailed analysis of SUCs will be conducted over the same period, and a detailed plan for T2.7 will be developed once all elements required for D2.3 are available. This is followed by the formulation of a general integration plan within the HEDGE-IoT architecture and the development of the initial version of the Reference Architecture (M11-M12).

As the project progresses, the plan includes that data space principles are integrated into the RA (M11-M12), to ensure compatibility with key components of the HEDGE-IoT project. The first version of functional requirements will be extracted and defined during M11-M13, providing essential guidance for the remaining stages of the architecture's development. The first internal review of D2.3 (M13) allows for feedback and improvements, after which the Reference Architecture is finalized (M14). A second review of D2.3 will be conducted (M15) to ensure that all necessary revisions are made between the partners, so that the functional requirements are finalized (M15-M16). The final internal review of D2.3 (M17) takes place before the deliverable is submitted on schedule in M17.

4 CONCLUSIONS

In conclusion, this deliverable presents the first version of the project's functional specifications, through a detailed definition of the SUCs based on BUCs and the IEC 62559 methodology. By identifying pilot-specific SUCs and general technical capabilities needed for the project, we have created a solid foundation that can be customized for each pilot. This flexibility is important, as the pilots differ significantly in their requirements and goals. The exploration of SUCs has provided insights into how systems and users will interact and what functionalities the systems must provide. This work will be updated if needed based on future work and feedback.

Additionally, our preliminary work on the RA offers essential guidance for the project’s future work. This section presents our initial approach to the project RA, beginning with the defined scope and detailing our methodology based on ISO 42010:2022. We also incorporate the 4+1 architectural view model, which allows us to examine the architecture from multiple perspectives, ensuring a comprehensive understanding of how the system will function across different contexts. The next steps work to be carried out is to review system use cases and use them as inputs for the reference architecture definition task.

Moving forward, it will be important to engage with stakeholders from each pilot to refine these specifications further. Their feedback will help us ensure that the technical capabilities and architecture align with their unique needs. References

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5 REFERENCES

[1] IEC, "IEC 62559-2:2015: Use case methodology – Part 2: Definition of the templates for use cases, actor list and requirements list,," 2015.

[2] ENTSO-E – ebIX – EFET Model, "Harmonized Electricity Market Role Model (HEMRM)," 2021.

[3] INTEGRID, "Generic Non-Functional Requirements".

[4] "ISO/IEC/IEEE 42010:2022(en) - Software, systems and enterprise — Architecture description," [Online]. Available: https://www.iso.org/obp/ui/#iso:std:iso-iec-ieee:42010:ed-2:v1:en.

[5] P. Kruchten, "Architectural Blueprints—The 4+1 View Model of Software Architecture," 1995.

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6 APPENDIX

6.1. APPENDIX A: IEC 62559-2 USE CASE TEMPLATE

1 Description of the use case

Use case describes functions of a system in a technology-neutral way. It identifies participating actors which can for instance be other systems or human actors which are playing a role within a use case. Use cases can be specified on different levels of granularity and are according to their level of technological abstraction and granularity either described as **Business Use Case (BUC)** or **System Use Case (SUC)**.

BUCs describe how Business Roles interact to execute a business process and are system agnostic. The Actors involved are business roles (organisations, organisational entities, or physical persons). SUCs depict a function or sub-function supporting one or more business processes. Actors involved are business roles and system roles (devices, information systems).

1.1 Name of the use case

ID	***Area / Domain(s) / Zones(s)***	***Name of Use Case***

1.2 Version management

Version Management			
Version No.	***Date***	***Name of Author(s)***	***Changes***
	DD.MM.YYYY		

1.3 Scope and objectives of use case

Scope and Objectives of Use Case	
Scope	The aim and boundaries of the use case.
Objective(s)	The goals that the use case is expected to achieve.
Related business case(s)	

1.4 Narrative of use case

Narrative of Use Case
Short description
Short text intended to summarize the main idea as service for the reader who is searching for a use case or looking for an overview. Recommendation: This short description should have not more than 150 words.
Complete description

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Provides a complete narrative of the use case from a user's point of view, describing what occurs when, why, with what expectation, and under what conditions. This narrative should be written in plain text so that non-domain experts can understand it. The complete description of the Use Case can range from a few sentences to a few pages. This section often helps the domain expert to think through the user requirements for the function before getting into the details required by the next sections of the Use Case.

1.5 Key performance indicators (KPI)

ID	Name	Description	Reference to mentioned use case objectives

1.6 Use case conditions

Use case conditions
Assumptions
May be used to define further, general assumption for this use case. In some use cases, it is critical to understand which preconditions or other assumptions are being made. · Any assumptions shall be identified, such as: which systems already exist, which contractual relations exist, and which configurations of systems are probably in place. · Any initial states of information exchanged in the steps in the next section shall be identified.
Prerequisites
Describes what condition(s) should have been met prior to the initiation of the use case, such as prior state of the actors and activities.

1.7 Further Information to the use case for classification / mapping

Classification Information
Relation to other use cases
Relation to other use cases in the same project.
Level of depth
Prioritisation
Generic, regional or national relation
Nature of the use case
This field can help to classify the main focus of the use case. EXAMPLE: Technical/system use case, business use cases (e.g., market processes), political, test use cases.
Further keywords for classification
Keywords can be defined in order to support extended search functionalities within a use case repository. Multiple keywords should be provided as a comma-separated list. EXAMPLE: Smart grid, electric vehicles, loading of vehicles, electricity metering, storage.

1.8 General Remarks

General Remarks

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Further comments which are not considered elsewhere.

2 Diagrams of use case

The diagram aims to illustrate the structure of the use case.
For clarification, in general it is recommended to provide drawing(s) by a graphic or as UML graphics. The drawing should show interactions which identify the steps where possible.

Diagram(s) of use case
Use case diagrams, activity diagrams, sequence diagrams illustrating the narrative.

3 Technical details

3.1 Actors

Use case actors, types, description, and further information specific to the use case; use case actors should be present in the narrative of the use case.
To improve consistency among Use Case descriptions, the can be used for actor names and description. Thus, the information included in the fields of the following table could be obtained from the Actors List defined in HEMRM (https://eepublicdownloads.entsoe.eu/clean-documents/EDI/Library/HRM/Harmonised_Role_Model_2023-01.pdf). Nevertheless, it is possible to add new Actors if needed.

Actors			
Actor Name	***Actor Type***	***Actor Description***	***Further information specific to this use case***

3.2 References

References (which are standards, reports, mandates and regulatory constraints) associated with the use case.

References						
No.	***Reference Type***	***Reference***	***Status***	***Impact on use case***	***Originator / organisation***	***Link***

4 Step by step analysis of use case

Template section 4 focuses on describing scenarios of the use case with a step-step analysis (sequence description). There should be a clear correlation between the narrative and these scenarios and steps.

4.1 Overview of scenarios

The table provides an overview of the different scenarios of the use case like normal and alternative scenarios which are described in section 4.2 of the template.
In general, the writer of the use case starts with the normal sequence (success). In case precondition or post-condition does not provide the expected output (e.g., no success = failure), alternative scenarios have to be defined.

Scenario conditions						
No.	**Scenario name**	**Scenario description**	**Primary actor**	**Triggering event**	**Pre-condition**	**Post-condition**

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			Refers to the actor that triggers the scenario. It is worth pointing out that the names of the Actors should be consistent with Actors List in all sections of the Use Case description.		Describes the state of the system before the scenario starts.	Describes the expected state of the system after the scenario is realized.

4.2 Steps – Scenarios

For this scenario, all the steps performed shall be described going from start to end using simple verbs like – get, put, cancel, subscribe etc. Steps shall be numbered sequentially – 1, 2, 3 and so on. Further steps can be added to the table, if needed (number of steps are not limited).
Should the scenario require detailed descriptions of steps that are also used by other use cases, it should be considered creating a new "sub" use case, then referring to that "subroutine" in this scenario.

Scenario								
Scenario name:	Name of the scenario							
Step No.	***Event***	***Name of process / activity***	***Description of process/ activity***	***Service***	***Information producer (actor)***	***Information receiver (actor)***	***Information Exchanged (IDs)***	***Requirement, R-IDs***
	Event that triggers the activity.	Label that would appear in a process diagram.	This describes what action takes place in this step. The focus should be less on the algorithms of the applications and more on the interactions and information flows between actors.	Identifies the nature of flow of information and the originator of the information (*).	Name of the actor that produces the information.	Name of the actor that receives the information.	Here the information can use a short ID referring to template section 5 for further details. Several information exchanged IDs can be listed, comma separated.	Refer to the identifiers (R-ID) of the detailed requirements that apply for each activity.

(*) Available options are:

- CREATE means that an information object is to be created at the Producer.
- GET (this is the default value if none is populated) means that the Receiver requests information from the Producer (default).
- CHANGE means that information is to be updated. Producer updates the Receiver's information.
- DELETE means that information is to be deleted. Producer deletes information from the Receiver.
- CANCEL, CLOSE imply actions related to processes, such as the closure of a work order or the cancellation of a control request.
- EXECUTE is used when a complex transaction is being conveyed using a service, which potentially contains more than one verb.
- REPORT is used to represent transferral of unsolicited information or asynchronous information flows. Producer provides information to the Receiver.

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- TIMER is used to represent a waiting period. When using the TIMER service, the Information Producer and Information Receiver fields shall refer to the same actor.
- REPEAT is used to indicate that a series of steps is repeated until a condition or trigger event. The condition is specified as the text in the "Event" column for this row or step. Following the word REPEAT, shall appear, in parenthesis, the first and last step numbers of the series to be repeated in the following form REPEAT(X-Y) where X is the first step and Y is the last step.

5 Information exchanged

These information objects are corresponding to the "Name of Information" of the "Information Exchanged" column referenced in the scenario steps in template section 4 "Step by Step Analysis". If appropriate, further requirements to the information objects can be added.

Information exchanged			
Information exchanged (ID)	***Name of information***	***Description of information exchanged***	***Requirement, R-IDs***
Refers to an identifier used in the field "Information Exchanged" of Table 4.2.	Is a unique ID which identifies the selected information in the context of the use case.	Brief description, in case a reference to existing data models/information classes should be added. Using existing canonical data models is recommended.	Can be used to define requirements referring to the information and not to the step as in the step by step analysis (see template section 6 below).

6 Requirements

Quality of Service Requirements		
Categories ID	**Category name for requirements**	**Category description**
QoS	Quality of Service	Generic properties that service/SUC should provide – quality attributes.
Requirement R-ID	**Requirement name**	**Requirement description**

Security Requirements		
Categories ID	**Category name for requirements**	**Category description**
Sec	Security	Authentication of user, confidentiality, integrity, prevention of denial of service, non-repudiation or accountability, error management.
Requirement R-ID	**Requirement name**	**Requirement description**

Data Management Requirements		
Categories ID	**Category name for requirements**	**Category description**
D	Data Management	Type of source of data, correctness or validity of data, timeliness or time stamping of data, volume of data, synchronization, or consistency of data across systems, timely

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		access to data, validation of data across organizational boundaries, transaction management, data naming, identification, formats across disparate systems, maintenance of data and databases.
Requirement R-ID	**Requirement name**	**Requirement description**

Discovery and Configuration Requirements		
Categories ID	**Category name for requirements**	**Category description**
Conf	Configuration	Locations, distances, communication layout, commonly used communication protocol media, network bandwidth, existing protocols, number of devices, systems, volume of data items, expected growth, etc.
Requirement R-ID	**Requirement name**	**Requirement description**

Other Requirements		
Categories ID	**Category name for requirements**	**Category description**
O	Regulatory obligation related to privacy	2016/679 GDPR (General Data Protection Regulation)
Requirement R-ID	**Requirement name**	**Requirement description**

7 Common Terms and Definitions

Should be defined in a common glossary for all use cases. Here relevant terms belonging to this use case are listed.

Common Terms and Definitions	
Term	**Definition**

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6.1. APPENDIX B: OVERVIEW OF THE IDENTIFICATION OF THE MAIN FUNCTIONS THROUGH A SUCS ANALYSIS

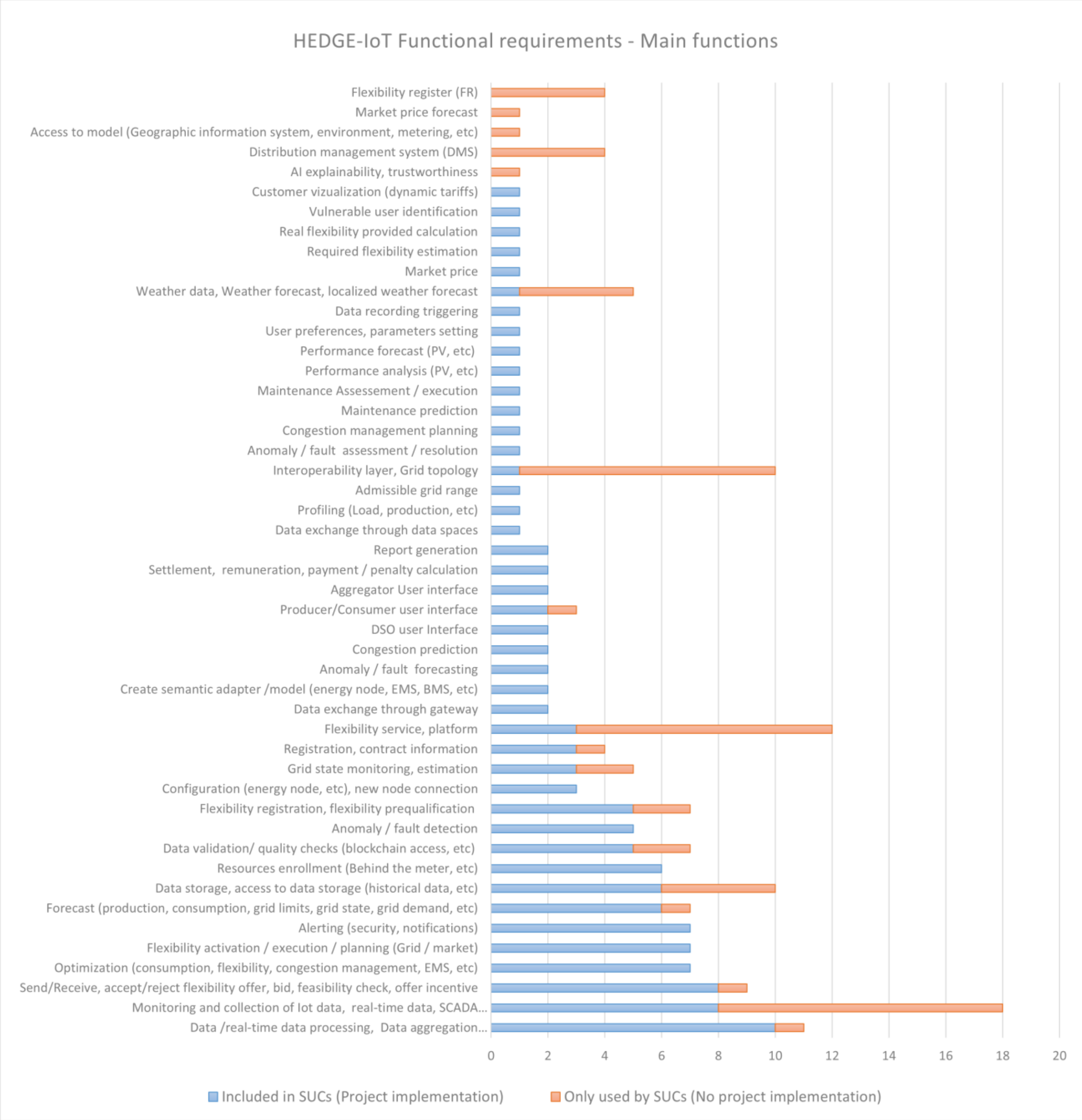

Figure 22: HEDGE-IoT Functional requirements - Main functions identifications

6.2. APPENDIX C: PILOTS' SYSTEM USE CASES DOCUMENTS

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HEDGE-IoT

HEDGE-IoT

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

D2.2

Functional Specifications of the HEDGE-IoT system

|Annex Document 1 - Finnish Pilot SUCs|

31/10/2024

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PROJECT INFORMATION

Project Number	101136216		
Project Acronym	HEDGE-IoT		
Project Full title	Holistic Approach towards Empowerment of the Digitalization of the Energy Ecosystem through adoption of IoT solutions		
Project Start Date	01 January 2024		
Project Duration	42 months		
Funding Instrument	Horizon Europe Framework Programme	Type of action	HORIZON-IA HORIZON Innovation Actions
Call	HORIZON-CL5-2023-D3-01-15		
Topic	Supporting the green and digital transformation of the energy ecosystem and enhancing its resilience through the development and piloting of AI-IoT Edge-cloud and platform solutions		
Coordinator	European Dynamics Luxembourg SA		

DELIVERABLE INFORMATION

Deliverable No.	D2.2							
Deliverable Title	Functional Specifications of the HEDGE-IoT system – Annex Document 1 – Finnish Pilot SUCs							
Work-Package No.	WP2							
Work-Package Title	Stakeholders' Requirements and System Specifications							
Lead Beneficiary	TRIALOG							
Main Author	Anna Kulmala (ABB) Antti Mutanen (ABB) Mehdi Attar (TAU) Sami Repo (TAU) Kari Mäki (VTT) Sayawu Diaba (VTT) And all Finnish pilot members							
Other Authors	Léo Cornec (TRI) Lenos Peratitis (ED) Aleksandra Raskovska (JSI)							
Due date	31/10/2024							
Deliverable Type	X	Document, Report (R)		Data management plan (DMP)		Websites, press & media action (DEC)		Other
Dissemination Level	X	Public (PU)		Sensitive (SEN)		Classified		
	PU: Public, fully open SEN: Sensitive, limited under the conditions of the Grant Agreement Classified R-UE/EU-R – EU RESTRICTED under the Commission Decision No2015/444							

	Classified C-UE/EU-C – EU CONFIDENTIAL under the Commission Decision No2015/444 Classified S-UE/EU-S – EU SECRET under the Commission Decision No2015/444

Document Revision History

Version	Date	Description of change	List of contributor(s)
0.1	09/10/2024	Compilation of all the pilot SUCs	Léo Cornec (TRIALOG)
0.2	16/10/2024	Review by European Dynamics	Lenos Peratitis (ED)
0.3	23/10/2024	Review by Institut Jozefstefan	Aleksandra Raskovska (JSI)
1.0	29/10/2024	Final document version for integration to Deliverable D2.2	Léo Cornec (TRIALOG)

EXECUTIVE SUMMARY

This document is an annex of HEDGE-IoT deliverable D2.2 titled "Functional Specifications of the HEDGE-IoT system" document. It provides specifications for the System Use Cases (SUCs) of the pilot.

Each SUC was defined by pilot members, based on the corresponding Business Use Case (BUC) and the IEC 62559-2 template, with support from the task leader for the methodology.

This document will be updated later in the project based on additional work and feedback. For the HEDGE-IoT project, the following sections and subsections of the IEC 62559-2 template were defined as mandatory to be completed by the pilot demonstrators for the SUCs:

1. Description of the use case
    1.1. Name of the use case
    1.2. Scope and objectives of the use case
    1.3. Narrative of the use case
2. Diagrams of the use case
3. Technical details
    3.1. Actors
4. Step-by-step analysis of use case
    4.1. Overview of scenarios
    4.2. Steps - scenarios
5. Information exchanged
6. Requirements

The following table links the BUCs and the SUCs of the pilot:

BUC ID & BUC name	SUC ID	SUC name
BUC-FI-01 Anomaly detection and fault forecasting to increase Medium Voltage (MV) distribution network resilience	SUC-FI-01.1	Data collection and anomaly detection
	SUC-FI-01.2	Fault forecasting
BUC-FI-02 Predictive and real-time congestion management (CM) to increase network hosting capacity	SUC-FI-02.1	Congestion prediction in distribution grids
	SUC-FI-02.2	Congestion management planning in distribution grids
	SUC-FI-02.3	State monitoring of the distribution grid
	SUC-FI-02.4	Congestion management decision-making in real-time

1 SUC-FI-01.1 – DATA COLLECTION AND ANOMALY DETECTION

1 Description of the use case

1.1 Name of the use case

ID	Area / Domain(s) / Zones(s)	Name of Use Case
SUC-FI-01.1	Energy system / Distribution grid / Distribution management	Data collection and anomaly detection

1.2 Version management

Version Management			
Version No.	Date	Name of Author(s)	Changes
V1	16.05.2024	Kari Mäki (VTT), Sayawu Diaba (VTT)	First version
V2	26.06.2024	Kari Mäki (VTT)	Major changes, including merging of SUCs
V3	21.08.2024	Kari Mäki (VTT)	Revised according to comments
V4	13.09.2024	Kari Mäki (VTT)	Revised according to comments
V5	16.09.2024	Kari Mäki (VTT)	New requirement guidelines

1.3 Scope and objectives of use case

Scope and Objectives of Use Case	
Scope	Processing of data stream from Intelligent Electronic Devices (IEDs), identification of abnormalities and storing indicator values
Objective(s)	Objectives: 1. To process and analyse the live data stream 2. To pick all issues that seem abnormal 3. To store their indicators into logs so that also long-term evolving phenomena can be identified in next phases
Related business case(s)	BUC-FI-01 Anomaly detection and fault forecasting to increase medium voltage (MV) distribution network resilience

1.4 Narrative of use case

Narrative of Use Case
Short description
The purpose of this SUC is to offer new tools for collecting network data and processing it for further usage to support network operators in managing grid faults and improving system resilience. The opportunity revolves around modern Intelligent Electronic Devices (IEDs) such as protection relays, which can measure different parameters with extremely high resolutions that allow detailed analysis. However, this data cannot be stored or transferred to Supervisory Control and Data Acquisition (SCADA) systems in full detail due to the massive amounts of data. The data

brought to operator room level through SCADA is currently filtered and less detailed, and only when faults occur is a more detailed fault information package (disturbance recording package) saved. The purpose of the SUC is to apply the latest edge and AI capabilities within the substation, where the full resolution data stream is available, and perform online analysis that can use full details and thus forecast events that are slowly building up in the grid. The solution does not store full-detail data but rather processes it online and keeps logs of any potentially deviating measurements or events.
Complete description
Overall, the piloted solution will improve grid operator's awareness and ability to prepare for and react to disturbances and faults in a timelier manner. The use case will focus on enabling usage of full-resolution data streams at the substation bus level for improved analytics by providing a stable and uniform data stream, as well as by providing indicators for detected anomalies. Currently, the grid operator primarily monitors the grid and takes actions based on the data available through the SCADA system. While SCADA data is accurate and real-time, it does not include the finest details available from modern IEDs, such as protection relays. SCADA-level data is always aggregated and filtered since transferring and storing full-resolution data is practically impossible. In the event of faults, more detailed data is saved through a buffer system that is triggered by the fault and includes moments before the fault occurred. At the same time, IEDs have progressed significantly and are already able to support advanced data analytics. Currently, these capabilities are underused due to challenges related to data collection, transfer and storage. Applying the latest developments in edge computing and AI-based analysis offers exciting possibilities for performing on-site analysis at substations and allows the use of all available details. The approach is to provide a data processing system that can manage real-time full resolution IEC 61850 data stream, to pick anomalies and to store indicators in separate counters for future use in the following SUC step. At this point, the system would be capable of providing proper data stream data format and identifying first indicators. The main idea is to apply machine learning for learning the normal status of the grid data, and to flag any abnormalities. At this point, the approach does not need to be fully deterministic, as the actual decisions on fault flagging will be made by the following SUC step. **Main steps:** 1. Anomaly detection 2. Anomaly counter log updating **Main technologies:** • IEDs providing full detail data • AI/ML for anomaly detection **Main infrastructure:** • EDGE server • Data link for input

1.5 Key performance indicators (KPI)

ID	***Name***	***Description***	***Reference to mentioned use case objectives***
KPI11	*Increased grid operational performance*	The system will improve grid resilience by offering improved monitoring and fault prediction	Objective 2 and 3

KPI 4	*Real-time data sharing among stakeholders*	The system relies on real-time data available through data link interface	Objective 1

1.6 Use case conditions

Use case conditions
Assumptions
• Continuous, uniform and time-stamped data stream from IEDs available • Adequate computational power is present at the EDGE level
Prerequisites
Precondition: Real-time data stream available Post condition: Indicator values stored for further decision making

1.7 Further Information to the use case for classification / mapping

Classification Information
Relation to other use cases
Linked to SUC-FI-01.2 • Providing anomaly detection data for decision making Linked to BUC-FI-01.1 • Executing the first part of the BUC process
Level of depth
Prioritisation
Generic, regional or national relation
Nature of the use case
Further keywords for classification

1.8 General Remarks

General Remarks

2 Diagrams of use case

Diagram(s) of use case

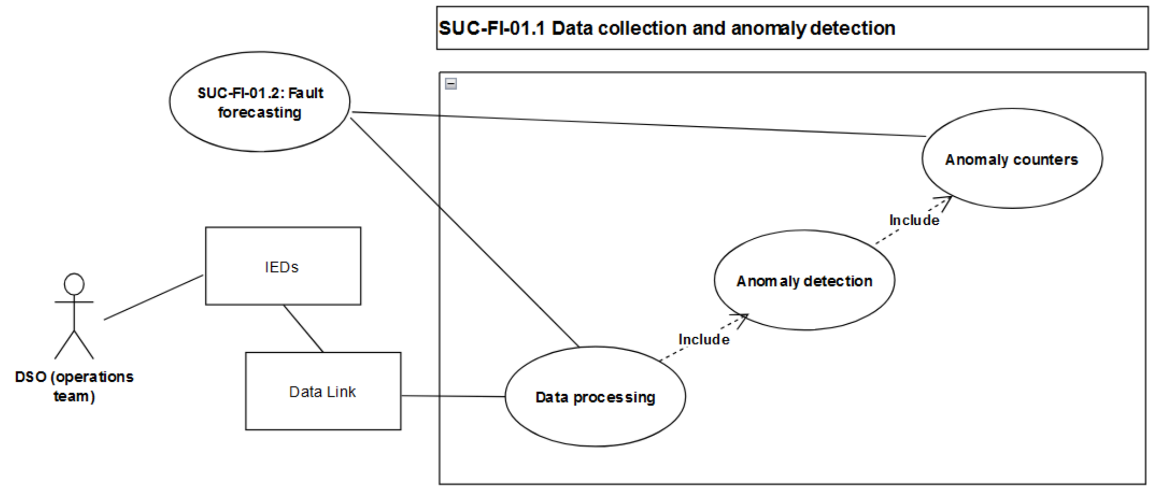


FIGURE 1: UML USE CASE DIAGRAM

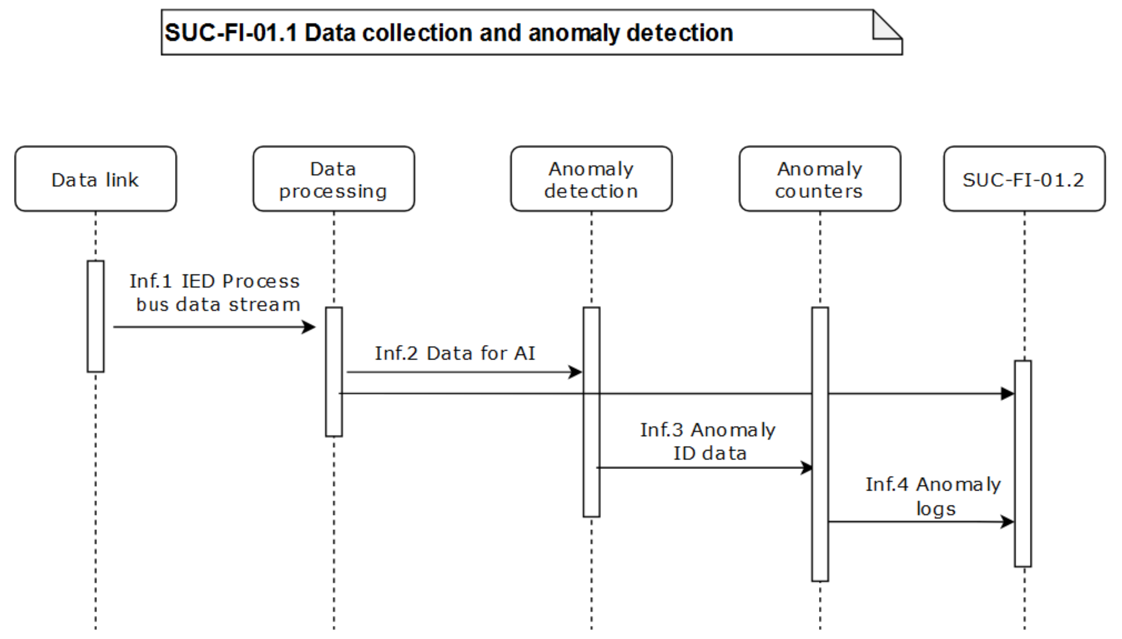


FIGURE 2: UML SEQUENCE DIAGRAM

3 Technical details

3.1 Actors

Actors			
Actor Name	***Actor Type***	***Actor Description***	***Further information specific to this use case***
DSO	Business actor	A party responsible for operating, ensuring the maintenance of, and, if necessary, developing the system in a given area and, where applicable, its interconnections with other systems, and for ensuring the long-term ability of the system to meet	Järvi-Suomen Energia

		reasonable demands for the distribution of electricity.	
System provider	Business actor	The party providing grid automation and management system, and being able to provide the data needed through the data link.	ABB
Service provider	Logical actor	The party that is running this use case as a service. Can be a dedicated service provider focusing on this service, or can be part of other service provider's portfolio.	VTT for piloting

3.2 References

References						
No.	***Reference Type***	***Reference***	***Status***	***Impact on use case***	***Originator / organisation***	***Link***

4 Step by step analysis of use case

4.1 Overview of scenarios

Scenario conditions						
No.	**Scenario name**	**Scenario description**	**Primary actor**	**Triggering event**	**Pre-condition**	**Post-condition**
Sc.1	Data collection and processing	The system reads and monitors continuous process bus level data stream provided by IEDs. The data includes several measurements and indicators on a high metering frequency. The system analyses the data continuously and identifies any abnormalities. Indicators are stored for each anomaly detected. However full resolution data can not be stored.	Process	Continuous	Data stream available	Anomalies identified Anomaly counters updated

4.2 Steps – Scenarios

Scenario								
Scenario name:		Sc.1 Data collection and processing						
Step No.	**Event**	**Name of process/ activity**	**Description of process/ activity**	**Service**	**Information producer (actor)**	**Information receiver (actor)**	**Information Exchanged (IDs)**	**Requirement, R-IDs**
St.1	Time	Initiate the process	Initiating the function	Create	DSO	Process	Inf.1	QoS.1, QoS.2
St.2	Process	Data processing	Data stream being processed into indicators, clustered, etc. as needed	Execute	Process	Process	Inf.2	Sec.1, D.1, D.2, D.3
St.3	Process	Anomaly identification	Based on processed data, any abnormalities will be identified	Execute	Process	Process	Inf.3	O.1
St.4	Store	Store anomaly identification data	Any identified data will be stored into counters	Report	Process	Process	Inf.4	D.4

5 Information exchanged

Information exchanged			
Information exchanged (ID)	*Name of information*	*Description of information exchanged*	*Requirement, R-IDs*
Inf.1	IED process bus data stream	All measurements and data available through IEC61850 SMV and/or MMS, further processed into data link	QoS.1, QoS.2, Conf.1
Inf.2	Data in the format applicable for AI algorithm	Live data further processed into right format	Sec.1, D.1, D.2, D.3
Inf.3	Anomaly identificatory data	Dataset available for identified event	D.4
Inf.4	Anomaly log	Continuously updating log of identified abnormalities	D.4

6 Requirements

Quality of Service Requirements		
Categories ID	**Category name for requirements**	**Category description**
QoS	Quality of Service	Generic properties that service/SUC should provide – quality attributes.
Requirement R-ID	**Requirement name**	**Requirement description**
QoS.1	Accuracy of data requirements	Requires full-resolution data and full measurement accuracy
QoS.2	Frequency of data exchanges	Essentially continuous

Security Requirements		
Categories ID	**Category name for requirements**	**Category description**
Sec	Security	Authentication of user, confidentiality, integrity, prevention of denial of service, non-repudiation or accountability, error management.
Requirement R-ID	**Requirement name**	**Requirement description**
Sec.1	Information integrity	Data stream integrity is essential. Missing or frozen data must be noted.

Data Management Requirements		
Categories ID	**Category name for requirements**	**Category description**
D	Data Management	Type of source of data, correctness or validity of data, timeliness or time stamping of data, volume of data, synchronization, or consistency of data across systems, timely access to data, validation of data across organizational boundaries, transaction management, data naming, identification, formats across disparate systems, maintenance of data and databases.
Requirement R-ID	**Requirement name**	**Requirement description**

D.1	Quality of data	Data timestamped and of proper quality, with indication of missing datapoints
D.2	Correctness of source data	Source data is always correct (e.g. by definition)
D.3	Format for AI algorithm input	Determined format for algorithm input
D.4	Format for anomaly log defined	Determined format for the log available

Discovery and Configuration Requirements		
Categories ID	**Category name for requirements**	**Category description**
Conf	Configuration	Locations, distances, communication layout, commonly used communication protocol media, network bandwidth, existing protocols, number of devices, systems, volume of data items, expected growth, etc.
Requirement R-ID	**Requirement name**	**Requirement description**
Conf.1	Commonly used communication protocol	IEC61850-9.2

Other Requirements		
Categories ID	**Category name for requirements**	**Category description**
O	Other requirements	Other requirements
Requirement R-ID	**Requirement name**	**Requirement description**
O.1	Adequate computational power	Capability to process detailed data stream on EDGE level at the substation

7 Common Terms and Definitions

Common Terms and Definitions	
Term	**Definition**
AI	Artificial Intelligence
BUC	Business use case
DMS	Distribution management system
DSO	Distribution system operator
IED	Intelligent Electronic Device
ML	Machine learning
MV	Medium voltage
SCADA	Supervisory Control and Data Acquisition
SUC	System use case

2 SUC-FI-01.2 – FAULT FORECASTING

1 Description of the use case

1.1 Name of the use case

ID	Area / Domain(s) / Zones(s)	Name of Use Case
SUC-FI-01.2	Energy system / Distribution grid / Distribution management	Fault forecasting

1.2 Version management

Version Management			
Version No.	**Date**	**Name of Author(s)**	**Changes**
V1	16.05.2024	Kari Mäki (VTT), Sayawu Diaba (VTT)	First version
V2	26.06.2024	Kari Mäki (VTT)	Major changes, including merging of SUCs
V3	21.08.2024	Kari Mäki (VTT)	Revised according to comments
V4	13.09.2024	Kari Mäki (VTT)	Revised according to comments
V5	16.09.2024	Kari Mäki (VTT)	New requirements format included

1.3 Scope and objectives of use case

Scope and Objectives of Use Case	
Scope	Methodology for decision making based on identified anomalies
Objective(s)	Objectives 1. Drawing decisions based on anomaly logs and data stream 2. Issuing status signal and warnings to the user 3. Triggering the fault recording process timely
Related business case(s)	BUC-FI-01 Anomaly detection and fault forecasting to increase medium voltage (MV) distribution network resilience

1.4 Narrative of use case

Narrative of Use Case
Short description
The purpose is to offer new tools for network operators to manage grid faults and improve system resilience. The opportunity revolves around existing data stream providing full resolution details that enable advanced analytics. This use case will monitor the indicators stored by previous SUC step, while at the same time it will perform analysis on the live data stream. The ultimate target is to define which situations fulfill the criteria to be flagged as potential faults that will require actions. The purpose of the SUC is to apply latest edge capabilities within the substation, where the stored indicators as well as full resolution data stream is available and perform online decision making that uses full details and thus also forecast events that are slowly building up in the grid.

This analysis should serve two purposes: to provide grid operators with early warnings concerning certain grid parts, and to trigger the detailed fault package recording at the correct timing.
Complete description
Overall, the piloted solution will improve grid operators' awareness and ability to prepare for and react to disturbances and faults in a timelier manner. The use case will focus on the possibilities of utilizing stored indicator values and full-resolution data streams at the substation bus level for improved analytics and to be able to make decisions on different situations and their severity. Different faults and incidents taking place in the Medium Voltage (MV) distribution grid often develop over time. Typical examples include cable insulation faults that evolve slowly or breaker malfunctions, which initially appear as slower opening or closing times before failure. Also, transformer faults are often preceded by a temperature rise. Many of these parameters are measured continuously; for instance, cable feeder harmonics or partial discharge measurements can indicate a developing insulation fault. Likewise, breaker operation times are monitored. By combining different data sources, new methods for identifying phenomena in the grid can be discovered. However, monitoring faults that evolve over different time scales remains challenging. The approach is to provide an early warning system for the grid operator If there is a warning about an impending fault on specific parts of the grid, the operator can take preparatory measures, such as performing grid topology changes to move important customers to another feeder, or otherwise attempt to limit the risk area. At the same, manual inspections or closer examination of measurements can be conducted to detect the problematic area. This could be implemented as “traffic light” model for the operator room: the system would display green-yellow-red light for specific grid parts, thus improving the operator’s awareness. As the system is a warning system and not a direct protection function, false triggers can also be tolerated to certain level. In practice, the system would be self-learning, using reinforcement learning solutions based on operator feedback to improve the model. With this approach, the main idea is to apply machine learning to decide which situations should be flagged towards DSO and grid service providers as potential faults. In this sense, the system does not need to know exactly what type of fault is about to occur, but instead detect that system is not in its normal state. At the same, a supporting dataset including the reasoning will be provided to the user in order to support the follow-up actions. **Main steps:** 1. Decision making 2. Event dataset composition 3. Status information and warning issuance 4. Fault recording triggering **Main technologies:** • IEDs providing full detail data, • ML for decision making **Main infrastructure:** • EDGE server • Data link for input • SCADA for output

1.5 Key performance indicators (KPI)

ID	Name	Description	Reference to mentioned use case objectives
KPI11	*Increased grid operational performance*	The system will improve grid resilience by offering improved monitoring and fault prediction	Objectives 1, 2, 3
KPI4	*Real-time data sharing among stakeholders*	The system relies on real-time data available through data link interface and provides up-to-date information for user	Objective 2

1.6 Use case conditions

Use case conditions
Assumptions
• Indicator data from SUC-FI-01.1 is continuously available and updated • Live data stream is available • Adequate computational power is present
Prerequisites
Precondition: Processed data stream is available. Indicator data is available. Computational power is adequate Postcondition: Potential faults and events are flagged as warnings towards DSO operations

1.7 Further Information to the use case for classification / mapping

Classification Information
Relation to other use cases
Linked to SUC-FI-01.1 • Getting the anomaly detection data as an input Linked to BUC-FI-01.1 • Executing the second part of the BUC process
Level of depth
Prioritisation
Generic, regional or national relation
Nature of the use case
Further keywords for classification

1.8 General Remarks

General Remarks

2 Diagrams of use case

Diagram(s) of use case

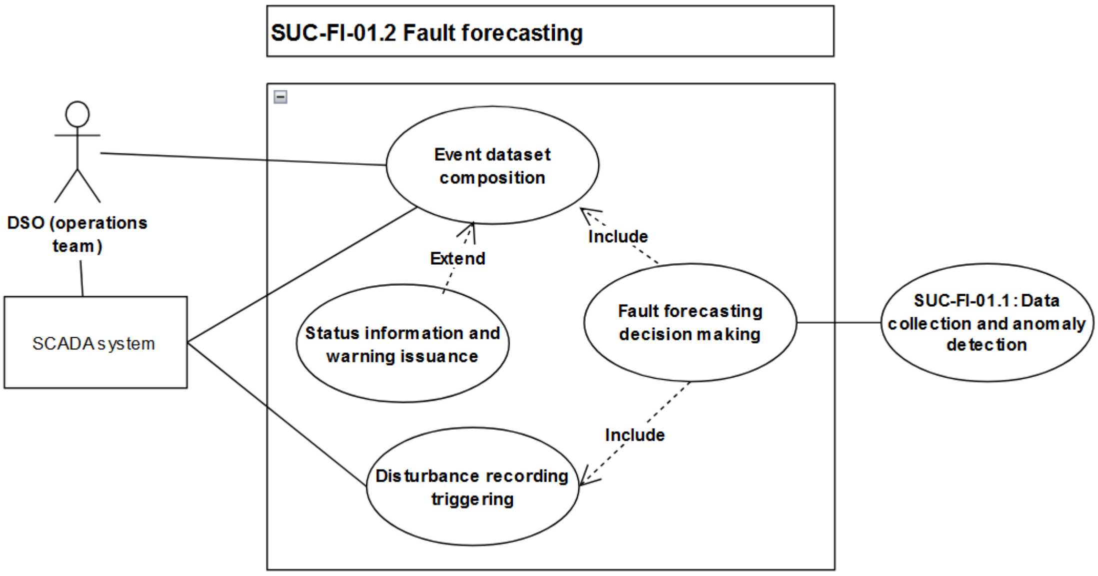


FIGURE 3: UML USE CASE DIAGRAM

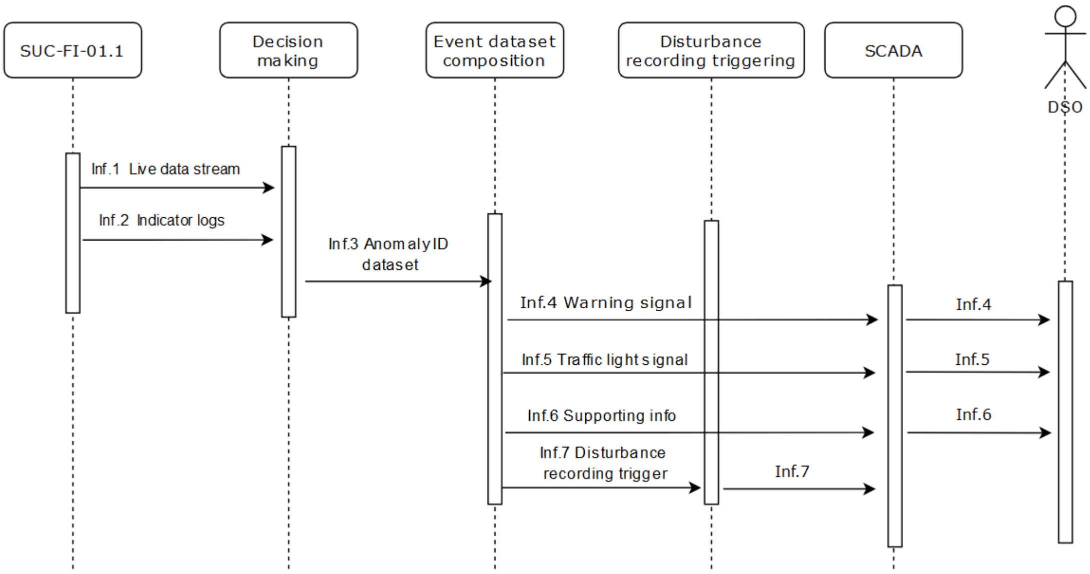


FIGURE 4: UML SEQUENCE DIAGRAM

3 Technical details

3.1 Actors

Actors			
Actor Name	***Actor Type***	***Actor Description***	***Further information specific to this use case***
DSO	Business actor	A party responsible for operating, ensuring the maintenance of, and, if necessary, developing the system in a given area and, where applicable, its interconnections with other systems, and for ensuring the long-term ability of the system to meet reasonable demands for the distribution of electricity.	Järvi-Suomen Energia
System provider	Business actor	The party providing grid automation and management system, and being able to provide the data needed through the data link.	ABB
Service provider	Logical actor	The party that is running this use case as a service. Can be a dedicated service provider focusing on this service, or can be part of other service provider's portfolio.	VTT for piloting

3.2 References

References						
No.	***Reference Type***	***Reference***	***Status***	***Impact on use case***	***Originator / organisation***	***Link***

4 Step by step analysis of use case

4.1 Overview of scenarios

Scenario conditions						
No.	**Scenario name**	**Scenario description**	**Primary actor**	**Triggering event**	**Pre-condition**	**Post-condition**
Sc.1	Fault forecasting	The system performs the analysis for detecting different types of anomalies. This includes identifying outliers, trends, and patterns that deviate from normal operational parameters.	Process	Continuous	Data processing and indicators available from SUC-FI-01.1	Warning and event dataset issued when thresholds reached

4.2 Steps – Scenarios

Scenario								
Scenario name:		Sc.1 Fault forecasting						
Step No.	***Event***	***Name of process/ activity***	***Description of process/ activity***	***Service***	***Information producer (actor)***	***Information receiver (actor)***	***Information Exchanged (IDs)***	***Requirement, R-IDs***
1	Time	Initiation	Initiation of the function	Create	Process	Process	Inf.1 Inf.2	D.1, QoS.1, QoS.2
2	Process	Run decision making algorithm	Based on the indicator data and current status of the live data stream, the system draws decisions whether the status should be flagged	Execute	Process	Process	Inf.3	O.1, QoS.2, D.2
3	Inform	Issue warnings and supporting information	Where flagged, provide user with warning and supporting dataset	Report	Process	DSO operations	Inf.4 Inf.5 Inf.6	D.3
4	Trigger	Trigger disturbanc e recording	Where flagged, provide a trigger signal for disturbance recording	Report	Process	SCADA	Inf.7	D.4

5 Information exchanged

Information exchanged			
Information exchanged (ID)	*Name of information.*	*Description of information exchanged*	*Requirement, R-IDs*
Inf.1	Anomality identification log	Log data from SUC-FI-01.1	D.1
Inf.2	Live data stream	Processed live data stream from SUC-FI-01.1	QoS.1, QoS.2
Inf.3	Anomality identification dataset	Indicators and dataset for identified anomality	D.3
Inf.4	Warning signal	Event notification	D.3
Inf.5	Traffic light signal	Status of traffic light (green/yellow/red)	D.3
Inf.6	Supporting information	Information on involved grid part, fault type, duration, etc.	D.3
Inf.7	Disturbance recording trigger	Disturbance recording trigger	D.4

6 Requirements

Quality of Service Requirements		
Categories ID	**Category name for requirements**	**Category description**
QoS	Quality of Service	Generic properties that service/SUC should provide – quality attributes.
Requirement R-ID	**Requirement name**	**Requirement description**
QoS.1	Accuracy of data requirements	Requires full resolution data and full measurement accuracy
QoS.2	Frequency of data exchanges	Essentially continuous

Security Requirements		
Categories ID	**Category name for requirements**	**Category description**
Sec	Security	Authentication of user, confidentiality, integrity, prevention of denial of service, non-repudiation or accountability, error management.
Requirement R-ID	**Requirement name**	**Requirement description**
Sec.1	Information integrity	Data stream integrity is essential. Missing or frozen data must be noted.

Data Management Requirements		
Categories ID	**Category name for requirements**	**Category description**
D	Data Management	Type of source of data, correctness or validity of data, timeliness or time stamping of data, volume of data, synchronization, or consistency of data across systems, timely access to data, validation of data across organizational boundaries, transaction management, data naming, identification, formats across disparate systems, maintenance of data and databases.

Requirement R-ID	Requirement name	Requirement description
D.1	Anomaly identification log available	Log data available and up to date from SUC-FI-01.1
D.2	Correctness of source data	Source data is always correct (e.g. by definition)
D.3	Defined format and interface	Formats and interfaces defined for issuing warnings, traffic lights and supporting information
D.4	Disturbance recording triggering	Format and interface defined for triggering the disturbance recording

Discovery and Configuration Requirements		
Categories ID	**Category name for requirements**	**Category description**
Conf	Configuration	Locations, distances, communication layout, commonly used communication protocol media, network bandwidth, existing protocols, number of devices, systems, volume of data items, expected growth, etc.
Requirement R-ID	**Requirement name**	**Requirement description**
Conf.1	Commonly used communication protocol	IEC61850-9.2

Other Requirements		
Categories ID	**Category name for requirements**	**Category description**
O	Other requirements	Other requirements
Requirement R-ID	**Requirement name**	**Requirement description**
O.1	Adequate computational power	Capability to process detailed data stream on EDGE level at the substation

7 Common Terms and Definitions

Common Terms and Definitions	
Term	**Definition**
AI	Artificial Intelligence
BUC	Business use case
DMS	Distribution management system
DSO	Distribution system operator
IED	Intelligent Electronic Device
ML	Machine learning
MV	Medium voltage
SCADA	Supervisory Control and Data Acquisition
SUC	System use case

3 SUC-FI-02.1 – CONGESTION PREDICTION IN DISTRIBUTION GRIDS

1 Description of the use case

1.1 Name of the use case

ID	Area / Domain(s) / Zones(s)	Name of Use Case
SUC-FI-02.1	Distribution grid	Congestion prediction in distribution grids

1.2 Version management

Version Management			
Version No.	**Date**	**Name of Author(s)**	**Changes**
V0.1	15.05.2024	Mehdi Attar (TAU)	Drafting section 1.4
V0.2	05.06.2024	Mehdi Attar	Drafting sections 2 and 3.1
V0.3	17.06.2024	Mehdi Attar, Sami Repo (TAU), Anna Kulmala (ABB), Antti Mutanen (ABB)	Drafting sections 4 and 5, improving sections 1,2 and 3
V0.4	16.07.2024	Mehdi Attar, Sami Repo	Completing all necessary sections
V1	07.08.2024	Mehdi Attar	Finalizing and improving the feel and look

1.3 Scope and objectives of use case

Scope and Objectives of Use Case	
Scope	DSO's congestion prediction in the day ahead timeframe
Objective(s)	The use case objective from DSO's perspective is: 1. Predict the grid congestion for the coming day
Related business case(s)	BUC-FI-02

1.4 Narrative of use case

Narrative of Use Case
Short description
For effective congestion management (CM), a Distribution System Operator (DSO) must function within both predictive and real-time frameworks. In each timeframe, two pivotal steps are crucial: i) monitoring the grid's state and ii) promptly implementing corrective actions if congestion occurs. This specific use case operates within the predictive timeframe, emphasizing proactive observation. It enables the DSO to forecast the grid's status for upcoming operations, typically the following day, and assess whether congestion is expected. By leveraging the insights derived from this use case, the DSO can identify grid conditions, identify potential congestion, and, if detected, utilize another use case (SUC-FI-02.2) for informed decision-making and corrective actions. This use case will only be simulated in the pilot.
Complete description

To identify any probable congestion situation in the grid, the DSO needs to perform two main tasks: i) forecasting the state of the grid, such as voltages and currents across the entire grid, and, ii) comparing the grid's actual state against its forecasted limits. By determining the grid's limits (e.g., the maximum current capacity of conductors) using dynamic line rating (DLR) technology, the DSO can compare the forecasted grid state with these limits and predict whether congestion will happen.

Considering DLR technology, incorporating weather data in the predictive analysis is valuable because the grid's limits are influenced by weather conditions. For example, in extremely cold weather, a pole-mounted transformer in the distribution grid can handle more current capacity compared to when the ambient temperature is high. This could impact whether a predicted grid state is perceived as congested or not.

From a functional perspective, the use case is presented in more detail in the following two steps:

1- **Grid state forecasting:**

Grid state forecasting involves a function that forecasts the load and generations of the grid. By forecasting the loads and generations, the DSO can perform a predictive power flow to obtain the voltages and currents in the grid. Forecasting the loads and generation depends on weather forecasts and electricity market prices. Therefore, load and generation forecasting needs two inputs: weather forecast and electricity prices. A weather forecast is needed because different weather conditions (e.g., weather temperature) affect electricity consumption, which impacts the grid's voltages and currents. A price forecast is needed because some customers may have electricity contracts with their retailer based on spot market prices, making them reactive to fluctuations in electricity market price. When electricity prices are low, customers may consume more, and when prices are high, they may consume less, impacting the grid's voltages and currents. Once the load and generation values are forecasted, grid state forecasting associates them with grid data (topology of the grid, characteristics such as impedances) and then performs a predictive power flow.

2- **Comparing the grid state forecast and forecasted grid limits**

The grid limits forecaster aims to predict the operational limits of the grid. This function is performed by the DLR technology provider, and its output will be used in this use case. The DLR only concerns the current capacity of the grid component, and the assumption is that the voltage limitations are fixed based on standard EN50160 [1]. By knowing the boundaries of grid operation, it becomes possible to anticipate whether the forecasted state of the grid in step 1 can cause congestion.

1.5 Key performance indicators (KPI)

ID	Name	Description	Reference to mentioned use
1	KPI9	Flexibility unlocked and transacted in markets	Objective 1+ SUC-FI-02.02's Objec
2	KPI17	Increased flexibility incorporation enabled by IoT/Edge technologies for grid security	Objective 1+ SUC-FI-02.02's Objec
3	KPI22	Increase Distributed Energy Resources (DERs) participation in flexibility provision	Objective 1+ SUC-FI-02.02's Objec

1.6 Use case conditions

Use case conditions
Assumptions
• The DSO is interested in knowing the state of its grid operation in the future to enhance predictability
Prerequisites
• The DSO must have the functional capability to perform load and generation forecasting, as well as predictive power flow • The DSO must have the data necessary for performing the load and generation forecasting and predictive power flow

1.7 Further Information to the use case for classification / mapping

Classification Information
Relation to other use cases
The output of this use case will be used in SUC-FI-02.02.
Level of depth
Prioritisation
Generic, regional or national relation
Nature of the use case
Further keywords for classification

1.8 General Remarks

General Remarks

2 Diagrams of use case

Diagram(s) of use case

Figure 5Figure 6 illustrates the functionalities and actors involved in implementing the congestion prediction use case (UC). For the load and generation forecasting, inputs from a weather forecaster, price forecaster, and data hub are required. A weather forecaster, which may be a private company or a public institution, provides weather-related forecast data such as wind speed, wind direction, ambient temperature, and solar irradiance. For example, the Finnish Meteorological Institute, a government agency, supplies weather forecasts that can be used for load and generation forecasting. Similarly, electricity price data is provided by a price forecast service, which could be, in this case, the Nord Pool's website, where day-ahead market prices are available. The data hub provides information on the history of loads and generation. Load and generation forecasting can then predict the values based on the inputs provided by the actors, as shown in the figure.

Once a time series of load and generation is available, grid state forecasting performs a predictive power flow using the grid model coming from a distributed management system (DMS), which includes grid topology and component characteristics (impedance of cables, transformers, etc), for every time step of its data. If the resolution of the forecast data is 10 minutes, there will be six values for the grid state variable (e.g., voltage and current) for each forecast hour. Finally, the congestion prediction compares the current values generated by grid state forecasting to the grid limits predicted by the DLR technology. The voltage forecast values are compared with the allowable voltage limits defined in EN50160. The comparison is conducted in steps, starting from the nearest prediction to the last row of the time series. This UC will output data future congestion is foreseen, including the location, intensity, time, and duration of the congestion problem.

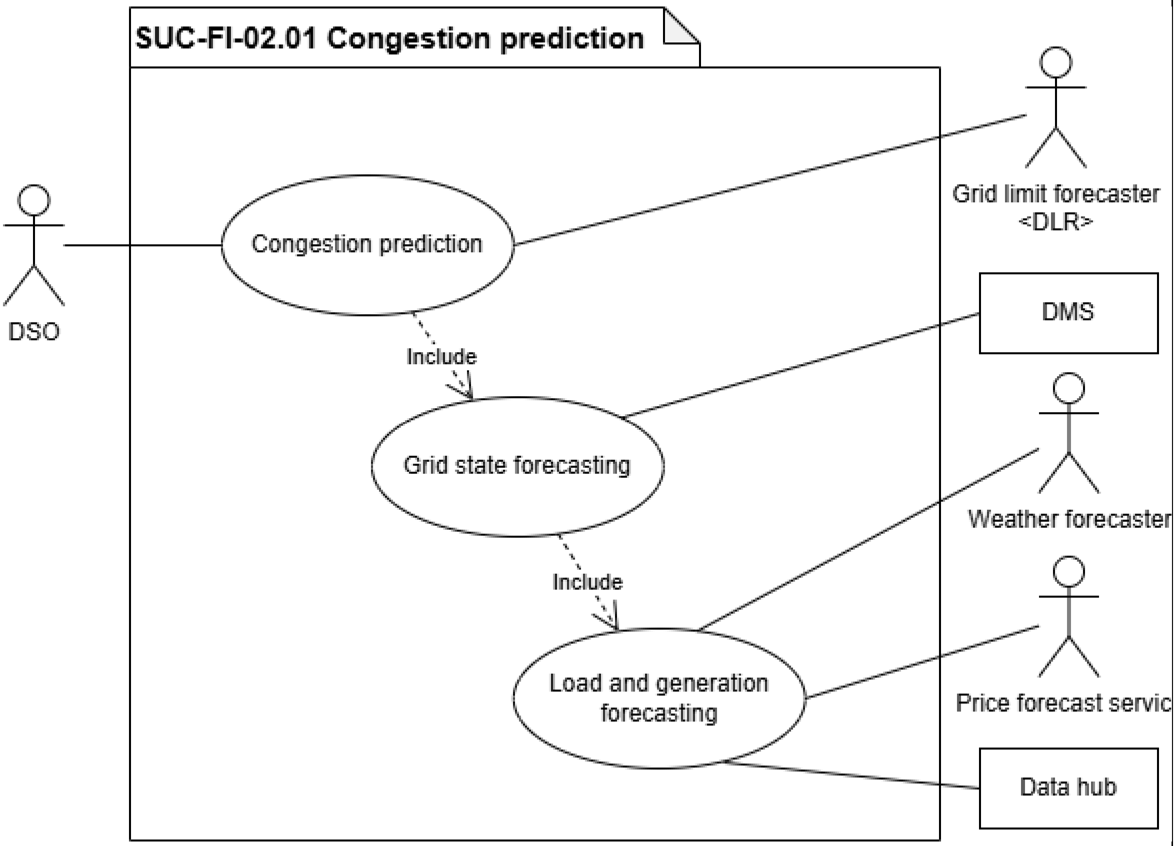


FIGURE 5: UML USE CASE DIAGRAM

3 Technical details

3.1 Actors

Actors			
Actor Name	***Actor Type***	***Actor Description***	***Further information specific to this use case***
DSO	Operator	A party responsible for operating, ensuring the maintenance of and, if necessary, developing the system in a given area and, where applicable, its interconnections with other systems, and for ensuring the long-term ability of the system to meet reasonable demands for the distribution of electricity.	The pilot's DSO is the Finnish DSO "Järvi-Suomen Enegia," which operates in Eastern Finland.
Weather forecaster	Operator	A party that forecasts the weather conditions.	The weather forecaster is the "Finnish Meteorological Institute".
Grid limit forecaster	Operator	A party that performs DLR functionality and provides the grid's capacity values.	The DLR technology.
Price forecast service	Operator	A party that forecasts the electricity market prices.	The price of the day ahead market is obtained from "Nord Pool".
Data hub	Logical actor	A system that stores the values of loads and generations and can share the data with authorized users.	-
DMS	Logical actor	A system that is run by DSO that performs several functions in grid operation.	Trimble software.

3.2 References

References						
No.	***Reference Type***	***Reference***	***Status***	***Impact on use case***	***Originator / organisation***	***Link***
1	Standard	Voltage characteristics of electricity supplied from the general distribution network	Available online			https://sales.sfs.fi/fi/index/tuotteet/SFSsahko/CENELEC/ID2/5/1230739.html.stx

4 Step by step analysis of use case

4.1 Overview of scenarios

Scenario conditions						
No.	**Scenario name**	**Scenario description**	**Primary actor**	**Triggering event**	**Pre-condition**	**Post-condition**
Sc. 1	Congestion prediction	The DSO aims to enhance the observability of its grid operation in the predictive time frame. The DSO performs a predictive power flow and compares the power flow results	DSO	Time	The DSO needs to have enough input data to perform the analysis. The input data are grid data,	-

		(state variables of the grid, such as voltage and current) with the grid limits. This would allow the DSO to observe in advance if there is any chance of congestion in its grid.			electricity market data, weather data, historical load and generation data, and grid limits data.	

4.2 Steps – Scenarios

Scenario								
Scenario name:		**Sc. 1. Congestion prediction**						
Step No.	**Event**	**Name of process/ activity**	**Description of process/ activity**	**Service**	**Information producer (actor)**	**Information receiver (actor)**	**Information Exchanged (IDs)**	**Requirement, R-IDs**
St.1	Time	Initiate the process	Initiating the prediction function	Create	DSO	Congestion prediction	Inf.1	Conf.1, Conf.2, QoS.2, QoS.3, Sec.3, Sec.4, D.1, D.4
St. 2	Initialization	Request grid state	Congestion prediction requests the calculation of the state forecast	Request	Congestion prediction	Grid state forecast	Inf. 2	Conf.1,Conf.2, QoS.2,QoS.3,Sec.3 ,Sec.4, D.1,D.4
St. 3	Request received	Request load+gen forecast	Grid state forecast requests the forecast values of loads and generations	Request	Grid state forecast	Load and generation forecast	Inf. 3	Conf.1,Conf.2,QoS. 2, QoS.3,Sec.3,Sec.4, D.1,D.4
St. 4	Request received	Request electricity price forecast	The load and generation forecast request the forecast values of electricity prices.	Request	Load and generation forecast	Price forecast service	Inf. 4	Conf.1, Conf.2, QoS.2, QoS.3,Sec.3,Sec.4, D.4, D.1
St. 5	Request received	Electricity price data	The electricity price forecast reports the time-series values of electricity prices.	Report	Price forecast service	Load and generation forecast	Inf. 5	Conf.1, Conf.2, QoS.1, QoS.2, QoS.3, Sec.2, Sec.3, D.1, D.2, D.3, D.4, D.5
St. 6	Request received	Request weather forecast	Load and generation forecast requests the weather-related forecast values.	Request	Load and generation forecast	Weather forecaster	Inf. 6	Conf.1, Conf.2, QoS.2, QoS.3,Sec.3,Sec.4, D.4, D.1
St. 7	Request received	Weather data	The weather forecast reports the time series of weather-related values.	Report	Weather forecaster	Grid state forecast	Inf. 7	Conf.1,Conf.2,QoS. 1, QoS.2,QoS.3,Sec.2, Sec.3, D.1, D.2, D.3, D.4, D.5
St. 8	Time	History of	The data hub provides the	Report	Data hub	Load and	Inf. 8	Conf.1,Conf.2,QoS.

		loads and generations values	historical values of loads and generations			generation forecast		1,QoS.2,QoS.3,Sec.2, Sec.3,D.1,D.2,D.3,D.4, D.5
St. 9	Request received	Forecast calculation	The load and generation forecast, calculates time series of load and generation values (kW) in the grid.	Execute	Load and generation forecast	Load and generation forecast	-	-
St. 10	Calculation ready	Load+gen data	The load and generation forecast reports the times series of loads and generations.	Report	Load and generation forecast	Grid state forecast	Inf. 10	Conf.1,Conf.2,QoS.1, QoS.2,QoS.3,Sec.1, Sec.2,Sec.3,Sec.4, D.1, D.2, D.3, D.4, D.5
St. 11	Time	Grid data	The DMS reports the grid data.	Report	DMS	Grid state forecast	Inf. 11	Conf.1,Conf.2, QoS.2,QoS.3,Sec.1, Sec.2, Sec.3, Sec.4, D.1, D.2, D.3, D.4, D.5
St. 12	Request message	Forecast calculation	The grid forecaster forecasts the grid state. The state variables of the grid, such as the grid's voltage and current, form a time series.	Execute	Grid state forecast	Grid state forecast	-	-
St. 13	Calculation ready	Grid state	The grid state forecaster reports the forecast for the grid state.	Report	Grid state forecast	Congestion prediction	Inf. 13	Conf.1,Conf.2,QoS.1,QoS.2,QoS.3,Sec.1,Sec.2,Sec.3,Sec.4 ,D.1,D.2,D.3, D.5
St. 14	Time	Grid limits data	The grid limits prediction, report the time series value of grid operational limits.	Report	Grid limits prediction	Congestion limits prediction	Inf. 14	Conf.1,Conf.2,QoS.1, QoS.2,QoS.3,Sec.1, Sec.2,Sec.3,Sec.4, D.1,D.2,D.3, D.4, D.5
St. 15	Grid state ready, grid limits data ready	Congestion prediction calculation	The congestion prediction compares the state of the grid with the grid limits and indicates if there is any	Execute	Congestion prediction	Congestion prediction	-	-

			violation.						

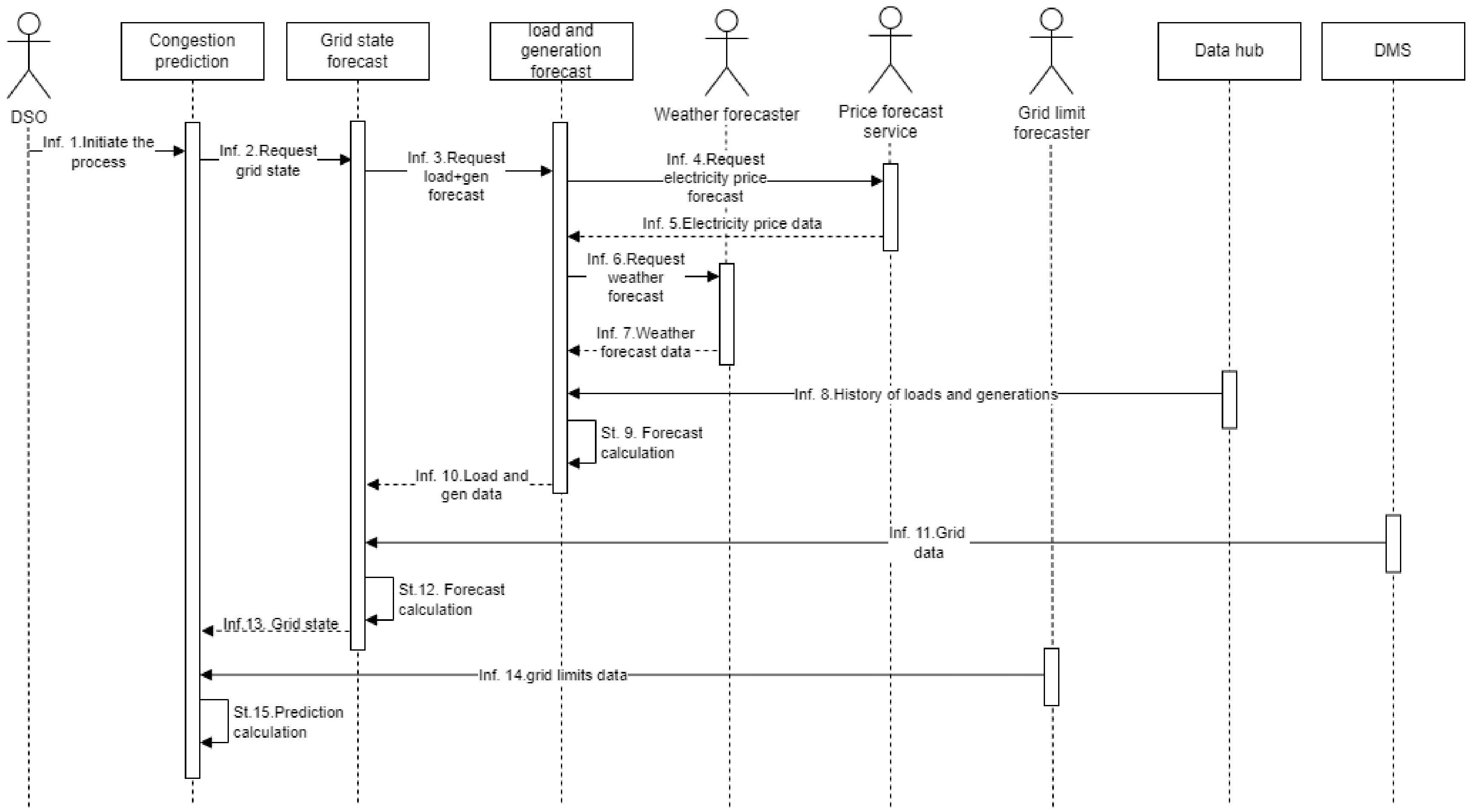


FIGURE 6: UML SEQUENCE DIAGRAM

5 Information exchanged

Information exchanged			
Information exchanged (ID)	**Name of information**	**Description of information exchanged**	**Requirement, R-IDs**
Inf. 1	Initiate the process	It is a time-triggered message indicating a need to perform congestion prediction functionality	Conf.1, Conf.2, QoS.2, QoS.3, Sec.3, Sec.4, D.1, D.4
Inf. 2	Request grid state	It is a request message	Conf.1,Conf.2, QoS.2,QoS.3,Sec.3,Sec.4, D.1,D.4
Inf. 3	Request load + generation forecast	It is a request message	Conf.1,Conf.2,QoS.2, QoS.3,Sec.3,Sec.4, D.1,D.4
Inf. 4	Request electricity price forecast	It is a request message	Conf.1, Conf.2, QoS.2, QoS.3,Sec.3,Sec.4,D.4, D.1
Inf. 5	Electricity price data	Time series of electricity prices for the future (e.g., 36 hours) and its history	Conf.1, Conf.2, QoS.1, QoS.2, QoS.3, Sec.2, Sec.3, D.1, D.2, D.3, D.4, D.5
Inf. 6	Request weather forecast	It is a request message	Conf.1, Conf.2, QoS.2, QoS.3,Sec.3,Sec.4, D.4, D.1
Inf. 7	Weather data	A time series of weather-related data for the future (e.g., 36 hours ahead) and history (e.g. 24 and 168 hours before). The data include attributes such as ambient temperature, wind speed and solar irradiance.	Conf.1,Conf.2,QoS.1, QoS.2,QoS.3,Sec.2, Sec.3, D.1, D.2, D.3, D.4, D.5
Inf. 8	History of loads and generations	A time series of historical values of loads and generations of the grid.	Conf.1,Conf.2,QoS.1,QoS.2,QoS.3,Sec.2, Sec.3,D.1,D.2,D.3,D.4, D.5
Inf. 10	Load+gen data	A time series of load and generation forecast values in kW. Each load and generation unit in the grid would have a separate time series, which might be aggregated for some loads/generators.	Conf.1,Conf.2,QoS.1, QoS.2,QoS.3,Sec.1, Sec.2,Sec.3,Sec.4,D.1, D.2, D.3, D.4, D.5
Inf. 11	Grid data	The data include grid topology and component characteristics (e.g., impedances). Only modifications of grid data are exchanged like change of switch status or added/removed components/customers. The grid data should include grid topologies of the prediction horizon including maintenance switching actions.	Conf.1,Conf.2, QoS.2,QoS.3,Sec.1, Sec.2, Sec.3, Sec.4, D.1, D.2, D.3, D.4, D.5
Inf. 13	Grid state	Time-series of state variables of the grid for the future (e.g., 36 hours), including voltage, current, active and reactive power	Conf.1,Conf.2,QoS.1,QoS.2,QoS.3,Sec.1,Sec.2,Sec.3,Sec.4,D.1,D.2,D.3, D.5
Inf. 14	Grid limits data	Time series of grid components' current capacity. Each critical grid component would have a separate time series.	Conf.1,Conf.2,QoS.1, QoS.2,QoS.3,Sec.1, Sec.2,Sec.3,Sec.4,D.1,D.2,D.3, D.4, D.5

6 Requirements

Requirements		
Categories ID	**Category name for requirements**	**Category description**
Conf	Configuration	Location, distances, communication layout, commonly used communication protocol media, network bandwidth, existing protocols, number of devices, systems, volume of data items, expected growth, etc.
Requirement R-ID	**Requirement name**	**Requirement description**
Conf.1	The operation mode of the information producer	Manual & Automatic
Conf.2	The operation mode of the information receiver	Manual & Automatic

Requirements		
Categories ID	**Category name for requirements**	**Category description**
QoS	Quality of service	Generic properties that service/SUC should provide – quality attributes.
Requirement R-ID	**Requirement name**	**Requirement description**
QoS.1	Elapsed time response requirements for exchanging data	Less than 1 second
QoS.2	Availability of information flows	99.9% + availability - Allowed outage: a few times per year, max 1 hour each.
QoS.3	Frequency of data exchange	Periodicity greater than a few minutes, OR upon event OR every few seconds.

Requirements		
Categories ID	**Category name for requirements**	**Category description**
Sec	Security	Authentication of user, confidentiality, integrity, prevention of denial of service, non-repudiation or accountability, error management.
Requirement R-ID	**Requirement name**	**Requirement description**
Sec.1	Eavesdropping	Ensuring confidentiality, avoiding illegitimate use of data, and preventing unauthorized reading of data.
Sec.2	Information integrity violation	Ensuring that data is not changed or destroyed.
Sec.3	Authentication	Ensuring that data comes from the stated source or goes to the authenticated receiver.
Sec.4	Information theft	Ensuring that data cannot be stolen or deleted by an unauthorized entity.

Requirements		
Categories ID	**Category name for requirements**	**Category description**
D	Data management	Type of source of data, correctness or validity of data, timeliness or time stamping of data, volume of data, synchronization or consistency of data

		across systems, timely access to data, validation of data across organizational boundaries, transaction management, data naming, identification, formats across disparate systems, maintenance of data and databases.
Requirement R-ID	**Requirement name**	**Requirement description**
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.
D.2	Up-to-date management	Received data must be up-to-date within seconds of source data changing.
D.3	Data consistency and synchronization management across systems	Second-by-second synchronization OR Day-by-day synchronization.
D.4	Management of data across organizational boundaries	Data exchanges go across boundaries between system developed by different vendors OR data exchanges go across organizational boundaries.
D.5	Naming of data items	Matching of names is handled by a "converter" at the Information Receiver.

7 Common Terms and Definitions

Common Terms and Definitions	
Term	**Definition**
DSO	Distribution system operator
CM	Congestion management
UC	Use case
DMS	Distribution management system
DLR	Dynamic line rating

4 SUC-FI-02.2 – CONGESTION MANAGEMENT PLANNING IN DISTRIBUTION GRIDS

1 Description of the use case

1.1 Name of the use case

ID	Area / Domain(s) / Zones(s)	Name of Use Case
SUC-FI-02.2	Distribution grid	Congestion management planning in distribution grids

1.2 Version management

Version Management			
Version No.	**Date**	**Name of Author(s)**	**Changes**
V0.1	15.05.2024	Mehdi Attar (TAU)	Drafting section 1.4
V0.2	05.06.2024	Mehdi Attar	Drafting sections 2 and 3.1
V0.3	17.06.2024	Mehdi Attar, Sami Repo (TAU), Anna Kulmala (ABB), Antti Mutanen (ABB)	Drafting sections 4 and 5, improving sections 1,2 and 3
V0.4	16.07.2024	Mehdi Attar, Sami Repo	Completing all necessary sections
V1	07.08.2024	Mehdi Attar	Finalizing and improving the feel and look

1.3 Scope and objectives of use case

Scope and Objectives of Use Case	
Scope	DSO's Congestion management (CM) planning in the day-ahead timeframe
Objective(s)	The use case objective from DSO's perspective is: 1. Enhance the preparedness of the grid operation for the coming day
Related business case(s)	BUC-FI-02

1.4 Narrative of use case

Narrative of Use Case
Short description
This use case (UC) requires inputs from SUC-FI-02.01 ,as CM planning is based on the information of the forecasted state of the grid. Suppose the forecasted grid state indicates a potential congestion case. In that case, this UC is used to determine the CM strategy and decide whether to utilize market-based flexibility, grid-side flexibility, or both. Market-based flexibility involves using a market such as the Local Flexibility Market (LFM) to procure flexibility in preparation for real-time congestion. Grid-side flexibility includes solutions based on the DSO's controllable elements that can help avoid congestion, such as reactive power control of capacitor banks or reactors, adjusting of onload tap changer (OLTC) transformers, grid reconfiguration, etc. Thus, this UC must determine the appropriate CM solution and act accordingly. For example, if the DSO

decides to participate in the LFM, it joins the LFM and procures flexibility. This UC will only be simulated in the pilot.
Complete description
When SUC-FI-02.01 indicates a probable congestion case, this UC is triggered. The UC must select the CM strategy and act accordingly in the second step. When deciding on a CM solution, the CM planning algorithm uses a rule-based method rather than optimization to evaluate and select the, since multiple CM solutions may be available. In the rule-based method, easier and cheaper solutions listed first, followed by more complex/costly solutions. The CM planning algorithm might first determine whether, for example, reactive power control can alleviate the congestion. A simulation is performed to assess whether reactive power control is sufficient; if not, the second solution, for example, utilizing LFM, is implemented, and this iterative process continues until either the congestion is resolved or no further CM solutions are available. The algorithm, based on its cost function and options, may have a list of several solutions. The algorithm goes through the list of items one by one and continues until the congestion is removed. When a solution is found, the algorithm instructs control room operator to act and provides control recommendations. Control recommendations may include a set point of grid components like tap changer control or flexibility-related data such as the amount of flexibility needed (kW), flexibility direction (up/down regulation), activation time, bidding area, etc. If the control room operator selects the market-based approach using the local flexibility market (LFM), the flexibility-related data is used to create flexibility requests. The market utilization algorithm generates a bid request containing the specified attributes and forwards them to LFM. Suppose the flexibility service providers (FSPs) participate in the LFM, and bid/s concerning the congestion problem are received. In that case, the CM planning algorithm selects from the bid pool and informs the market about it. If the control room operator selects the grid-side flexibility, the required information, such as the grid component setting, is stored for real-time action. Storing that information allows the control room operator to utilize it in real time if congestion appears. If the control room operator selects both market-based and grid-side flexibility, the instructions for both solutions are followed, as previously mentioned.

1.5 Key performance indicators (KPI)

ID	***Name***	***Description***	***Reference to mentioned use case objectives***
1	KPI9	Flexibility unlocked and transacted in markets	Objective 1+ SUC-FI-02.01's Objective 1
2	KPI17	Increased flexibility incorporation enabled by IoT/Edge technologies for grid security	Objective 1+ SUC-FI-02.01's Objective 1
3	KPI22	Increase DERs participation in flexibility provision	Objective 1+ SUC-FI-02.01's Objective 1

1.6 Use case conditions

Use case conditions
Assumptions
• The SUC-FI-02.01 provides inputs for this UC • The DSO is interested in acting in advance to enhance its preparedness
Prerequisites
• The DSO has a CM planning algorithm • The DSO has enough data for the CM planning algorithm to function

1.7 Further Information to the use case for classification / mapping

Classification Information
Relation to other use cases
This UC receives inputs from SUC-FI-02.01.
Level of depth
Prioritisation
Generic, regional or national relation
Nature of the use case
Further keywords for classification

1.8 General Remarks

General Remarks

2 Diagrams of use case

Diagram(s) of use case

Figure 7 illustrates the functionalities and actors involved in implementing the CM planning UC. The UC is triggered when a potential congestion is expected in the grid, as indicated by SUC-FI-02.01, as shown in the figure. The CM planning algorithm, depending on the available CM alternatives, may select grid-side flexibility, market-based flexibility, or both to resolve the congestion. For grid-side flexibility, the algorithm requires inputs such as grid data (e.g. characteristics of grid components, the topology of the grid, impedances, etc.) from the distribution management system (DMS). The algorithm also requires input from the flexibility register (FR) concerning flexibility-related data, such as the location of flexibility resources, their technical characteristics, qualification results, etc. The FR isa metadata register that contains information related to distributed energy resources (DERs). Utilizing the information from FR and DMS, the CM planning algorithm goes through a list of CM solutions one by one. At each step, the algorithm applies one CM alternative, runs a predictive power flow, and checks whether the CM is removed or not and that is why the algorithm continues until there is no congestion left or no CM alternative left in the list. It is important to note that the load and generation forecast values are also required for the predictive power flow to function. Since these values are already available in SUC-FI-02.01, they are not recalculated in this UC to avoid redundancy and are imported from SUC-FI-02.01.

Once the CM algorithm completes identifying CM alternatives, it sends control recommendations that reflect the chosen CM alternative/s to the control room operator. The operator selects from the list of recommendations, based on the situation and some external factor (e.g., experience). If market-based flexibility utilization is selected, the control room operator sends the information about the flexibility needed to the market-based flexibility utilization function, which manages message exchange with local flexibility market (LFM) operated by the Nominated Electricity Market Operator (NEMO). The market-based flexibility utilization algorithm informs the CM planning algorithm about the bids in the market, allowing the CM planning to create a merit order list of bids and select the desired one/s. Finally, the CM planning informs the market-based utilization algorithm about the selected bids, which are relayed to the NEMO to inform the FSPs about the taken bids. On the other hand, if the control room operator selects the grid-side flexibility utilization, the operator stores the control recommendations (e.g., the setpoint of controllable grid assets) to be used later on when congestion appears. In case both market-base and grid-side flexibility utilization are selected, both mentioned processes are followed.

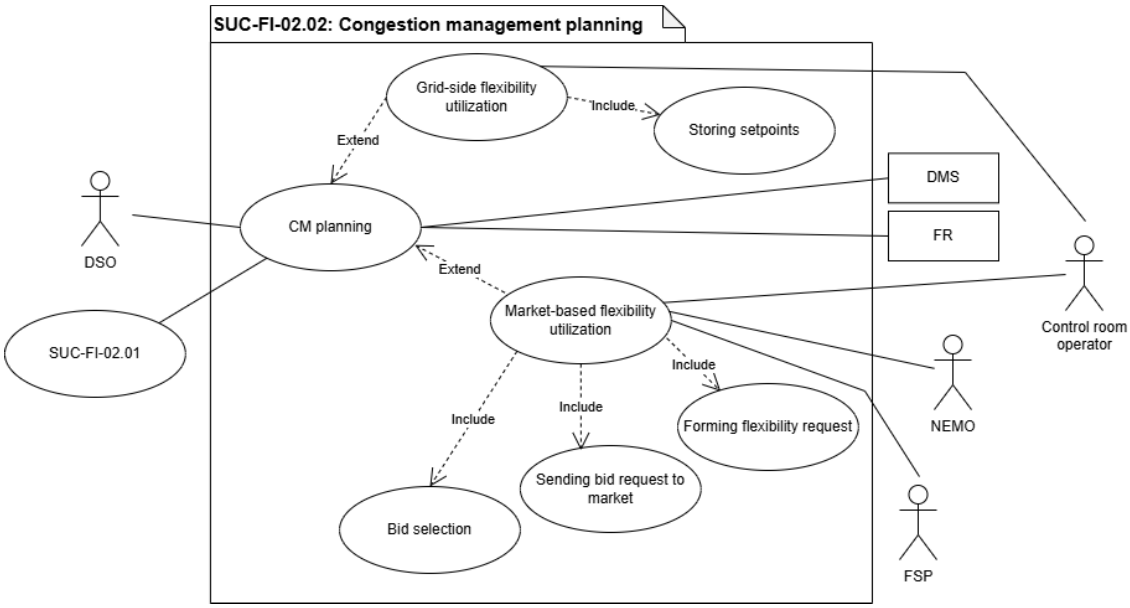


FIGURE 7: UML USE CASE DIAGRAM

3 Technical details

3.1 Actors

Actors			
Actor Name	***Actor Type***	***Actor Description***	***Further information specific to this use case***
DSO	Operator	A party responsible for operating, ensuring the maintenance of and, if necessary, developing the system in a given area and, where applicable, its interconnections with other systems, and for ensuring the long-term ability of the system to meet reasonable demands for the distribution of electricity.	The pilot's DSO is the Finnish DSO "Järvi-Suomen Enegia," which operates in Eastern Finland.
DMS	Logical actor	A system that is run by DSO that performs several functions in grid operation.	-
FR	Logical actor	A system that contains all the information concerning DERs, such as their technology, their location in the grid, qualification results, their characteristics (power in kW, volume in kWh, etc), FSP, etc.	The FR data for DER resources might be hardcoded in the pilot.
NEMO	Operator	A party that provides a service whereby the offers to sell flexibility/electricity are matched with bids to buy flexibility/electricity.	The market could be an LFM.
Control room operator	Operator	A human operator in the control room is responsible for monitoring the system and applying control decisions in real time.	-
FSP	Operator	A party that aggregates resources for usage by a service provider for market services.	The FSP can be a company that extracts flexibility from district heating technology.

3.2 References

References						
No.	***Reference Type***	***Reference***	***Status***	***Impact on use case***	***Originator / organisation***	***Link***

4 Step by step analysis of use case

4.1 Overview of scenarios

Scenario conditions						
No.	**Scenario name**	**Scenario description**	**Primary actor**	**Triggering event**	**Pre-condition**	**Post-condition**
Sc. 1	CM planning	The CM planning algorithm, based on the information from the congestion case, selects and recommends the CM alternative/s to	DSO	Congestion is expected to happen in the grid	The DSO has a congestion prediction algorithm	-

		the control room operator.				
Sc. 2	Market-based flexibility utilization	The control room operator, on behalf of DSO, participates in the market to procure flexibility.	DSO	The control room operator selects market-based flexibility	Congestion is foreseen, and CM planning has recommended the use of market-based flexibility	-
Sc. 3	Grid-side flexibility utilization	The control room operator stores the data required to realize grid-side flexibility.	DSO	The control room operator selects grid-based flexibility	Congestion is foreseen, and CM planning has recommended the use of grid-side flexibility	-

4.2 Steps – Scenarios

Scenario								
Scenario name:		**Sc. 1.CM planning**						
Step No.	**Event**	**Name of process/ activity**	**Description of process/ activity**	**Service**	**Information producer (actor)**	**Information receiver (actor)**	**Information Exchanged (IDs)**	**Requirement, R-IDs**
St.1	Congestion is predicted in SUC.FI.02.01	Data of congestion case/s	The congestion prediction algorithm reports the data of congestion case/s	Report	Congestion prediction	CM planning	Inf. 1	Conf.1,Conf.2,QoS.1,QoS.2, QoS.3,Sec.1, Sec.2, Sec.3, Sec.4,D.1, D.2,D.3,D.4,D.5
St. 2	Time	Grid data	The DMS reports the grid data	Report	DMS	CM planning	Inf. 2	Conf.1,Conf.2, QoS.2,QoS.3,Sec.1, Sec.2, Sec.3, Sec.4, D.1, D.2, D.3, D.4, D.5
St. 3	Time	DERs' data	The FR reports the DERs' data	Report	FR	CM planning	Inf. 3	Conf.1, Conf.2,QoS.1,QoS.2, QoS.3, Sec.1, Sec.2, Sec.3, Sec.4, D.1, D.2, D.3, D.4, D.5
St. 4	Congestion case/s received.	CM decision-making	The CM planning performs a predictive power flow while utilizing different CM alternatives to remove congestion	Execute	CM planning	CM planning	-	
St. 5	Calculation completed	Control recommendation/s	The CM planning forwards the control recommendations	Report	CM planning	Control room operator	Inf. 5	Conf.1, Conf.2,QoS.1,QoS.,QoS.3,Sec.1,Sec.2, Sec.3, Sec.4, D.1, D.2, D.3, D.4, D.5
St. 6	Control recommendations received	Alternative selection	The control room operator, from the list of control recommendations, selects desired CM alternative/s	Execute	Control room operator	Control room operator	-	

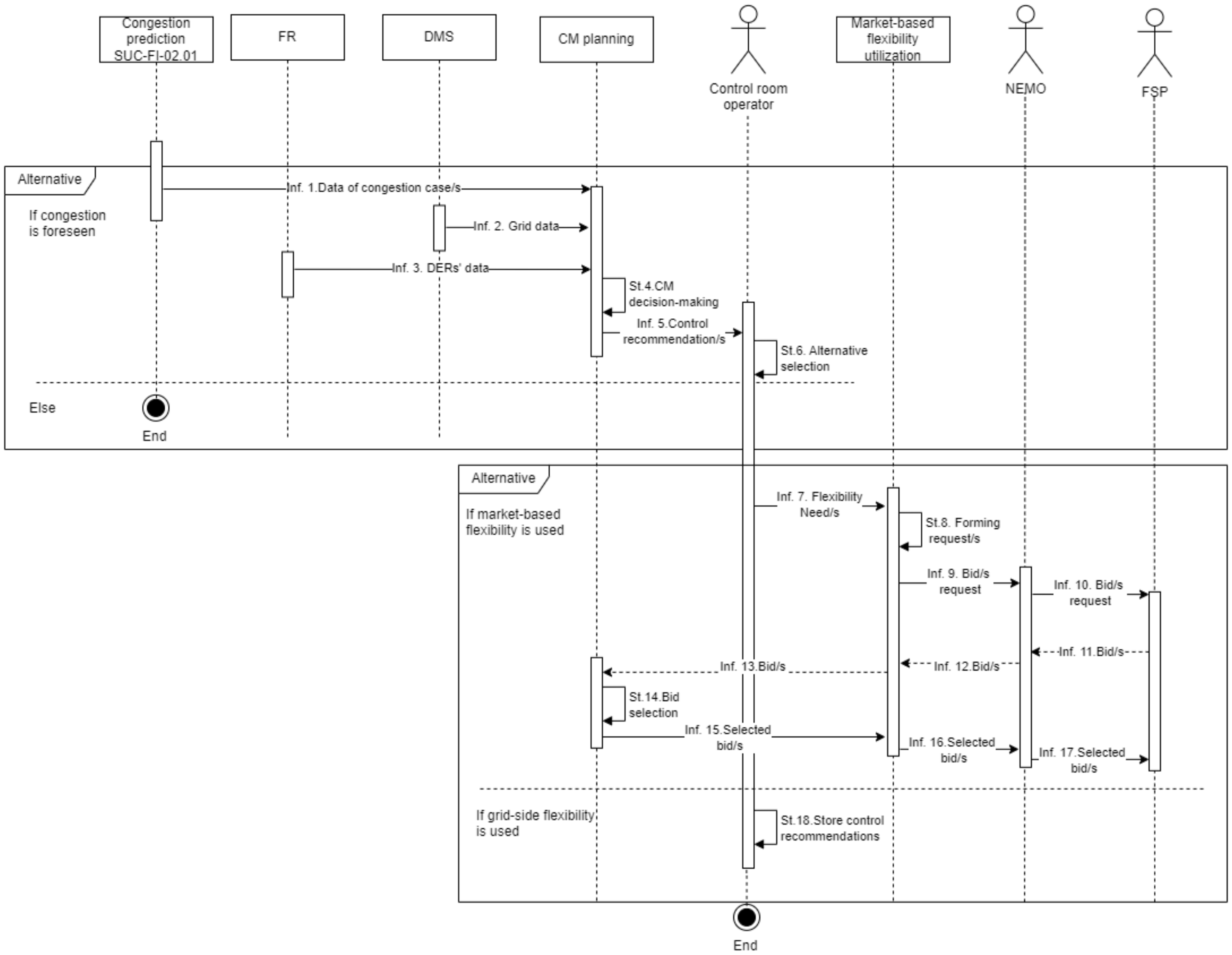


FIGURE 8: UML SEQUENCE DIAGRAM

Scenario								
Scenario name:		**Sc. 2: Market-based flexibility utilization**						
Step No.	**Event**	**Name of process/ activity**	**Description of process/ activity**	**Service**	**Information producer (actor)**	**Information receiver (actor)**	**Information Exchanged (IDs)**	**Requirement, R-IDs**
St.1	The market-based solution is selected in Sc. 1	Flexibility needs	The control room operator reports the flexibility needs	Report	Control room operator	Market-based flexibility utilization	Inf. 7, according to Fig. 2.	Conf.1, Conf.2,QoS.1,QoS.2, QoS.3, Sec.1, Sec.2, Sec.3, Sec.4, D.1, D.2, D.3, D.4, D.5
St. 2	Flexibility needs received	Forming request/s	The market-based flexibility utilization forms the flexibility request to be used in the market	Execute	Market-based flexibility utilization	Market-based flexibility utilization	-	
St. 3	Calculation completed	Bid/s request	The market-based flexibility utilization algorithm requests flexibility bids from the market	Request	Market-based flexibility utilization	NEMO	Inf. 9, according to Fig. 2	Conf.1, Conf.2,QoS.1,QoS.2, QoS.3, Sec.1, Sec.2, Sec.3, Sec.4, D.1, D.2, D.3, D.4, D.5
St. 4	Bid/s request received	Bid/s request	Market requests from FSPs to bid/s in response to bid/s request	Request	NEMO	FSP	Inf. 10, according to Fig. 2	Conf.1, Conf.2,QoS.1,QoS.2, QoS.3, Sec.1, Sec.2, Sec.3, Sec.4, D.1, D.2, D.3, D.4, D.5
St. 5	Bid/s request received	Bid/s	The FSP responds to the bid request	Report	FSP	NEMO	Inf. 11, according to Fig. 2	Conf.1, Conf.2,QoS.1,QoS.2, QoS.3, Sec.1, Sec.2, Sec.3, Sec.4, D.1, D.2, D.3, D.4, D.5
St. 6	Bid/s received	Bid/s	The market reports the bid/s to the CM planning	Report	NEMO	Market-based flexibility utilization	Inf. 12, according to Fig. 2	Conf.1, Conf.2,QoS.1,QoS.2, QoS.3, Sec.1, Sec.2, Sec.3, Sec.4, D.1, D.2, D.3, D.4, D.5
St. 7	Bid/s received	Bid/s	Market-based flexibility utilization reports the available bids in the market	Report	Market-based flexibility	CM planning	Inf. 13, according to Fig. 2	Conf.1, Conf.2,QoS.1,QoS.2, QoS.3, Sec.1, Sec.2,

					utilization			Sec.3, Sec.4, D.1, D.2, D.3, D.4, D.5
St. 8	Bid/s received	Bid selection	The CM planning selects from the bids	Execute	CM planning	CM planning	-	
St. 9	Bid selection calculation completed	Selected bid/s	The CM planning reports the selected bid/s	Report	CM planning	Market-based flexibility utilization	Inf. 15, according to Fig. 2	Conf.1, Conf.2,QoS.1,QoS.2, QoS.3, Sec.1, Sec.2, Sec.3, Sec.4, D.1, D.2, D.3, D.4, D.5
St. 10	Bid/s received	Selected bid/s	The Market-based flexibility utilization reports the selected bids	Report	Market-based flexibility utilization	NEMO	Inf. 16, according to Fig. 2	Conf.1, Conf.2,QoS.1,QoS.2, QoS.3, Sec.1, Sec.2, Sec.3, Sec.4, D.1, D.2, D.3, D.4, D.5
St. 11	Selected bid/s received	Selected bid/s	The market informs the FSPs about selected bids	Report	NEMO	FSP	Inf. 17, according to Fig. 2	Conf.1, Conf.2,QoS.1,QoS.2, QoS.3, Sec.1, Sec.2, Sec.3, Sec.4, D.1, D.2, D.3, D.4, D.5

Scenario								
Scenario name:		***Sc. 3: Grid-side flexibility utilization***						
Step No.	***Event***	***Name of process/ activity***	***Description of process/ activity***	***Service***	***Information producer (actor)***	***Information receiver (actor)***	***Information Exchanged (IDs)***	***Requirement, R-IDs***
St.1	The grid-side flexibility solution is selected in Sc. 2.	Store control recommendations	The control room operator stores the control recommendation settings so that those settings can be taken into use if congestion happens in the future	Execute	Control room operator	Control room operator	-	

5 Information exchanged

Information exchanged			
Information exchanged (ID)	***Name of information***	***Description of information exchanged***	***Requirement, R-IDs***
Inf. 1	Data of congestion case/s	The data include congestion time, duration, intensity, location, and congestion ID.	Conf.1,Conf.2,QoS.1,QoS.2, QoS.3,Sec.1, Sec.2, Sec.3, Sec.4,D.1, D.2,D.3,D.4,D.5
Inf. 2	Grid's data	The data include grid topology and component characteristics (e.g., impedances). Only modifications of grid data are exchanged like change of switch status or added/removed components/customers. The grid data should include grid topologies of the prediction horizon including maintenance switching actions.	Conf.1,Conf.2, QoS.2,QoS.3,Sec.1, Sec.2, Sec.3, Sec.4, D.1, D.2, D.3, D.4, D.5
Inf. 3	DERs' data	The data include the location of DER resources in the distribution grid, technology, qualification results, availability, characteristics (energy, power, etc.), FSP, etc.	Conf.1, Conf.2,QoS.1,QoS.2, QoS.3, Sec.1, Sec.2, Sec.3, Sec.4, D.1, D.2, D.3, D.4, D.5
Inf. 5	Control recommendation/s	The data indicate whether flexibility from the market, grid, or both should be used. For each recommended solution, the message includes settings and required actions to realize the required control action/s.	Conf.1, Conf.2,QoS.1,QoS.2, QoS.3, Sec.1, Sec.2, Sec.3, Sec.4, D.1, D.2, D.3, D.4, D.5
Inf. 7	Flexibility needs	The data include activation time, volume, location, duration, and direction (up/down).	Conf.1, Conf.2,QoS.1,QoS.2, QoS.3, Sec.1, Sec.2, Sec.3, Sec.4, D.1, D.2, D.3, D.4, D.5
Inf 9, 10	Bid/s request	The data include activation time, volume, location, duration, direction (up/down), and congestion ID.	Conf.1, Conf.2,QoS.1,QoS.2, QoS.3, Sec.1, Sec.2, Sec.3, Sec.4, D.1, D.2, D.3, D.4, D.5
Inf. 11, 12, 13	Bid/s	The data include activation time, volume, location, duration, direction, price, congestion ID, bid ID.	Conf.1, Conf.2,QoS.1,QoS.2, QoS.3, Sec.1, Sec.2, Sec.3, Sec.4, D.1, D.2, D.3, D.4, D.5
Inf.15, 16, 17	Selected bid/s	Bid ID/s	Conf.1, Conf.2,QoS.1,QoS.2, QoS.3, Sec.1, Sec.2, Sec.3, Sec.4, D.1, D.2, D.3, D.4, D.5

6 Requirements

Requirements		
Categories ID	**Category name for requirements**	**Category description**

Conf	Configuration	Location, distances, communication layout, commonly used communication protocol media, network bandwidth, existing protocols, number of devices, systems, volume of data items, expected growth, etc.
Requirement R-ID	**Requirement name**	**Requirement description**
Conf.1	The operation mode of the information producer	Manual & Automatic
Conf.2	The operation mode of the information receiver	Manual & Automatic

Requirements		
Categories ID	**Category name for requirements**	**Category description**
QoS	Quality of service	Generic properties that service/SUC should provide – quality attributes.
Requirement R-ID	**Requirement name**	**Requirement description**
QoS.1	Elapsed time response requirements for exchanging data	Less than 1 second
QoS.2	Availability of information flows	99.9% + availability - Allowed outage: a few times per year, max 1 hour each.
QoS.3	Frequency of data exchange	Periodicity greater than a few minutes, OR upon event OR every few seconds.

Requirements		
Categories ID	**Category name for requirements**	**Category description**
Sec	Security	Authentication of user, confidentiality, integrity, prevention of denial of service, non-repudiation or accountability, error management.
Requirement R-ID	**Requirement name**	**Requirement description**
Sec.1	Eavesdropping	Ensuring confidentiality, avoiding illegitimate use of data, and preventing unauthorized reading of data.
Sec.2	Information integrity violation	Ensuring that data is not changed or destroyed.
Sec.3	Authentication	Ensuring that data comes from the stated source or goes to the authenticated receiver.
Sec.4	Information theft	Ensuring that data cannot be stolen or deleted by an unauthorized entity.

Requirements		
Categories ID	**Category name for requirements**	**Category description**
D	Data management	Type of source of data, correctness or validity of data, timeliness or time stamping of data, volume of data, synchronization or consistency of data across systems, timely access to data, validation of data across organizational

		boundaries, transaction management, data naming, identification, formats across disparate systems, maintenance of data and databases.
Requirement R-ID	**Requirement name**	**Requirement description**
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.
D.2	Up-to-date management	Received data must be up-to-date within seconds of source data changing.
D.3	Data consistency and synchronization management across systems	Second-by-second synchronization OR Day-by-day synchronization.
D.4	Management of data across organizational boundaries	Data exchanges go across boundaries between system developed by different vendors OR data exchanges go across organizational boundaries.
D.5	Naming of data items	Matching of names is handled by a "converter" at the information Receiver.

7 Common Terms and Definitions

Common Terms and Definitions	
Term	**Definition**
DSO	Distribution system operator
DER	Distributed energy resource
CM	Congestion management
UC	Use case
NEMO	Nominated electricity market operator
FSP	Flexibility service provider
FR	Flexibility register
DMS	Distribution management system
OLTC	Onload tap changer

5 SUC-FI-02.3 – STATE MONITORING OF THE DISTRIBUTION GRID

1 Description of the use case

1.1 Name of the use case

ID	*Area / Domain(s) / Zones(s)*	*Name of Use Case*
SUC-FI-02.03	Distribution grid	State monitoring of the distribution grid

1.2 Version management

Version Management			
Version No.	*Date*	*Name of Author(s)*	*Changes*
V0.1	15.05.2024	Mehdi Attar (TAU)	Drafting section 1.4
V0.2	05.06.2024	Mehdi Attar	Drafting sections 2 and 3.1
V0.3	17.06.2024	Mehdi Attar, Sami Repo (TAU), Anna Kulmala (ABB), Antti Mutanen (ABB)	Drafting sections 4 and 5, improving sections 1,2 and 3
V0.4	16.07.2024	Mehdi Attar, Sami Repo	Completing all necessary sections
V1	07.08.2024	Mehdi Attar	Finalizing and improving the feel and look

1.3 Scope and objectives of use case

Scope and Objectives of Use Case	
Scope	Distribution grid's state monitoring in real-time
Objective(s)	The use case objective from DSO's perspective is: 1. Enhance the observability of the grid congestion in real time
Related business case(s)	BUC-FI-02

1.4 Narrative of use case

Narrative of Use Case
Short description
This use case (UC) is similar to SUC-FI-02.01, with the main difference being that this UC is performed in real-time, while SUC-FI-02.01 is performed in the predictive time frame. This UC aims to enhance DSO's real-time observability of its grid as, without that, the DSO may not know whether the state of its grid is within an acceptable range or not. By using this UC, the DSO gains a better view of the state of its grid and, if congestion occurs, can use another use case (SUC-FI-02.04) for decision-making and control actions.
Complete description
This UC includes two main functions: estimating the state of the grid and comparing it with the grid limits (e.g., the current capacity of grid components). Estimating the state of the grid is performed under the state estimation function. Once the state of the grid is known, the values (voltages and currents) are compared with the grid limit values to evaluate whether the state of

the grid is in an acceptable range. The function to estimate the grid limits is performed by an actor called a grid limits estimator, which is based on an entity that realizes dynamic line rating (DLR) technology. Grid state monitoring, using these two functions, can observe the state of the grid in real-time. The two functionalities performed by state monitoring are described as follows: 1. Grid state estimation This functionality includes estimating the load and generation values (e.g., kW) across the grid as well as utilizing the online measurements from sensors located in different locations of the grid. The load and generation values estimations, as well as online measurements, allow the state estimation to estimate the grid's state in real time. 2. Comparing grid limits with state variables of grid operation The state monitoring functionality compares the values generated by grid state estimation (Step 1) with grid limits generated by the grid limits estimator actor and checks whether the grid is congested.

1.5 Key performance indicators (KPI)

ID	Name	Description	Reference to mentioned use case objectives
1	OB1	Different types of IoT/edge devices to be exploited in Demo Areas e.g., Smart Meter, HEMS, Sensors, inverter	Objective 1+SUC-FI-02.04's objective 1
2	KPI4	Real-time data sharing among stakeholders	Objective 1+ +SUC-FI-02.04's objective 1
3	KPI8	IoT/Edge/Fog sites uptime and availability	Objective 1+SUC-FI-02.04's objective 1

1.6 Use case conditions

Use case conditions
Assumptions
• The DSO is interested in knowing the state of its grid operation in real time to enhance observability
Prerequisites
• The DSO must have the online measurement values (e.g., voltage, current) and pseudo measurements (load and generation profiles) to perform a function to realize this UC • The DSO must have the functional capability to perform load and generation estimation, as well as grid state estimation

1.7 Further Information to the use case for classification / mapping

Classification Information
Relation to other use cases
The output of this use case will be used in SUC-FI-02.04
Level of depth
Prioritisation
Generic, regional or national relation
Nature of the use case

Further keywords for classification

1.8 General Remarks

General Remarks

2 Diagrams of use case

Diagram(s) of use case

Figure 9 illustrates the functionalities and actors involved in implementing the state monitoring UC. The state monitoring function includes comparing the grid state estimation with grid limits. This enables the state monitoring UC to observe the state of the grid and indicate if congestion is occurring. For the grid limits, the actor grid limits estimator performs the calculation and provides the current capacity of grid components based on DLR technology. The voltage limits are derived from the EN50160 [1] standard. The state monitoring utilizes the state estimation function to estimate the grid state.

The state estimation function essentially requires three inputs: online measurements, pseudo measurements, and grid data. Online measurements could come from IEDs of controllable devices (e.g., battery storage, tap changer transformer) and measurement devices (current transformers (CT), potential transformers (PTs), etc.) which are installed specifically for measurement. Online measurements from intelligent electronic devices (IEDs) and measurement devices are collected and provided to state estimation function. The pseudo measurement involves the estimation of load and generation values, and the load and profiling function obtains the historical values of load and generations from the data hub. The load and generation profiles are then used to estimate load and generation values in real time. Using the values of online and pseudo measurement, in addition to grid data from the distribution management system (DMS), the state estimation can perform its task. Finally, as previously mentioned, state monitoring compares the grid state variables with the grid limit values to determine whether congestion is present.

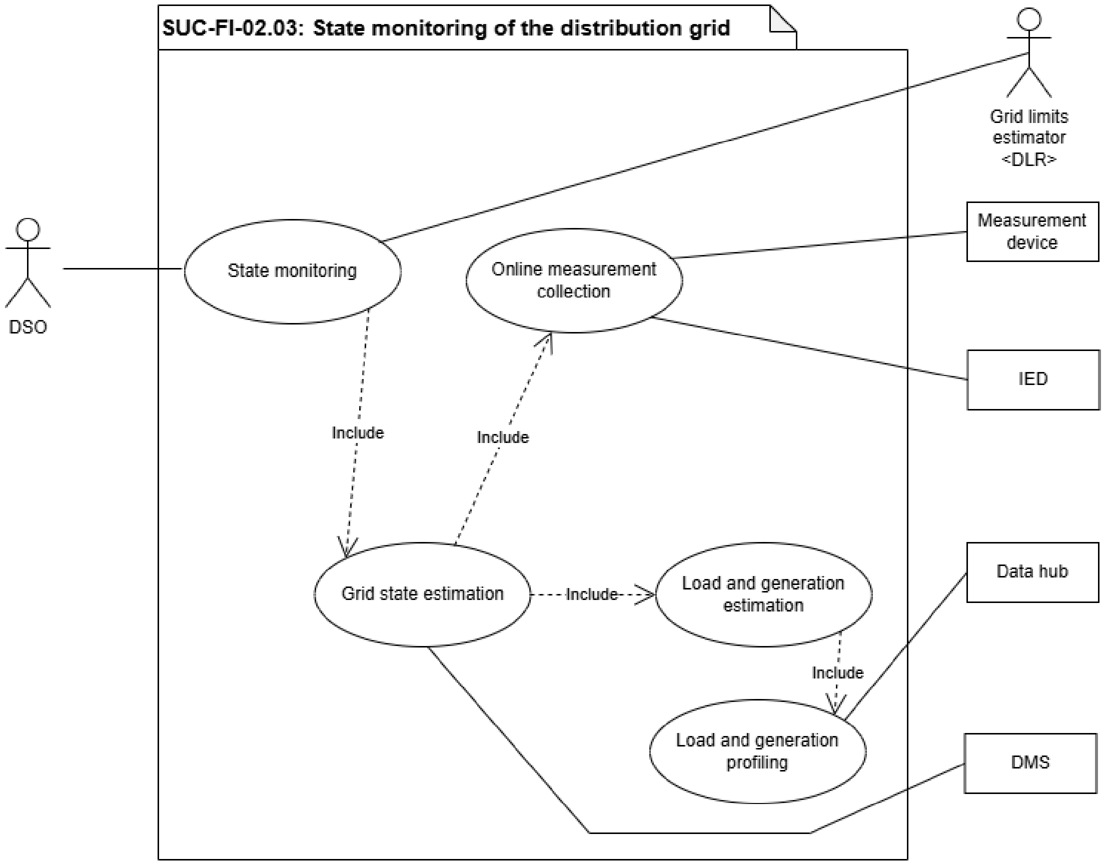


FIGURE 9: UML USE CASE DIAGRAM

3 Technical details

3.1 Actors

Actors			
Actor Name	***Actor Type***	***Actor Description***	***Further information specific to this use case***

Distribution System Operator (DSO)	Operator	A party responsible for operating, ensuring the maintenance of and, if necessary, developing the system in a given area and, where applicable, its interconnections with other systems, and for ensuring the long-term ability of the system to meet reasonable demands for the distribution or transmission of electricity.	The pilot's DSO is the Finnish DSO "Järvi-Suomen Enegia," which operates in Eastern Finland.
Data hub	Logical actor	A system that stores the values of loads and generations.	-
DMS	Logical actor	A system that is run by DSO that performs several functions in grid operation.	-
Grid limit estimator	Operator	A party that performs DLR functionality and provides the grid's capacity values.	The DLR technology
IED	Logical actor	A system that performs several functions such as measurement, monitoring, and control.	-
Measurement device	Logical actor	A device that measures a value in a system, for example, voltage magnitude, current, voltage angle, current angle, etc.	-

3.2 References

References						
No.	***Reference Type***	***Reference***	***Status***	***Impact on use case***	***Originator / organisation***	***Link***
1	Standard	Voltage characteristics of electricity supplied from the general distribution network	Available online			https://sales.sfs.fi/fi/index/tuotteet/SFSsahko/CENELEC/ID2/5/1230739.html.stx

4 Step by step analysis of use case

4.1 Overview of scenarios

Scenario conditions						
No.	**Scenario name**	**Scenario description**	**Primary actor**	**Triggering event**	**Pre-condition**	**Post-condition**
Sc. 1	Grid state observation	The DSO aims to enhance the observability of its grid operation in the real-time timeframe. The DSO performs a state estimation and compares the power flow results (state variables of the grid, such as voltage and	DSO	Time	The DSO needs to have enough input data to perform the analysis. The input data are grid data, online measurement data, and pseudo measurement data.	

		current) with the estimation of grid limits. This would allow the DSO to observe in real-time the state of the grid.				

4.2 Steps – Scenarios

Scenario								
Scenario name:		**Sc.1. Grid state observation**						
Step No.	**Event**	**Name of process/ activity**	**Description of process/ activity**	**Service**	**Information producer (actor)**	**Information receiver (actor)**	**Information Exchanged (IDs)**	**Requirement, R-IDs**
St.1	Time	Initiate the process	Initiating the prediction function	Create	DSO	State monitoring	Inf.1	Conf.1, Conf.2, QoS.2, QoS.3, Sec.3, Sec.4, D.1, D.4
St. 2	Initialization	Request grid state	State monitoring requests the calculation of the state estimation	Request	State monitoring	Grid state estimation	Inf. 2	Conf.1,Conf.2, QoS.2,QoS.3,Sec.3,Sec. 4, D.1,D.4
St. 3	Request received	Request load+gen values	Grid state estimation requests the estimated values of loads and generations	Request	Grid state estimation	Load and generation estimation	Inf. 3	Conf.1,Conf.2,QoS.2, QoS.3,Sec.3,Sec.4, D.1,D.4
St. 4	Request received	Request load and gen profiles	The load and generation estimation requests the profiles of loads and generations.	Request	Load and generation estimation	Load and generation profiling	Inf. 4	Conf.1,Conf.2,QoS.2, QoS.3,Sec.3,Sec.4, D.1,D.4
St. 5	Time	Historical values of loads and generations	The data hub reports the historical values of loads and generations	Report	Data hub	Load and generation profiling	Inf. 5	Conf.1,Conf.2,QoS.1,QoS. 2,QoS.3,Sec.2, Sec.3,Sec.4,D.1,D.2,D.3,D .4, D.5
St. 6	Request received	Profiling calculation	The load and generation profiling calculations are performed.	Execute	Load and generation profiling	Load and generation profiling	-	-
St. 7	Calculation ready and request received	Load and generation profiles	The load and generation profiling reports the values of profiles.	Report	Load and generation profiling	Load and generation estimation	Inf. 7	Conf.1,Conf.2,QoS.1, QoS.2,QoS.3,Sec.1, Sec.2,Sec.3,Sec.4,D.1, D.2, D.3, D.4, D.5
St. 8	Request received	Estimation calculation	The load and generation estimation calculation is performed	Execute	Load and generation estimation	Load and generation estimation	-	-
St. 9	Calculation ready	Load and generation	The load and generation estimation reports the values	Report	Load and generation	Grid state estimation	Inf. 9	Conf.1,Conf.2,QoS.1, QoS.2,QoS.3,Sec.1,

		values	of loads and generations.		estimation			Sec.2,Sec.3,Sec.4,D.1,D.2, D.3, D.4, D.5
St. 10	Time	Measurement data	The measurement device reports the measured values.	Report	Measurement device	Online measurement collection	Inf. 10	Conf.1,Conf.2,QoS.1, QoS.2,QoS.3,Sec.1, Sec.2,Sec.3,Sec.4,D.1,D.2, D.3, D.4, D.5
St. 11	Time	Measurement data	The IED reports the measured values.	Report	IED	Online measurement collection	Inf. 11	Conf.1,Conf.2,QoS.1, QoS.2,QoS.3,Sec.1, Sec.2,Sec.3,Sec.4,D.1,D.2, D.3, D.4, D.5
St. 12	Time	Measurement data	The online measurement data reports the collection of measured data.	Report	Online measurement collection	Grid state estimation	Inf. 12	Conf.1,Conf.2,QoS.1, QoS.2,QoS.3,Sec.1, Sec.2,Sec.3,Sec.4,D.1,D.2, D.3, D.4, D.5
St. 13	Time	Grid data	The DMS reports the grid data.	Report	DMS	Grid state estimation	Inf. 13	Conf.1,Conf.2,QoS.1, QoS.2,QoS.3,Sec.1, Sec.2,Sec.3,Sec.4,D.1,D.2, D.3, D.4, D.5
St. 14	Request received	Estimation calculation	The state estimation calculates the grid's state	Execute	Grid state estimation	Grid state estimation	-	-
St. 15	Calculation ready	Real-time grid state	The grid state estimator reports the grid state.	Report	Grid state estimator	State monitoring	Inf. 15	Conf.1,Conf.2,QoS.1, QoS.2,QoS.3,Sec.1, Sec.2,Sec.3,Sec.4,D.1,D.2, D.3, D.4, D.5
St. 16	Time	Grid limits data	The grid limits estimator reports the value of grid operational limits.	Report	Grid limits estimator	State monitoring	Inf. 16	Conf.1,Conf.2,QoS.1, QoS.2,QoS.3,Sec.1, Sec.2,Sec.3,Sec.4,D.1,D.2,D.3, D.4, D.5
St. 17	Grid state ready, grid limits data ready	Grid state analysis	The state monitoring compares the state of the grid with the grid limits and indicates if there is any violation.	Execute	State monitoring	State monitoring	-	-

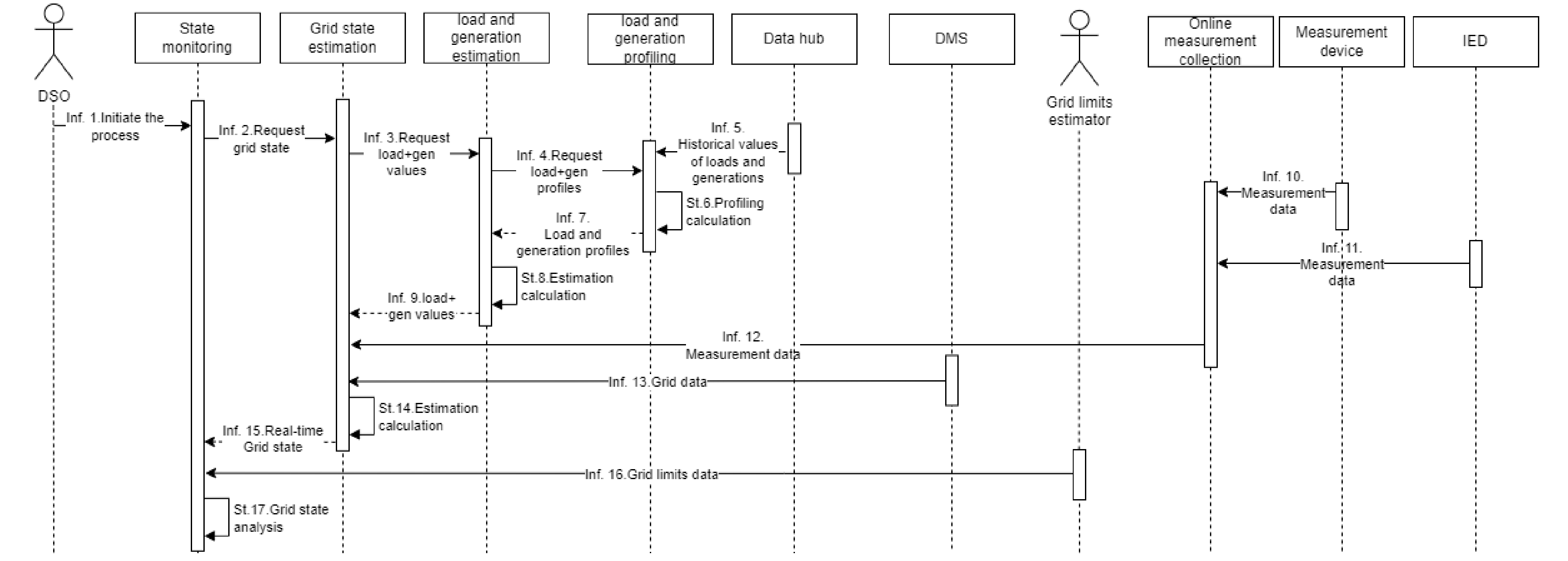


FIGURE 10: UML SEQUENCE DIAGRAM

5 Information exchanged

Information exchanged			
Information exchanged (ID)	***Name of information***	***Description of information exchanged***	***Requirement, R-IDs***
Inf. 1	Initiate the process	It is a time-triggered message indicating a need to perform congestion prediction functionality.	Conf.1, Conf.2, QoS.2, QoS.3, Sec.3, Sec.4, D.1, D.4
Inf. 2	Request grid state	It is a request message	Conf.1,Conf.2, QoS.2,QoS.3,Sec.3,Sec.4, D.1,D.4
Inf. 3	Request load and generation values	It is a request message	Conf.1,Conf.2,QoS.2, QoS.3,Sec.3,Sec.4, D.1,D.4
Inf. 4	Request load and generation profiles	It is a request message	Conf.1,Conf.2,QoS.2, QoS.3,Sec.3,Sec.4, D.1,D.4
Inf. 5	Historical values of loads and generations	The data includes a time series of historical values of load consumption (e.g., in kW) and generation production in (e.g., in kW).	Conf.1,Conf.2,QoS.1,QoS.2,QoS.3, Sec.2, Sec.3,Sec.4,D.1,D.2,D.3,D.4, D.5
Inf. 7	Load and generation profiles	The data includes a categorization and profiles of load and generation.	Conf.1,Conf.2,QoS.1, QoS.2,QoS.3,Sec.1, Sec.2,Sec.3,Sec.4,D.1, D.2, D.3, D.4, D.5
Inf. 9	Load and generation values	The data include an estimation of load and generation values in kW.	Conf.1,Conf.2,QoS.1, QoS.2,QoS.3,Sec.1, Sec.2,Sec.3,Sec.4,D.1,D.2, D.3, D.4, D.5
Inf. 10, 11, 12	Measurement data	The data include measurement values from IEDs/measurement devices across the grid.	Conf.1,Conf.2,QoS.1, QoS.2,QoS.3,Sec.1, Sec.2,Sec.3,Sec.4,D.1,D.2, D.3, D.4, D.5
Inf. 13	Grid data	The data include grid topology and component characteristics (e.g., impedances).	Conf.1,Conf.2, QoS.2,QoS.3,Sec.1, Sec.2, Sec.3, Sec.4, D.1, D.2, D.3, D.4, D.5
Inf. 15	Real-time grid state	State variables of the grid in real-time, including voltage, current, active and reactive power, etc.	Conf.1,Conf.2,QoS.1, QoS.2,QoS.3,Sec.1, Sec.2,Sec.3,Sec.4,D.1,D.2, D.3, D.4, D.5
Inf. 16	Grid limits data	The data include the values related to the grid components' current capacity. Each critical grid component would have a separate value.	Conf.1,Conf.2,QoS.1, QoS.2,QoS.3,Sec.1, Sec.2,Sec.3,Sec.4,D.1,D.2,D.3, D.4, D.5

6 Requirements

Requirements		
Categories ID	**Category name for requirements**	**Category description**
Conf	Configuration	Location, distances, communication layout, commonly used communication protocol media, network bandwidth, existing protocols, number of devices, systems, volume of data items, expected growth, etc.

Requirement R-ID	Requirement name	Requirement description
Conf.1	The operation mode of the information producer	Manual & Automatic
Conf.2	The operation mode of the information receiver	Manual & Automatic

Requirements		
Categories ID	**Category name for requirements**	**Category description**
QoS	Quality of service	Generic properties that service/SUC should provide – quality attributes.
Requirement R-ID	**Requirement name**	**Requirement description**
QoS.1	Elapsed time response requirements for exchanging data	Less than 1 second
QoS.2	Availability of information flows	99.9% + availability - Allowed outage: a few times per year, max 1 hour each.
QoS.3	Frequency of data exchange	Periodicity greater than a few minutes, OR upon event OR every few seconds.

Requirements		
Categories ID	**Category name for requirements**	**Category description**
Sec	Security	Authentication of user, confidentiality, integrity, prevention of denial of service, non-repudiation or accountability, error management.
Requirement R-ID	**Requirement name**	**Requirement description**
Sec.1	Eavesdropping	Ensure confidentiality, avoid illegitimate use of data, and prevent unauthorized reading of data.
Sec.2	Information integrity violation	Ensuring that data is not changed or destroyed.
Sec.3	Authentication	Ensuring that data comes from the stated source or goes to the authenticated receiver.
Sec.4	Information theft	Ensuring that data cannot be stolen or deleted by an unauthorized entity.

Requirements		
Categories ID	**Category name for requirements**	**Category description**
D	Data management	Type of source of data, correctness or validity of data, timeliness or time stamping of data, volume of data, synchronization or consistency of data across systems, timely access to data, validation of data across organizational boundaries, transaction management, data naming, identification, formats across disparate systems, maintenance of data and databases.
Requirement R-ID	**Requirement name**	**Requirement description**

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.
D.2	Up-to-date management	Received data must be up-to-date within seconds of source data changing.
D.3	Data consistency and synchronization management across systems	Second-by-second synchronization OR Day-by-day synchronization.
D.4	Management of data across organizational boundaries	Data exchanges go across boundaries between system developed by different vendors OR data exchanges go across organizational boundaries.
D.5	Naming of data items	Matching of names is handled by a "converter" at the Information Receiver.

7 Common Terms and Definitions

Common Terms and Definitions	
Term	**Definition**
DSO	Distribution system operator
CM	Congestion management
UC	Use case
DMS	Distribution management system
DLR	Dynamic line rating
IED	Intelligent electronic device
CT	Current transformer
PT	Potential transformer

6 SUC-FI-02.4 – CONGESTION MANAGEMENT DECISION-MAKING IN REAL-TIME

1 Description of the use case

1.1 Name of the use case

ID	Area / Domain(s) / Zones(s)	Name of Use Case
SUC-FI-02.4	Distribution grid	Congestion management decision-making in real-time

1.2 Version management

Version Management			
Version No.	**Date**	**Name of Author(s)**	**Changes**
V0.1	15.05.2024	Mehdi Attar (TAU)	Drafting section 1.4
V0.2	05.06.2024	Mehdi Attar	Drafting sections 2 and 3.1
V0.3	17.06.2024	Mehdi Attar, Sami Repo (TAU), Anna Kulmala (ABB), Antti Mutanen (ABB)	Drafting sections 4 and 5, improving sections 1,2 and 3
V0.4	16.07.2024	Mehdi Attar, Sami Repo	Completing all necessary sections
V1	07.08.2024	Mehdi Attar	Finalizing and improving the feel and look

1.3 Scope and objectives of use case

Scope and Objectives of Use Case	
Scope	DSO's Congestion management (CM) decision-making in the real-time timeframe
Objective(s)	The use case objective from DSO's perspective is: 1. Remove/alleviate congestion in the real-time operation of the grid
Related business case(s)	BUC-FI-02

1.4 Narrative of use case

Narrative of Use Case
Short description
This use case (UC) is triggered by SUC-FI-02.03. This UC is executed only when there is congestion in the grid. In that case, the UC aims to solve the congestion using controllable resources both from the grid and the market (e.g., local flexibility market (LFM)). Once the decision is made by the CM decision-making algorithm, the operator in the DSO's control room is informed about the corrective control action, and the operator decides whether to implement the corrective measure.
Complete description
If congestion occurs in the distribution grid, this UC is used to evaluate the list of potential CM solutions and verify whether those solutions can resolve the congestion. The DSO's control room operator is then informed about the selected CM solution/s, and the control action can be executed manually via the operator. The list of CM solutions could include reactive power control in the primary substation, online tap changer control (OLTC) transformer control, active power

curtailment of loads, etc. These solutions are under grid-side and market-based flexibility. Depending on the DSO's preference, the list of CM alternatives is numbered, so the easiest/cheapest solution is numbered first, followed by harder-to-realize/more expensive solutions. Whenever congestion occurs, the algorithm starts with the first option in the list and evaluates whether the solution is sufficient, until congestion is completely resolved, or the algorithm runs out of options. The benefit this approach is its simplicity and guaranteed convergence, both of which are important in real-time applications.

1.5 Key performance indicators (KPI)

ID	*Name*	*Description*	*Reference to mentioned use case objectives*
1	OB1	Different types of IoT/edge devices to be exploited in Demo Areas e.g., Smart Meter, HEMS, Sensors, inverter	Objective 1+SUC-FI-02.03's objective 1
2	KPI4	Real-time data sharing among stakeholders	Objective 1+SUC-FI-02.03's objective 1
3	KPI8	IoT/Edge/Fog sites uptime and availability	Objective 1+SUC-FI-02.03's objective 1

1.6 Use case conditions

Use case conditions
Assumptions
• The SUC-FI-02.03 provides inputs for this UC • The DSO is interested in acting in real-time to remove/alleviate congestion
Prerequisites
• The DSO has a CM decision-making algorithm • The DSO has enough data for the CM algorithm to function

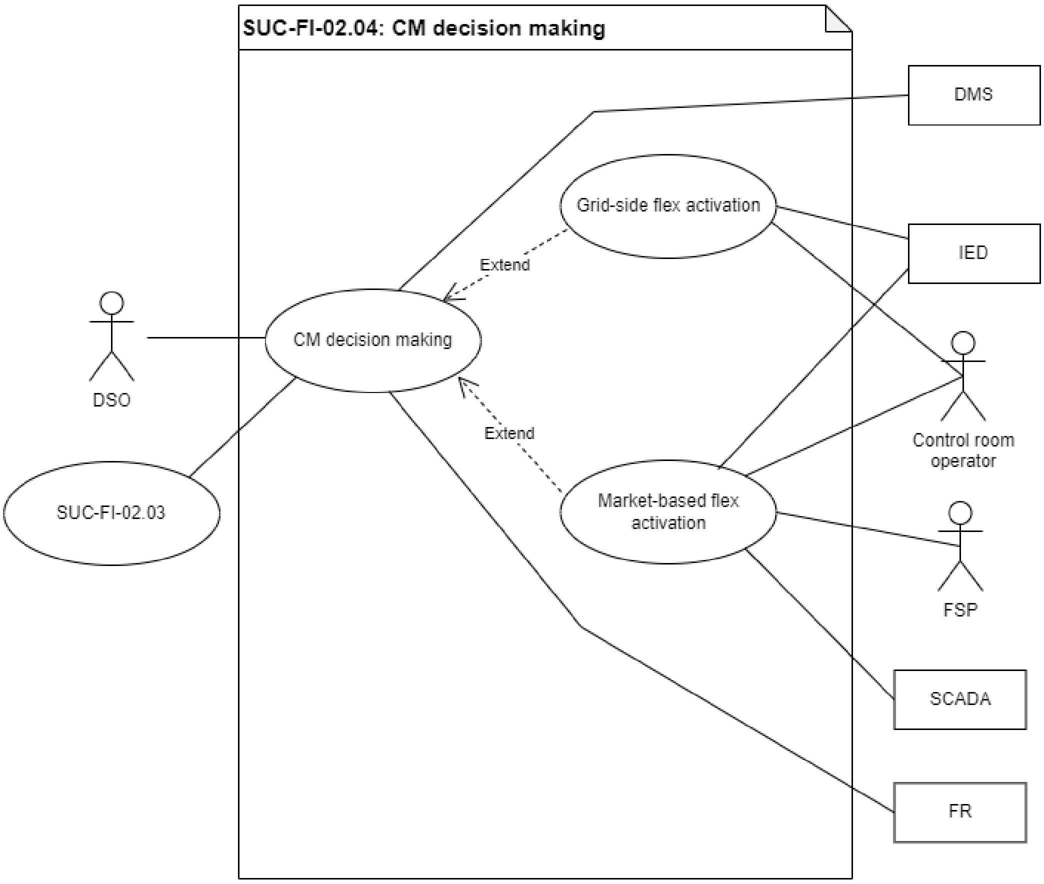
1.7 Further Information to the use case for classification / mapping

Classification Information
Relation to other use cases
This UC receives inputs from SUC-FI-02.03
Level of depth
Prioritisation
Generic, regional or national relation
Nature of the use case
Further keywords for classification

1.8 General Remarks

General Remarks

2 Diagrams of use case

Diagram(s) of use case
Figure 11 illustrates the functions and actors involved in CM decision-making. As shown, the DSO is the primary actor in the UC, and it is triggered by SUC-FI-02.03. When congestion is currently happening, for the DSO to perform CM decision-making, it needs DER information (e.g., availability, size, etc.) from the flexibility register (FR), as well as grid data (e.g., grid topology and component characteristics) from distribution management system (DMS). With both DERs' and grid data, the CM decision-making goes through a list of CM alternatives and evaluates each alternative separately. At each step, if the congestion is still present (based on simulations), the algorithm adds more alternatives to the existing ones. This process continues unless congestion is removed, or the algorithm runs out of available CM alternatives. Once the calculation is completed, the CM alternatives in the form of control recommendations are provided to the control room operator. The operator selects the desired alternatives based on the current circumstances of grid operation (e.g., experience and available data from other sources of information). If market-based flexibility activation is selected, the operator sends an activation request to DER's flexibility service provider (FSP). If grid-side flexibility is selected, the operator sends control commands through the supervisory control and data acquisition (SCADA) system to the controllable grid component. If both market-based and grid-side flexibility are used, both of them get activated.  FIGURE 11: UML USE CASE DIAGRAM

3 Technical details

3.1 Actors

Actors			
Actor Name	***Actor Type***	***Actor Description***	***Further information specific to this use case***
DSO	Operator	A party responsible for operating, ensuring the maintenance of and, if necessary, developing the system in a given area and, where applicable, its interconnections with other systems, and for ensuring the long-term ability of the system to meet reasonable demands for the distribution of electricity.	The pilot's DSO is the Finnish DSO "Järvi-Suomen Enegia," which operates in Eastern Finland.
DMS	Logical actor	A system that is run by DSO that performs several functions in grid operation.	-
FR	Logical actor	A system that contains all the information concerning DERs, such as their technology, their location in the grid, qualification results, their characteristics (power in kW, volume in kWh, etc.), FSP, etc.	The FR data for DER resources might be hardcoded in the pilot.
IED	Logical actor	A system that performs several functions such as measurement, monitoring, and control.	-
Control room operator	Operator	A human operator in the control room is responsible for monitoring the system and applying control decisions in real-time.	-
FSP	Operator	A party that aggregates resources for usage by a service provider for market services.	The FSP can be a company that extracts flexibility from district heating technology.
SCADA	Logical actor	A system run by DSO that gathers and analyses real-time data to monitor the state of the grid.	-

3.2 References

References						
No.	***Reference Type***	***Reference***	***Status***	***Impact on use case***	***Originator / organisation***	***Link***

4 Step by step analysis of use case

4.1 Overview of scenarios

Scenario conditions						
No.	**Scenario name**	**Scenario description**	**Primary actor**	**Triggering event**	**Pre-condition**	**Post-condition**
Sc. 1	CM decision making	The CM decision making algorithm, based on the information from the congestion	DSO	Congestion is currently happening in the grid	The DSO has state monitoring algorithm	

		case, recommends the CM alternative/s to the control room operator.				
Sc. 2	Market-based flexibility activation	The control room operator, on behalf of DSO, sends required commands for activation of flexibility.	DSO	The control room operator selects market-based flexibility.	Congestion is currently happening, and CM decision-making has recommended the use of market-based flexibility.	
Sc. 3	Grid-side flexibility activation	The control room operator sends required commands through SCADA to activate grid-side flexibility.	DSO	The control room operator selects grid-side flexibility	Congestion is currently happening, and CM decision-making has recommended the use of grid-side flexibility	

4.2 Steps – Scenarios

Scenario								
Scenario name:		**Sc. 1. CM decision making**						
Step No.	**Event**	**Name of process/ activity**	**Description of process/ activity**	**Service**	**Information producer (actor)**	**Information receiver (actor)**	**Information Exchanged (IDs)**	**Requirement, R-IDs**
St.1	Congestion is predicted in SUC.FI.02.03	Data of congestion case/s	The state monitoring algorithm reports the data of congestion case/s	Report	State monitoring	CM decision-making	Inf. 1	Conf.1,Conf.2,QoS.1,QoS.2, QoS.3,Sec.1, Sec.2, Sec.3, Sec.4,D.1, D.2,D.3,D.4,D.5
St. 2	Time	DERs' data	The FR reports the DERs' data.	Report	FR	CM decision-making	Inf. 2	Conf.1, Conf.2,QoS.1,QoS.2, QoS.3, Sec.1, Sec.2, Sec.3, Sec.4, D.1, D.2, D.3, D.4, D.5
St. 3	Time	Grid data	The DMS reports the grid data.	Report	DMS	CM decision-making	Inf. 3	Conf.1,Conf.2, QoS.2,QoS.3,Sec.1, Sec.2, Sec.3, Sec.4, D.1, D.2, D.3, D.4, D.5
St. 4	Congestion case/s received	Decision-making	The CM decision-making performs a power flow while utilizing different CM alternatives to remove congestion.	Execute	CM decision-making	CM decision-making	-	-
St. 5	Calculation completed	Control recommendation/s	The CM decision-making forwards the control recommendations.	Report	CM decision-making	CM decision-making	Inf. 5	Conf.1, Conf.2,QoS.1,QoS.2, QoS.3, Sec.1, Sec.2, Sec.3, Sec.4, D.1, D.2, D.3, D.4, D.5
St. 6	Control recommendations received	Alternative selection	The control room operator, from the list of control recommendations, selects desired CM alternative/s.	Execute	Control room operator	Control room operator	-	-

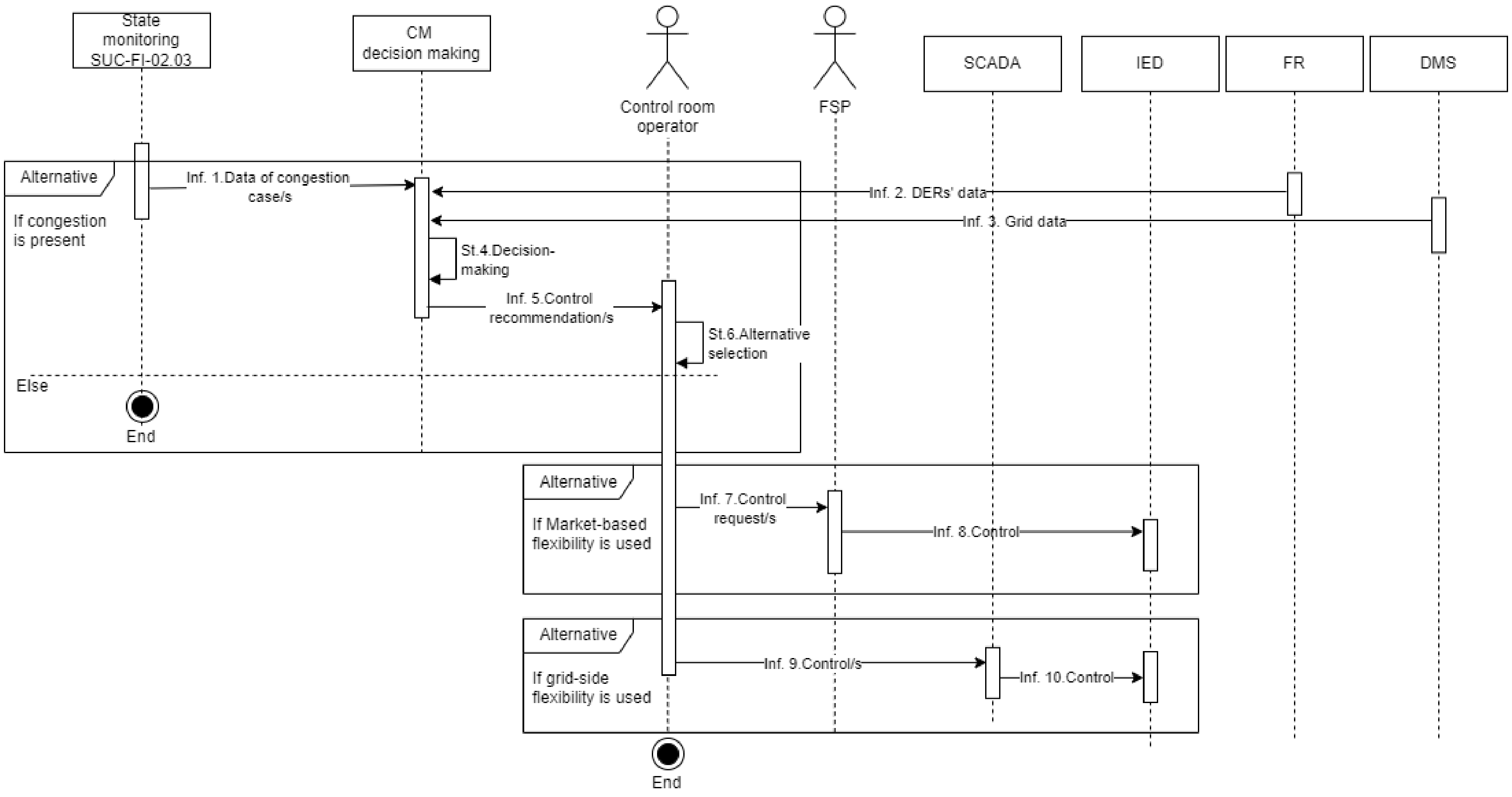


FIGURE 12: UML SEQUENCE DIAGRAM

Scenario								
Scenario name:		**Sc. 2: Market-based flexibility activation**						
Step No.	**Event**	**Name of process/ activity**	**Description of process/ activity**	**Service**	**Information producer (actor)**	**Information receiver (actor)**	**Information Exchanged (IDs)**	**Requirement, R-IDs**
St.1	The market-based solution is selected in Sc. 1	Control/s request	The control room operator reports the control requests.	Report	Control room operator	FSP	Inf. 7, according to Fig. 2.	Conf.1, Conf.2,QoS.1,QoS. 2, QoS.3, Sec.1, Sec.2, Sec.3, Sec.4, D.1, D.2, D.3, D.4, D.5
St. 2	Request received	Control	The FSP reports the control command.	Report	FSP	IED	Inf. 8, according to Fig. 2.	Conf.1, Conf.2,QoS.1,QoS. 2, QoS.3, Sec.1, Sec.2, Sec.3, Sec.4, D.1, D.2, D.3, D.4, D.5

Scenario								
Scenario name:		**Sc. 3: Grid-side flexibility activation**						
Step No.	**Event**	**Name of process/ activity**	**Description of process/ activity**	**Service**	**Information producer (actor)**	**Information receiver (actor)**	**Information Exchanged (IDs)**	**Requirement, R-IDs**
St.1	The grid-side flexibility solution is selected in Sc. 1.	Control	The control room operator reports the control commands.	Report	Control room operator	SCADA	Inf. 9, according to Fig. 2	Conf.1, Conf.2,QoS.1,QoS. 2, QoS.3, Sec.1, Sec.2, Sec.3, Sec.4, D.1, D.2, D.3, D.4, D.5
St. 2	Control command received	Control	The SCADA applies the control command.	Report	SCADA	SCADA	Inf. 10. According to Fig. 2	Conf.1, Conf.2,QoS.1,QoS. 2, QoS.3, Sec.1, Sec.2, Sec.3, Sec.4, D.1, D.2, D.3, D.4, D.5

5 Information exchanged

Information exchanged			
Information exchanged (ID)	**Name of information**	**Description of information exchanged**	**Requirement, R-IDs**
Inf. 1	Data of congestion case/s	The data include congestion time, duration, intensity, location, and congestion ID.	Conf.1,Conf.2,QoS.1,QoS.2, QoS.3,Sec.1, Sec.2, Sec.3, Sec.4,D.1, D.2,D.3,D.4,D.5
Inf. 2	DERs' data	The data include the location of DER resources in the distribution grid, technology, qualification results, availability, characteristics (energy, power, etc.), FSP, etc.	Conf.1, Conf.2,QoS.1,QoS.2, QoS.3, Sec.1, Sec.2, Sec.3, Sec.4, D.1, D.2, D.3, D.4, D.5
Inf. 3	Grid's data	The data include the topology of the distribution grid, characteristics (e.g., impedances) and grid components' information.	Conf.1,Conf.2, QoS.2,QoS.3,Sec.1,Sec.2, Sec.3, Sec.4, D.1, D.2, D.3, D.4, D.5
Inf. 5	Control recommendation/s	The data indicate whether flexibility from the market, grid, or both should be used. For each recommended solution, the message includes settings and required actions to realize the required control action/s.	Conf.1, Conf.2,QoS.1,QoS.2, QoS.3, Sec.1, Sec.2, Sec.3, Sec.4, D.1, D.2, D.3, D.4, D.5
Inf. 7	Control request/s	The data include the ID or characteristics of the DER resource, in addition to activation time, duration, and required volume (kWh)/power (kW).	Conf.1, Conf.2,QoS.1,QoS.2, QoS.3, Sec.1, Sec.2, Sec.3, Sec.4, D.1, D.2, D.3, D.4, D.5
Inf. 8	Control	The data include the settings to control the DER resource.	Conf.1, Conf.2,QoS.1,QoS.2, QoS.3, Sec.1, Sec.2, Sec.3, Sec.4, D.1, D.2, D.3, D.4, D.5
Inf. 9	Control/s	The data includes the ID of the controllable resource and requires setting.	Conf.1, Conf.2,QoS.1,QoS.2, QoS.3, Sec.1, Sec.2, Sec.3, Sec.4, D.1, D.2, D.3, D.4, D.5
Inf. 10	Control	The data include the setting of controllable grid components.	Conf.1, Conf.2,QoS.1,QoS.2, QoS.3, Sec.1, Sec.2, Sec.3, Sec.4, D.1, D.2, D.3, D.4, D.5

6 Requirements

Requirements		
Categories ID	**Category name for requirements**	**Category description**
Conf	Configuration	Location, distances, communication layout, commonly used communication protocol media, network bandwidth, existing protocols, number of devices, systems, volume of data items, expected growth, etc.

Requirement R-ID	Requirement name	Requirement description
Conf.1	The operation mode of the information producer	Manual & Automatic
Conf.2	The operation mode of the information receiver	Manual & Automatic

Requirements		
Categories ID	**Category name for requirements**	**Category description**
QoS	Quality of service	Generic properties that service/SUC should provide – quality attributes.
Requirement R-ID	**Requirement name**	**Requirement description**
QoS.1	Elapsed time response requirements for exchanging data	Less than 1 second
QoS.2	Availability of information flows	99.9% + availability - Allowed outage: a few times per year, max 1 hour each.
QoS.3	Frequency of data exchange	Periodicity greater than a few minutes, OR upon event OR every few seconds.

Requirements		
Categories ID	**Category name for requirements**	**Category description**
Sec	Security	Authentication of user, confidentiality, integrity, prevention of denial of service, non-repudiation or accountability, error management.
Requirement R-ID	**Requirement name**	**Requirement description**
Sec.1	Eavesdropping	Ensuring confidentiality, avoiding illegitimate use of data, and preventing unauthorized reading of data.
Sec.2	Information integrity violation	Ensuring that data is not changed or destroyed.
Sec.3	Authentication	Ensuring that data comes from the stated source or goes to the authenticated receiver.
Sec.4	Information theft	Ensuring that data cannot be stolen or deleted by an unauthorized entity.

Requirements		
Categories ID	**Category name for requirements**	**Category description**
D	Data management	Type of source of data, correctness or validity of data, timeliness or time stamping of data, volume of data, synchronization or consistency of data across systems, timely access to data, validation of data across organizational boundaries, transaction management, data naming, identification, formats across disparate systems, maintenance of data and databases.
Requirement R-ID	**Requirement name**	**Requirement description**

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.
D.2	Up-to-date management	Received data must be up-to-date within seconds of source data changing.
D.3	Data consistency and synchronization management across systems	Second-by-second synchronization OR Day-by-day synchronization.
D.4	Management of data across organizational boundaries	Data exchanges go across boundaries between system developed by different vendors OR data exchanges go across organizational boundaries.
D.5	Naming of data items	Matching of names is handled by a "converter" at the information Receiver.

7 Common Terms and Definitions

Common Terms and Definitions	
Term	**Definition**
DSO	Distribution system operator
CM	Congestion management
UC	Use case
FSP	Flexibility service provider
FR	Flexibility register
DMS	Distribution management system
SCADA	Supervisory control and data acquisition
DER	Distributed energy resources
IED	Intelligent electronic device

HEDGE-IoT

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

D2.2
Functional Specifications of the HEDGE-IoT system

|Annex Document 2 - Greek Pilot SUCs|

31/10/2024

Co-funded by the European Union

This project has received funding from the European Union's Horizon Europe research and innovation programme under the Grant Agreement number 101136216. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Climate, Infrastructure and Environment Executive Agency. Neither the European Union nor the granting authority can be held responsible for them.

PROJECT INFORMATION

<table>
<tr><td>Project Number</td><td colspan="3">101136216</td></tr>
<tr><td>Project Acronym</td><td colspan="3">HEDGE-IoT</td></tr>
<tr><td>Project Full title</td><td colspan="3">Holistic Approach towards Empowerment of the Digitalization of the Energy Ecosystem through adoption of IoT solutions</td></tr>
<tr><td>Project Start Date</td><td colspan="3">01 January 2024</td></tr>
<tr><td>Project Duration</td><td colspan="3">42 months</td></tr>
<tr><td>Funding Instrument</td><td>Horizon Europe Framework Programme</td><td>Type of action</td><td>HORIZON-IA HORIZON Innovation Actions</td></tr>
<tr><td>Call</td><td colspan="3">HORIZON-CL5-2023-D3-01-15</td></tr>
<tr><td>Topic</td><td colspan="3">Supporting the green and digital transformation of the energy ecosystem and enhancing its resilience through the development and piloting of AI-IoT Edge-cloud and platform solutions</td></tr>
<tr><td>Coordinator</td><td colspan="3">European Dynamics Luxembourg SA</td></tr>
</table>

DELIVERABLE INFORMATION

<table>
<tr><td>Deliverable No.</td><td colspan="8">D2.2</td></tr>
<tr><td>Deliverable Title</td><td colspan="8">Functional Specifications of the HEDGE-IoT system – Annex Document 2 – Greek Pilot SUCs</td></tr>
<tr><td>Work-Package No.</td><td colspan="8">WP2</td></tr>
<tr><td>Work-Package Title</td><td colspan="8">Stakeholders' Requirements and System Specifications</td></tr>
<tr><td>Lead Beneficiary</td><td colspan="8">TRIALOG</td></tr>
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<tr><td>Due date</td><td colspan="8">31/10/2024</td></tr>
<tr><td>Deliverable Type</td><td>X</td><td>Document, Report (R)</td><td></td><td>Data management plan (DMP)</td><td></td><td>Websites, press & media action (DEC)</td><td></td><td>Other</td></tr>
<tr><td>Dissemination Level</td><td>X</td><td>Public (PU)</td><td></td><td>Sensitive (SEN)</td><td></td><td colspan="3">Classified</td></tr>
<tr><td></td><td colspan="8">PU: Public, fully open
SEN: Sensitive, limited under the conditions of the Grant Agreement
Classified R-UE/EU-R – EU RESTRICTED under the Commission Decision No2015/444</td></tr>
</table>

Document Revision History

Version	Date	Description of change	List of contributor(s)
0.1	16/10/2024	Compilation of all the pilot SUCs	Léo Cornec (TRIALOG)
0.2	23/10/2024	Review by European Dynamics	Lenos Peratitis (ED)
0.3	26/10/2024	Review by Institut Jozefstefan	Gregor Kosec (JSI)
1.0	29/10/2024	Final document version for integration to Deliverable D2.2	Léo Cornec (TRIALOG)

EXECUTIVE SUMMARY

This document is an annex to the document HEDGE-IoT deliverable D2.2 "Functional Specifications of the HEDGE-IoT system". It contains specifications for the System Use Cases (SUCs) of the pilot project.

Each SUC was defined by the members of the pilot project based on the corresponding Business Use Case (BUC) and the IEC 62559-2 template with the support of the Methodology Task Leader.

This document will be updated throughout the project based on additional work and feedback.

For the HEDGE IoT project, the following sections and subsections of the IEC 62559-2 template have been defined as mandatory fields to be filled in by the pilot demonstrators for the SUCs:

1. Description of the use case
    1.1. Name of the use case
    1.2. Scope and objectives of the use case
    1.3. Narrative of the use case
2. Diagrams of the use case
3. Technical details
    3.1. Actors
4. Step-by-step analysis of use case
    4.1. Overview of scenarios
    4.2. Steps - scenarios
5. Information exchanged
6. Requirements

The following table summarises the BUCs and SUCs of the pilot project:

BUC ID & BUC name	**SUC ID**	**SUC name**
BUC-GR-01 Flexibility management through active prosumers/consumers engagement	SUC-GR-01.01	Optimization of Flexibility Distribution
	SUC-GR-01.02	Demand Forecasting
	SUC-GR-01.03	Production Forecasting
	SUC-GR-01.04	Edge Processing
	SUC-GR-01.05	User Interaction
BUC-GR-02 Leveraging data exchange and AI edge algorithms for energy forecasting and prevention of critical grid events	SUC-GR-02.01	Energy Grid Management using Forecasting Data
BUC-GR-03 Flexibility trading platform for mitigating problems of the T&D networks	SUC-GR-03.01	Registration & Prequalification on Local Flexibility Market
	SUC-GR-03.02	Flexibility Trading

1 SUC-GR-01.01 – OPTIMIZATION OF FLEXIBILITY DISTRIBUTION

1 Description of the use case

1.1 Name of the use case

ID	*Area / Domain(s) / Zones(s)*	*Name of Use Case*
SUC-GR-01.01	Local Flexibility Market / Demand Response Programs / IoT integration	Optimization of flexibility distribution

1.2 Version management

Version Management			
Version No.	*Date*	*Name of Author(s)*	*Changes0.*
0.1	04.06.2024	Nikos Dimitropoulos – ICCS	1st Draft
0.2	19.07.2024	Nickie Gkolia - ICCS	Refinement
0.3	27.08.2024	Nickie Gkolia - ICCS	Modifications to comply with the template provided
1.0	15.10.2024	Nickie Gkolia - ICCS	Final first version

1.3 Scope and objectives of use case

Scope and Objectives of Use Case	
Scope	Enabling private consumers to take flexibility measures in response to a signal from the aggregator. The aggregator develops an optimisation module to meet the flexibility signal coming from the local flexibility market (LFM). The optimisation module focuses on determining the optimal demand response (DR) scenarios to bid on the LFM and the corresponding incentives to be offered to consumers for implementing the flexibility measures.
Objective(s)	The main objectives are: 1. To determine whether the aggregator will be able to bid based on the available flexibility and consumer behaviour in LFM. 2. To find the optimal DR strategies to be competitive under market conditions. 3. To find the necessary incentives for consumers.
Related business case(s)	BUC-GR-01: Flexibility management through active prosumers/consumers engagement

1.4 Narrative of use case

Narrative of Use Case
Short description
The Aggregator is responsible to aggregate the available flexibility assets of consumers, model their behaviour and identify the feasibility to bid for a flexibility product in the LFM. Monitoring of consumption near real time the analysis of consumption and production (for prosumers) and the modelling of their potential response to a flexibility event are crucial to determine the right incentives for consumers to accept the flexibility measure. The aggregator receives the capacity, price and time of the flexibility product and runs the optimisation algorithm to optimise the aggregated flexibility

measures of its portfolio (consumers' flexibility assets and demand-side management) and then decides whether or not to bid for the flexibility product.
Complete description
This use case describes how an aggregator manages and optimises the flexibility assets of consumers and prosumers in order to participate in the local flexibility market (LFM). The aggregator is responsible for monitoring consumption and production data in near real-time, modelling consumer behaviour and determining the feasibility of bids for a flexibility product. The aim is to make optimal decisions on whether or not to bid for a flexibility product based on the aggregated flexibility of its portfolio. Main Steps of the Use Case: 1. **Notification of a flexibility product:** the aggregator is notified of a new flexibility product available in the LFM, including details such as capacity, price and timeframe for the flexibility action. 2. **Forecasting and assessment:** Based on the timeframe for the flexibility action, the aggregator uses forecasting models to predict both consumer demand and production (for prosumers). This step assesses the ability of consumers and prosumers to respond to the flexibility request based on their current and expected consumption and production patterns. 3. **Optimisation of incentives:** The aggregator runs an optimisation algorithm to determine the best incentives it can offer to consumers to encourage them to participate in the flexibility action. This includes calculating the potential consumer responses and the overall cost-effectiveness of incentivising those responses. 4. **Consumer response and decision making:** The aggregator collects consumer responses regarding their willingness to participate in the flexibility action based on the incentives offered. Depending on these responses and the optimisation results, the aggregator decides whether to accept the bid for the flexibility product in the LFM. 5. **Bid acceptance or rejection:** If the aggregator decides to proceed, a bid is submitted for the flexibility product. If the conditions are unfavourable or the response is insufficient, the aggregator decides not to bid. Main Technologies Used: 1. **Real-time** monitoring systems: To collect and analyse consumption and production data from consumers and prosumers. 2. **Forecasting models:** Machine learning and statistical models to predict consumer demand and production capacity based on historical and real-time data. 3. **Optimisation algorithms:** Advanced algorithms to optimise the selection of consumer incentives and maximise the overall flexibility offered to the market. 4. **Communication** platform: For communicating with consumers, collecting responses and disseminating incentives. Hardware: 1. Servers for data processing and storage. 2. IoT devices and smart metres for real-time monitoring of consumers and prosumers. SUCs scenarios: 1. **Optimisation module:** The aggregator uses optimisation algorithms to determine the best incentives for consumers to participate in flexibility measures. This process involves analysing forecast demand and production data, possible consumer responses and the overall profitability of the flexibility offer. 2. **Requesting flexibility actions from consumers:** The aggregator communicates with consumers and informs them of the flexibility required and the associated incentives. Consumers then decide whether to accept the proposed flexibility action based on the information provided. 3. **Decision to bid on the LFM:** After the aggregator has gathered the flexibility potential of the consumers and analysed their responses, it decides whether to accept the offer on the local flexibility market. This decision is made if the expected benefits exceed the costs and match the market requirements.

4. **Decision not to submit a bid on the LFM:** If the responses from consumers are insufficient, the forecasts are unfavourable or the costs of the incentives exceed the potential benefits, the aggregator decides not to submit a bid on the local flexibility market.

1.5 Key performance indicators (KPI)

ID	*Name*	*Description*	*Reference to mentioned use case objectives*
OB1	Different types of IoT/edge devices to be exploited in Demo Areas e.g., Smart Meter, HEMS, Sensors, inverter	The IoT/edge devices to be used within this SUC	Obj.2, Obj.3
OB4	Users involved in the piloting	Number of users part of the Greek Demo, based on the installations of edge/IoT devices	Obj.1, Obj.2, Obj.3
KPI3	% Of planned usage of HEDGE-IoT tools/data services (e.g., transactions, periodicity) in field demos	Number of HEDGE-IoT tools and data services used within this SUC	Obj.2
KPI6	End-users' bill reduction by offering flexibility services	The amount of electricity cost reduction due to flexibility services	Obj.3
KPI7	Increased RES and IoT deployment for providing flexibility services	Amount of RES and IoT devices available in this SUC	Obj.2
KPI9	Flexibility unlocked and transacted in markets	Amount of flexibility that is accepted by consumers due to market signals	Obj.2, Obj.3
KPI10	Number of consumers engaged with flexibility services	Number of consumers that receive flexibility requests	Obj.1, Obj.2, Obj.3
KPI17	Increased flexibility incorporation enabled by IoT/Edge technologies for grid security	Capacity of assets available for DR to limit grid disturbances	Obj.2
KPI22	Increase DERs participation in flexibility provision	Participation of residential assets (e.g., PVs, BESS, heat pumps, EVs) in flexibility events	Obj.1, Obj.2, Obj.3

1.6 Use case conditions

Use case conditions
Assumptions
• Availability and installation of Edge IoT Devices in households • Availability in historical consumer data • Data Quality and Accessibility/Availability • Consumers/Prosumers Participation and Consent
Prerequisites
• Consumers/Prosumers should have IoT devices in selected homes and buildings. • Weather conditions and forecasts should be available (electricity demand forecast and PV forecast for prosumers) • Prosumers/consumers are willing to provide the data from the IoT devices via the energy supplier • Adequate flexibility offers from the local flexibility market (BUC-GR-03) are available (via the grid operators) to conduct the experiment

1.7 Further Information to the use case for classification / mapping

<table>
<tr><th>Classification Information</th></tr>
<tr><th>Relation to other use cases</th></tr>
<tr><td>Linked to SUC-GR-01.02:
Provision of demand forecasts
Linked to SUC-GR-01.03:
Provision of forecasts for PV production
Linked to SUC-GR-01.04:
Ability to capture accurate real-time data at the edge level
Ability to perform edge processing and operations at household level (e.g. scripting of optimisation modules, identification of rapid changes in consumption values, validation of flexibility measures)
Link with SUC-GR-01.05:
Provision of an interface for interaction with consumers and notification of possible flexibility measures</td></tr>
<tr><th>Level of depth</th></tr>
<tr><td>High</td></tr>
<tr><th>Prioritisation</th></tr>
<tr><td>High</td></tr>
<tr><th>Generic, regional, or national relation</th></tr>
<tr><td>National</td></tr>
<tr><th>Nature of the use case</th></tr>
<tr><td>System Use Case: Technical specifications to perform the optimisation algorithm and interact with residential consumers</td></tr>
<tr><th>Further keywords for classification</th></tr>
<tr><td></td></tr>
</table>

1.8 General Remarks

General Remarks

2 Diagrams of use case

Diagram(s) of use case

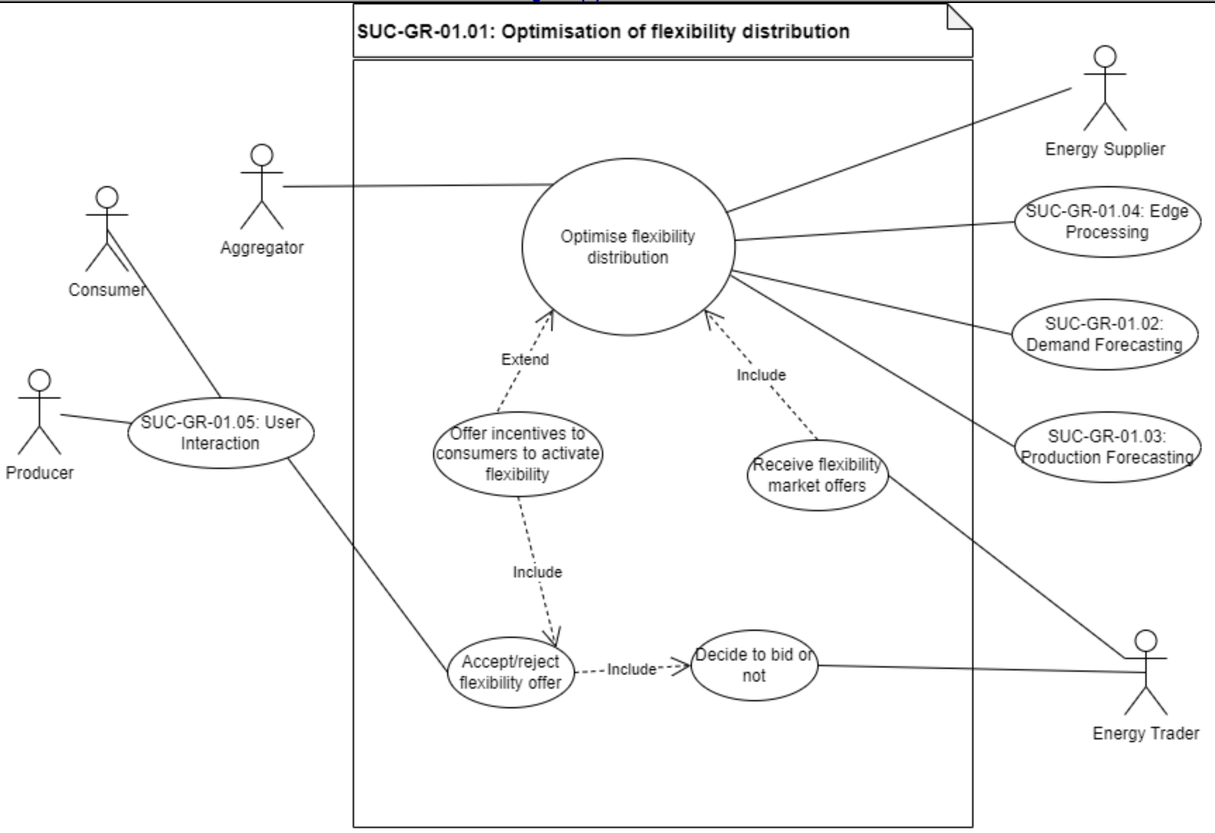



FIGURE 1: UML USE CASE DIAGRAM

3 Technical details

3.1 Actors

Actors			
Actor Name	***Actor Type***	***Actor Description***	***Further information specific to this use case***
Consumer	Business Actor	Residential consumers, possessing IoT devices monitoring their consumption.	Public Power Corporation customers (PPC)
Producer	Business Actor	Small residential PV owners, promoting self-consumption (mostly under net-metering schemes	Public Power Corporation customers (PPC)
Aggregator	Business Actor	An entity processing, analysing, and monitoring energy consumption/production data, operating the AI algorithms for demand/production forecasts, and performing the optimisation algorithms for the flexibility offers	Public Power Corporation (PPC)
Energy Supplier	Business Actor	Collects consumer and prosumers data and is responsible for invoicing the consumers.	Public Power Corporation (PPC)
Energy Trader	Business Actor	The energy trader receives a flexibility offer from the LFM and decides to bid or not, based on the available flexibility resources available in the aggregator	Public Power Corporation (PPC)

3.2 References

References						
No.	***Reference Type***	***Reference***	***Status***	***Impact on use case***	***Originator / organisation***	***Link***

4 Step by step analysis of use case

4.1 Overview of scenarios

Scenario conditions						
No.	**Scenario name**	**Scenario description**	**Primary actor**	**Triggering event**	**Pre-condition**	**Post-condition**
Sc.1	Optimizatio n Module	The aggregator runs the optimisation algorithm to identify the incentives to offer to consumers and its profit	Aggregat or	A flexibility product is available in the LFM for bidding	The flexibility offer specifies the amount of energy, the price offered and the time to perform it	The aggregator receives the incentives to be offered to the consumers and the relevant flexibility assets to be involved under which capacity
Sc.2	Request flexibility actions of consumers	The aggregator informs the consumers regarding the potential flexibility actions to perform and offer them the incentives	Aggregat or, consumer s, prosumer s	The optimisation module provides its results	The specifications of the flexibility actions cover the time and the flexibility assets to be involved	The consumers accept or decline the identified flexibility actions
Sc 3.	Decision to bid in the LFM	The aggregator decides to bid for the flexibility product	Aggregat or	Consumers have provided their decision	The aggregator runs an evaluation script to identify that the optimisation algorithm and the consumers' decisions are within its limit	Proceeds with bidding in the LFM and validate that the flexibility actions are performed
Sc. 4	Decision not to bid in the LFM	The aggregator decided not to bid for the flexibility product	Aggregat or	Consumers have provided their decision	No preconditions	No flexibility transacted

4.2 Steps – Scenarios

Scenario								
Scenario name:	Sc.1 Optimisation module							
Step No.	***Event***	***Name of process/ activity***	***Description of process/ activity***	***Service***	***Information producer (actor)***	***Information receiver (actor)***	***Information Exchanged (IDs)***	***Requirement, R-IDs***
St. 1	The Energy Trader sends a signal to the UI (User Interface) that a new flexibility product is available	Flexibility product availability	The energy trader sends a request to the aggregator to analyse the flexibility offer through the UI	REPORT	Energy Trader	SUC-GR-01.05: User Interaction	Inf.1	QoS.1, QoS.2, Sec.1, Sec.2, Sec.3, D.1, D.2, D.3, Conf.3, Conf.4
St. 2	The Aggregator is informed that a flexibility product is available in the LFM	Flexibility Analysis Request	The Aggregator is informed that a flexibility product is available in the LFM, and it needs to analyse it	GET	SUC-GR-01.05: User Interaction	Aggregator	Inf.2	QoS.1, QoS.2, Sec.1, Sec.2, Sec.3, D.1, D.2, D.3, Conf.3, Conf.4
St. 3	The Aggregator requests the relevant data to proceed with the optimisation algorithms	Data gathering Request	The Aggregator requests the relevant data to proceed with the optimisation algorithms	GET	Aggregator	Energy Supplier	Inf.3	QoS.1, QoS.2, Sec.1, Sec.2, Sec.3, D.1, D.2, D.3, Conf.1, Conf.3, Conf.4, O.1, O.2, O.3
St. 4	The aggregator receives all relevant data from the energy supplier	Data gathering Return	The aggregator receives all relevant data to proceed with the optimisation models	GET	Energy Supplier	Aggregator	Inf.4	QoS.1, QoS.2, Sec.1, Sec.2, Sec.3, D.1, D.2, D.3, Conf.1, Conf.2, Conf.3, Conf.4, O.1, O.2, O.3
St. 5	The Aggregator proceeds with the demand forecasting	Demand Forecastin g Kick-off	The aggregator runs demand forecasting to identify the consumption flexibility of the customers	EXECUTE	Aggregator	SUC-GR-01.02: Demand Forecasting	Inf.5	Sec.1, Sec.2, Sec.3, D.1, D.2, D.3, Conf.1, Conf.3
St. 6	The Aggregator receives the	Demand Forecastin	The aggregator gets the results from demand	GET	SUC-GR-01.02:	Aggregator	Inf.6	Sec.1, Sec.2, Sec.3, D.1, D.2, D.3, Conf.2,

	results from the demand forecasting process	g Results	forecasting to identify the consumption flexibility of the customers		Demand Forecasting			Conf.3
St. 7	Aggregator proceeds with the production forecasting	Production Forecastin g Kick-off	The aggregator runs production forecasting to identify the consumption flexibility of the customers	EXECUTE	Aggregator	SUC-GR-01.03: Production Forecasting	Inf.7	Sec.1, Sec.2, Sec.3, Conf.1, Conf.3,
St. 8	The Aggregator receives the results from the production forecasting process	Production Forecastin g Results	The aggregator gets the results from production forecasting to identify the production flexibility of the customers	GET	SUC-GR-01.03: Production Forecasting	Aggregator	Inf.8	Sec.1, Sec.2, Sec.3, D.1, D.2, D.3, Conf.2, Conf.3
St. 9	The Aggregator runs the optimization algorithm	Optimizati on module	The aggregator runs the optimization algorithm	EXECUTE	Aggregator	Aggregator	-	Conf.1, Conf.3
St. 10	Aggregator has the optimisation results available and creates the offers to customers	Optimisati on results	The aggregator has available the incentives to offer and the capacity of flexibility assets to distribute the flexibility in consumers	EXECUTE	Aggregator	Aggregator	-	Sec.1, Sec.2, Sec.3, D.1, D.2, D.3, Conf.1

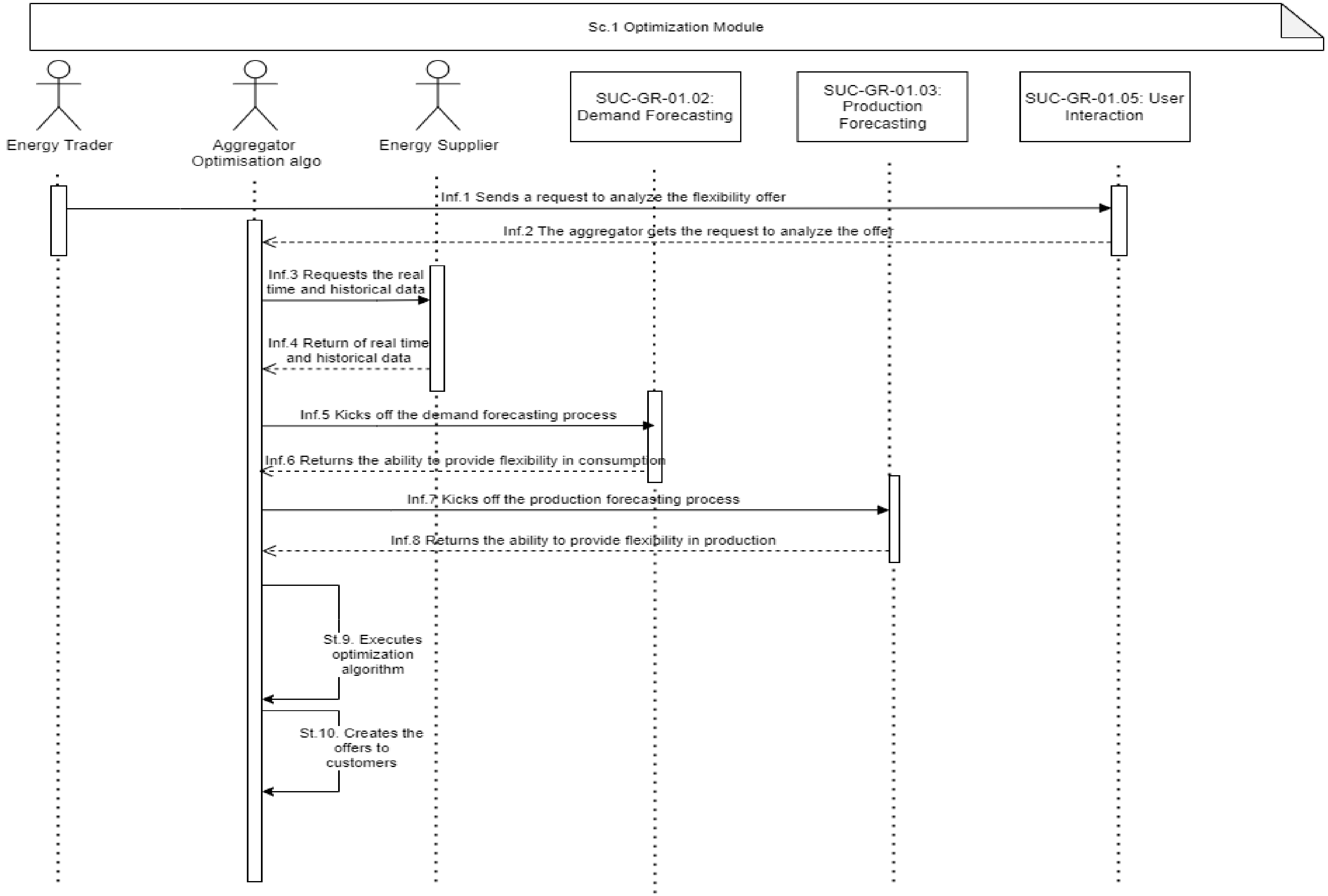


FIGURE 2: SUC-GR-01.01 SC.1 SEQUENCE DIAGRAM

Scenario								
Scenario name:		Sc.2 Request flexibility actions of consumers						
Step No.	**Event**	**Name of process/ activity**	**Description of process/ activity**	**Service**	**Information producer (actor)**	**Information receiver (actor)**	**Information Exchanged (IDs)**	**Requirement, R-IDs**
St. 1	Aggregator sends to the UI the flexibility actions that the customers can perform and request their decision	Flexibility request Sending	The aggregator contacts consumers through the GUI to inform them of the potential flexibility assets to be triggered and request their decision	REPORT	Aggregator	SUC-GR-01.05: User Interaction	Inf.9	QoS.1, QoS.2, Sec.1, Sec.2, Sec.3, D.1, D.2, D.3, Conf.1
St. 2	The customers receive the flexibility request in the UI	Flexibility request Receipt	The customers receive the flexibility request in the UI	GET	SUC-GR-01.05: User Interaction	Consumers/Producers	Inf.10	QoS.1, QoS.2, Sec.1, Sec.2, Sec.3, D.1, D.2, D.3, Conf.2, Conf.3
St. 3	Customers' decision	Customers' decision	The consumers decide should they proceed with the flexibility actions	EXECUTE	Consumers/Producers	Consumers/Producers	-	
St. 4	Consumers' decision report to UI	Customers' decision to UI	The consumers accept or not the requested flexibility actions through the UI	REPORT	Consumers/Producers	SUC-GR-01.05: User Interaction	Inf.11	QoS.1, QoS.2, Sec.1, Sec.2, Sec.3, Conf.1, Conf.3
St. 5	The aggregator views the customers' decision in the UI	Customers' decision to aggregator	The aggregator views the customers' decision (accept or reject) for the flexibility actions in the UI	GET	SUC-GR-01.05: User Interaction	Aggregator	Inf.12	QoS.1, QoS.2, Sec.1, Sec.2, Sec.3, D.1, D.2, D.3, Conf.2, Conf.3

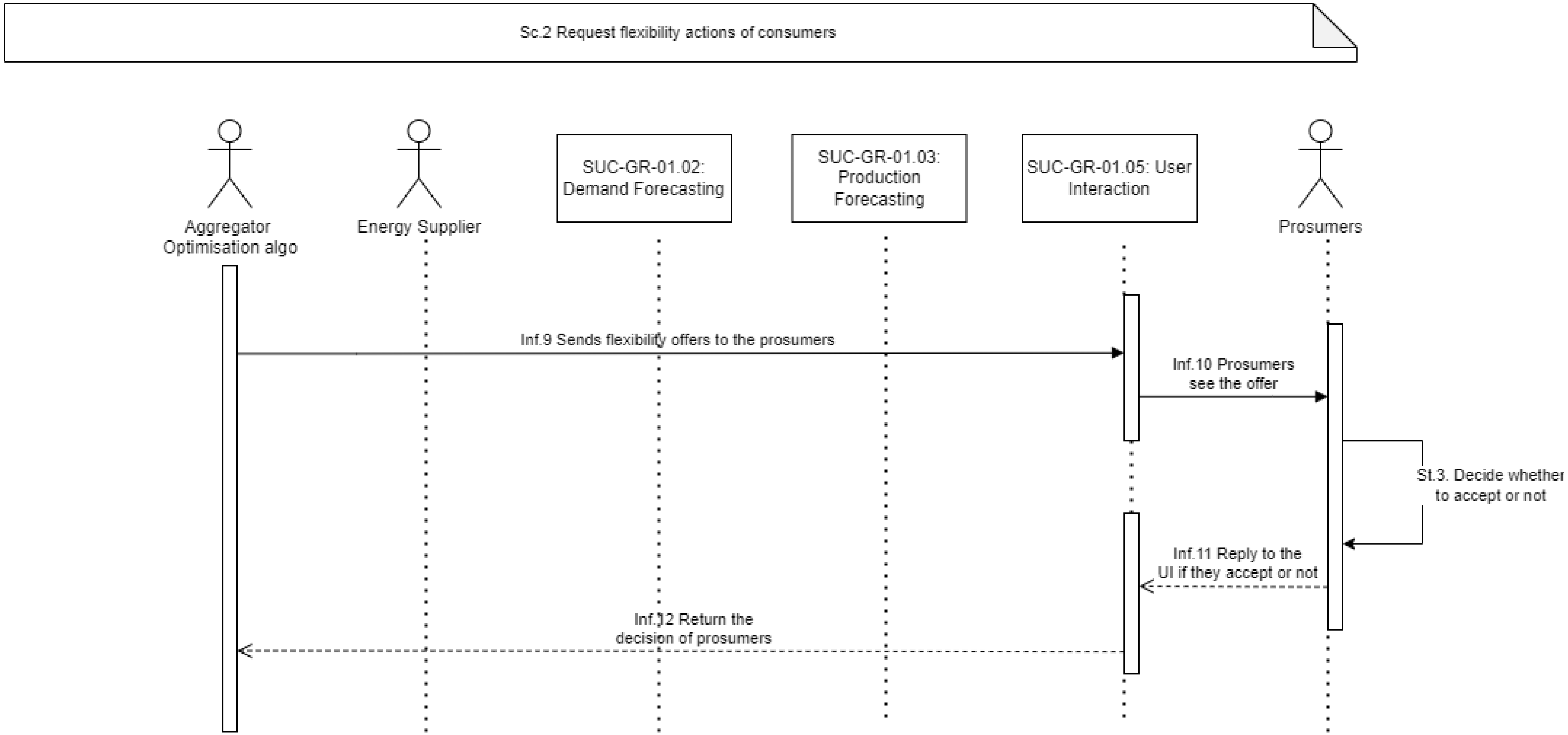


FIGURE 3: SUC-GR-01.01 SC.2 SEQUENCE DIAGRAM

Scenario								
Scenario name:	Sc.3 Decision to bid in the LFM							
Step No.	**Event**	**Name of process/ activity**	**Description of process/ activity**	**Service**	**Information producer (actor)**	**Information receiver (actor)**	**Information**	**Requirement, R-IDs**
St. 1	Aggregator aggregates the decisions and validate the flexibility actions	Validation of flexibility distribution	The aggregator validates the consumers' decision with the optimisation results to proceed with bidding in the LFM	EXECUTE	Aggregator	Aggregator	–	Sec.1, Sec.2, Sec.3, D.1, D.2, D.3, Conf.3
St. 2	Flexibility bid to UI	Flexibility bid to UI	The aggregator notifies UI that it can bid in the LFM	REPORT	Aggregator	SUC-GR-01.05: User Interaction	Inf.13	QoS.1, QoS.2, Sec.1, Sec.2, Sec.3, D.1, D.2, D.3, Conf.1, Conf.3
St. 3	Flexibility bid to the Energy Trader	Flexibility bid to the Energy Trader	The Energy Trader gets the signal that the bid is feasible	GET	SUC-GR-01.05: User Interaction	Energy Trader	Inf.14	QoS.1, QoS.2, Sec.1, Sec.2, Sec.3, D.1, D.2, D.3, Conf.2, Conf.3
St. 4	Flexibility Validation	Flexibility Validation	The aggregator monitors the consumers' actions to ensure that the flexibility actions proceed as agreed	EXECUTE	Aggregator	Aggregator	–	QoS.1, QoS.2, Sec.1, Sec.2, Sec.3, D.1, D.2, D.3, Conf.4

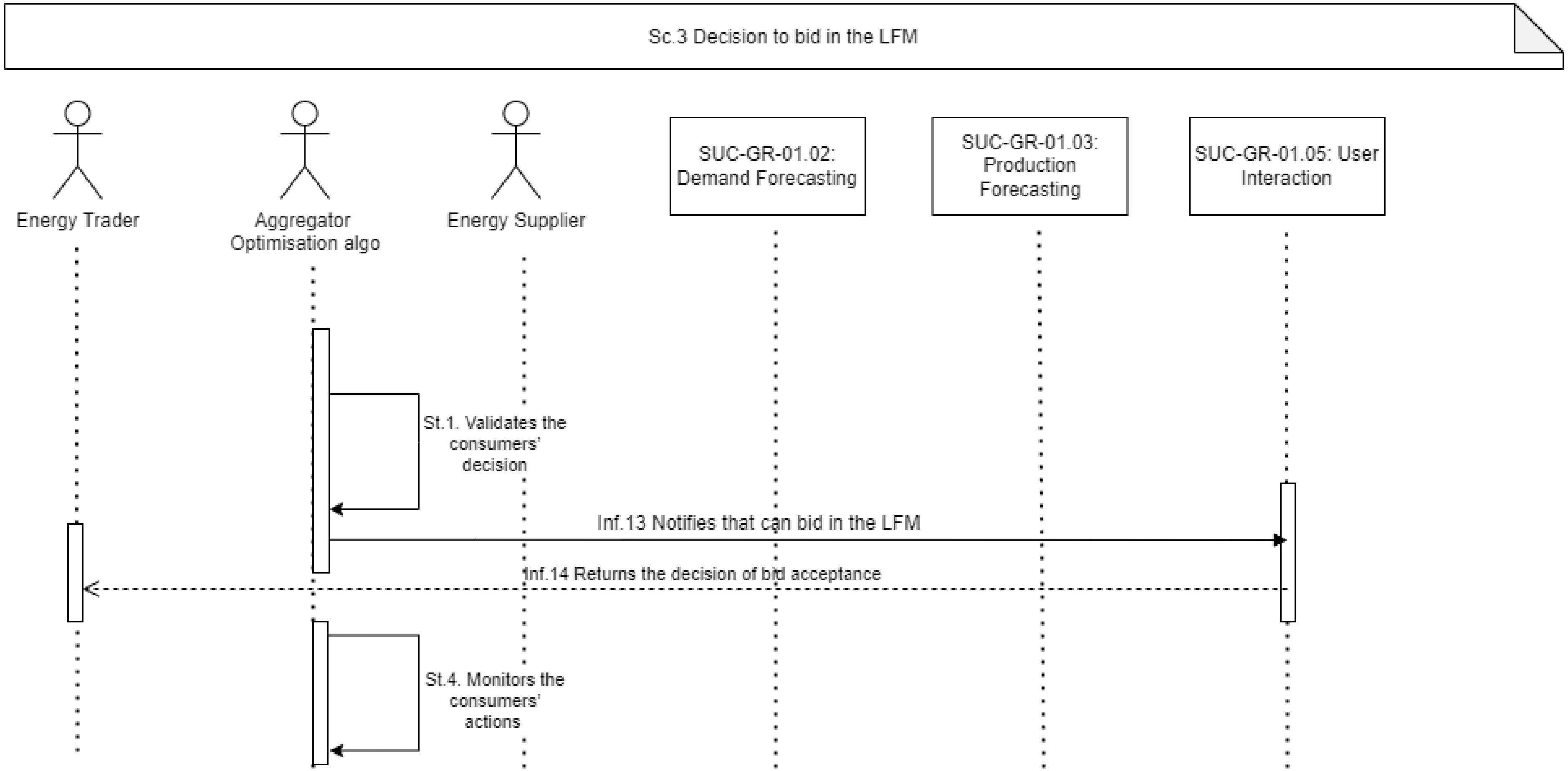


FIGURE 4: SUC-GR-01.01 SC.3 SEQUENCE DIAGRAM

Scenario								
Scenario name:		Sc.4 Decision not to bid in the LFM						
Step No.	**Event**	**Name of process/ activity**	**Description of process/ activity**	**Service**	**Information producer (actor)**	**Information receiver (actor)**	**Information Exchanged (IDs)**	**Requirement, R-IDs**
St. 1	Aggregator aggregates the decisions and validate the flexibility actions	Validation of flexibility distribution	The aggregator validates the consumers' decision with the optimisation results to proceed with bidding in the LFM	EXECUTE	Aggregator	Aggregator	-	Sec.1, Sec.2, Sec.3, D.1, D.2, D.3
St. 2	Flexibility bid to UI	Flexibility bid to UI	The aggregator notifies the UI that cannot bid in the LFM	REPORT	Aggregator	SUC-GR-01.05: User Interaction	Inf.15	QoS.1, QoS.2, Sec.1, Sec.2, Sec.3, D.1, D.2, D.3, Conf.1, Conf.3
St. 3	Flexibility bid to the Energy Trader	Flexibility bid to the Energy Trader	The Energy Trader gets the signal that the bid is not feasible	GET	SUC-GR-01.05: User Interaction	Energy Trader	Inf.16	QoS.1, QoS.2, Sec.1, Sec.2, Sec.3, D.1, D.2, D.3, Conf.2, Conf.3
St. 4	Aggregator's notification to the UI that the flexibility action is not required	Aggregator's notification to the UI that the flexibility action is not required	The aggregator notifies the UI that the accepted flexibility action that it is not required	REPORT	Aggregator	SUC-GR-01.05: User Interaction	Inf.17	QoS.1, QoS.2, Sec.1, Sec.2, Sec.3, D.1, D.2, D.3, Conf.1, Conf.3
St. 5	Consumer notification	Consumers' notification	The customers see that the accepted flexibility action is not required	GET	SUC-GR-01.05: User Interaction	Consumers, Prosumers	Inf.18	QoS.1, QoS.2, Sec.1, Sec.2, Sec.3, D.1, D.2, D.3, Conf.2, Conf.3

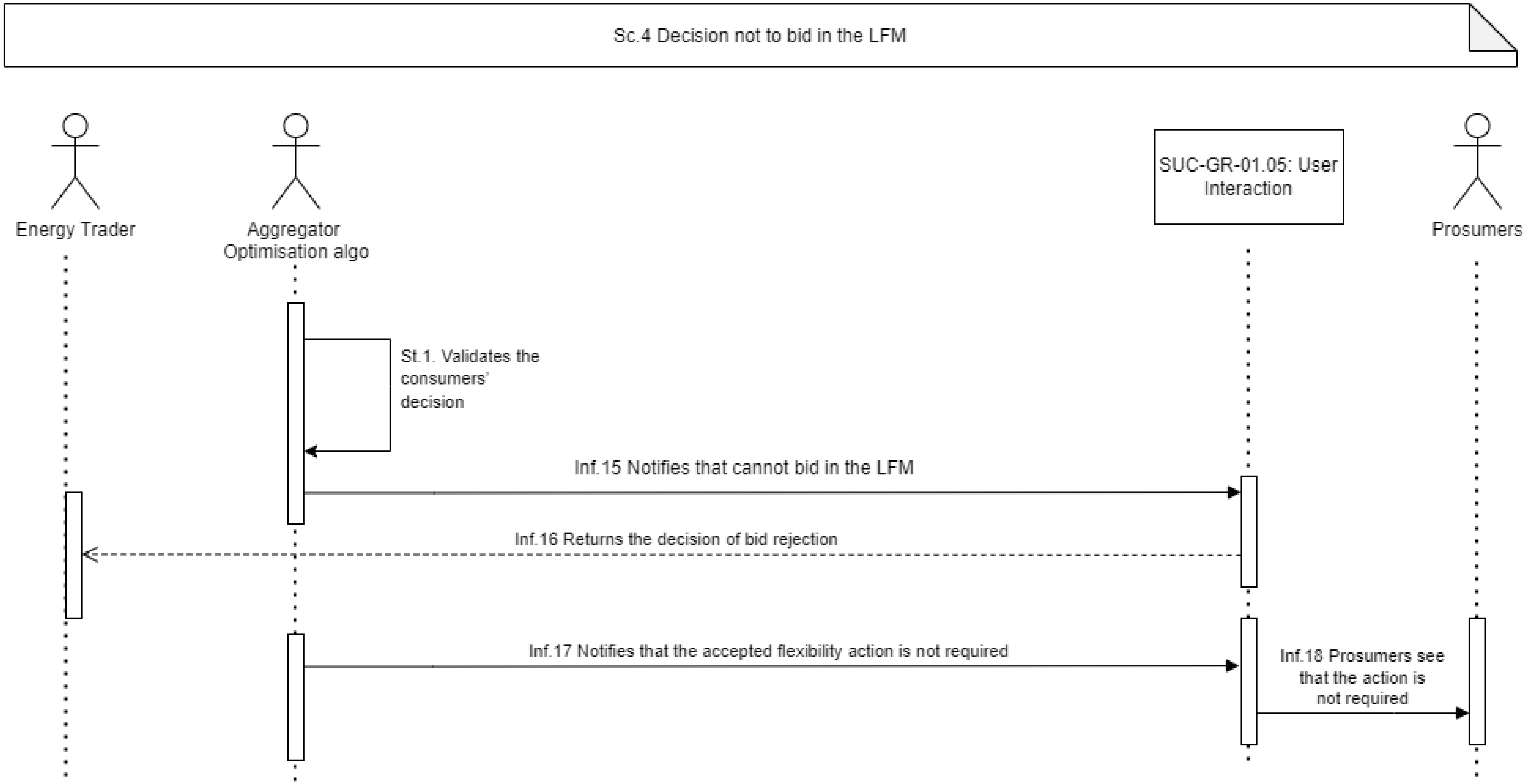


FIGURE 5: SUC-GR-01.01 SC.4 SEQUENCE DIAGRAM

5 Information exchanged

Information exchanged			
Information exchanged (ID)	*Name of information*	*Description of information exchanged*	*Requirement, R-IDs*
Inf.1	Flexibility product availability	The Energy trader sends a request to the aggregator to analyse the flexibility offer through the UI	QoS.1, QoS.2, Sec.1, Sec.2, Sec.3
Inf.2	Flexibility Analysis Request	The Aggregator is informed via the UI that a flexibility product is available in the LFM, and it needs to analyse it	QoS.1, QoS.2, Sec.1, Sec.2, Sec.3
Inf.3	Data gathering Request	The Aggregator requests the relevant data to proceed with the optimisation algorithms	QoS.1, QoS.2, Sec.1, Sec.2, Sec.3, O.1, O.2, O.3
Inf.4	Return of the real-time and historical data	Return of all the real-time and historical consumption and production data	QoS.1, QoS.2, Sec.1, Sec.2, Sec.3, O.1, O.2, O.3
Inf.5	Demand Forecasting Kick-off	The aggregator runs demand forecasting to identify the consumption flexibility of the customers	Sec.1, Sec.2, Sec.3
Inf.6	Demand Forecasting Results	The aggregator gets the results from demand forecasting to identify the consumption flexibility of the customers	QoS.1, QoS.2, Sec.1, Sec.2, Sec.3
Inf.7	Production Forecasting Kick-off	The aggregator runs production forecasting to identify the production flexibility of the customers	QoS.1, QoS.2, Sec.1, Sec.2, Sec.3
Inf.8	Production Forecasting Results	The aggregator gets the results from production forecasting to identify the production flexibility of the customers	Sec.1, Sec.2, Sec.3
Inf.9	Flexibility request Sending	The aggregator contacts consumers through the GUI to inform them of the potential flexibility assets to be triggered and request their decision	QoS.1, QoS.2, Sec.1, Sec.2, Sec.3
Inf.10	Flexibility request Receipt	The customers receive the flexibility request in the UI	QoS.1, QoS.2, Sec.1, Sec.2, Sec.3
Inf.11	Customers' decision to UI	The consumers accept or not the requested flexibility actions through the UI	QoS.1, QoS.2, Sec.1, Sec.2, Sec.3
Inf.12	Customers' decision to aggregator	The aggregator views the customers' decision (accept or reject) for the flexibility actions in the UI	QoS.1, QoS.2, Sec.1, Sec.2, Sec.3
Inf.13	Flexibility bid to UI	The aggregator notifies UI that it can bid in the LFM	QoS.1, QoS.2, Sec.1, Sec.2, Sec.3
Inf.14	Flexibility bid to the Energy Trader	The Energy Trader gets the signal that the bid is feasible	QoS.1, QoS.2, Sec.1, Sec.2, Sec.3

Inf.15	Flexibility bid to UI	The aggregator notifies the UI that cannot bid in the LFM	QoS.1, QoS.2, Sec.1, Sec.2, Sec.3
Inf.16	Flexibility bid to the Energy Trader	The Energy Trader gets the signal that the bid is not feasible	QoS.1, QoS.2, Sec.1, Sec.2, Sec.3
Inf.17	Aggregator's notification to the UI that the flexibility action is not required	The aggregator notifies the UI that the accepted flexibility action that it is not required	QoS.1, QoS.2, Sec.1, Sec.2, Sec.3
Inf.18	Consumers' notification	The customers see that the accepted flexibility action is not required	QoS.1, QoS.2, Sec.1, Sec.2, Sec.3

6 Requirements

Quality of Service Requirements		
Categories ID	**Category name for requirements**	**Category description**
QoS	Quality of Service	Generic properties that service/SUC should provide – quality attributes.
Requirement R-ID	**Requirement name**	**Requirement description**
QoS.1	Contractual timelines for data exchange	Contractual timelines for exchanging data are required
QoS.2	Frequency of data exchanges	Periodicity greater than a few seconds

Security Requirements		
Categories ID	**Category name for requirements**	**Category description**
Sec	Security	Authentication of user, confidentiality, integrity, prevention of denial of service, non-repudiation or accountability, error management.
Requirement R-ID	**Requirement name**	**Requirement description**
Sec.1	Information theft	Ensuring that data cannot be stolen or deleted by an unauthorized entity is quite important
Sec.2	Information integrity violation	Ensuring that data is not changed or destroyed is quite important
Sec.3	Replay	Ensuring that data cannot be resent by an unauthorized source is quite important

Data Management Requirements		
Categories ID	**Category name for requirements**	**Category description**
D	Data Management	Type of source of data, correctness or validity of data, timeliness or time stamping of data, volume of data, synchronization, or consistency of data across systems, timely access to data, validation of data across

		organizational boundaries, transaction management, data naming, identification, formats across disparate systems, maintenance of data and databases.
Requirement R-ID	**Requirement name**	**Requirement description**
D.1	Management of data across organizational boundaries	Data exchanges go across organizational boundaries
D.2	Correctness of source data	Source data is always correct
D.3	Data consistency and synchronization management across systems	Minute-by-minute synchronization

Discovery and Configuration Requirements		
Categories ID	**Category name for requirements**	**Category description**
Conf	Configuration	Locations, distances, communication layout, commonly used communication protocol media, network bandwidth, existing protocols, number of devices, systems, volume of data items, expected growth, etc.
Requirement R-ID	**Requirement name**	**Requirement description**
Conf.1	Operation mode of Information Producer	Automatic or on demand
Conf.2	Operation mode of Information Receiver	Automatic or on demand
Conf.3	Relative maturity of current implementation	Very mature and widely implemented
Conf.4	Distance between entities	Many kilometres

Other Requirements		
Categories ID	**Category name for requirements**	**Category description**
O	Regulatory obligation related to privacy	2016/679 GDPR (General Data Protection Regulation)
Requirement R-ID	**Requirement name**	**Requirement description**
O.1	Personal data processing	Personal data may not be processed unless there is at least one legal basis to do so.
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.
O.3	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.

7 Common Terms and Definitions

Common Terms and Definitions	
Term	**Definition**
PPC	Public Power Corporation
LFM	Local Flexibility Market
DR	Demand Response

2 SUC-GR-01.02 – DEMAND FORECASTING

1 Description of the use case

1.1 Name of the use case

ID	Area / Domain(s) / Zones(s)	Name of Use Case
SUC-GR-01.02	Local Flexibility Market / Demand Response Programs / IoT integration	Demand Forecasting

1.2 Version management

Version Management			
Version No.	Date	Name of Author(s)	Changes0.
0.1	03.06.2024	Nickie Gkolia - ICCS	1st Draft
0.2	16.07.2024	Nickie Gkolia - ICCS	Extended Version
0.3	26.07.2024	Nickie Gkolia - ICCS	Refinement
0.4	27.08.2024	Nickie Gkolia - ICCS	Modifications to comply with the template provided
1.0	15.10.2024	Nickie Gkolia - ICCS	Final first version

1.3 Scope and objectives of use case

Scope and Objectives of Use Case	
Scope	To forecast the demand of the customers to identify their ability to offer flexibility. The aggregator will use this information to run the optimization algorithm and decide if it can bid for a flexibility market product.
Objective(s)	The main objectives are: 1. To develop a robust system to accurately forecast the demand of customers. This involves collecting and analysing historical data, identifying patterns, and predicting future consumption trends. 2. To assess the ability of customers to offer flexibility in their energy usage. 3. To ensure the system can process and update data in real-time or near real-time to reflect the most current demand 4. To help the system operators to identify grid issues and request flexibility
Related business case(s)	BUC-GR-01: Flexibility management through active prosumers/consumers engagement BUC-GR-02: Leveraging data exchange and ai edge algorithms for energy forecasting and prevention of critical grid events

1.4 Narrative of use case

Narrative of Use Case
Short description
The system forecasts demand from residential customers based on real-time and historical data from smart metres and household appliances that are processed on site. This information helps the aggregator assess customer flexibility and decide on bidding strategies for flexibility market products. By integrating precise demand forecasts with an optimisation algorithm, the system supports well-founded decisions. It ensures scalability, reliability and compliance with legal requirements while

protecting customer data. System operators also use the forecast data to recognise potential grid problems and ensure grid stability.
Complete description
This use case describes a residential demand forecasting system that utilises both real-time and historical data from smart metres and household appliances. The data is processed locally on site to produce short to medium term and long term demand forecasts. These forecasts are essential for two main purposes: they help aggregators optimise their bidding strategies for flexibility market products and support system operators in identifying and resolving potential grid problems. The system integrates customers' flexibility data into an optimisation algorithm to support decision-making processes for both market participation and grid stability management. The SUC comprises the following steps: 1. Data from household appliances and smart metres is collected in real time 2. Historical data is provided by the energy supplier. 3. All data is pre-processed. 4. The aggregator uses both real-time and historical data to forecast customer consumption. 5. The system operators (SOs) use the forecast data to recognise potential grid problems. The SUC includes the following scenarios: 1. **Data collection**: real-time data is collected from smart metres and household appliances to capture current energy consumption and usage patterns. Historical data is provided by energy suppliers to capture past consumption trends and behaviours over different time periods. 2. **Pre-processing of the data:** The system pre-processes all collected data to ensure it is clean, organised and suitable for forecasting. This step includes cleaning, normalising and aggregating the data over different time periods to prepare for analysis. 3. **Demand forecasting for aggregator optimisation:** Using the pre-processed real-time and historical data, the system forecasts demand from residential customers. These forecasts are used to determine the flexibility potential of customers, which is then integrated into an optimisation algorithm. The algorithm helps aggregators to make informed decisions about bids for flexibility market products. 4. **Demand forecasting to identify grid problems:** Grid operators use the forecast data to identify potential grid problems such as demand peaks or supply bottlenecks. By analysing this data, they can proactively manage grid stability and submit bids for flexibility measures to the market operator to solve these problems. Main technologies used: 1. **Smart metres and IoT** devices: for real-time data collection of household energy consumption. 2. **Edge computing:** Processes data locally, reduces latency and bandwidth usage and enables faster analyses and decisions. 3. **Machine learning models:** For accurate demand forecasting based on historical and real-time data 4. **Optimisation algorithms:** For analysing forecasted data and determining the best strategies for participating in the flexibility market. 5. **Data analysis platforms:** For data pre-processing, forecasting and integrating the results into decision-making processes. Hardware: 1. **Smart metres and IoT** devices: Are used in households to collect energy consumption data in real time. 2. **Edge server:** Positioned close to data sources for initial data processing and rapid analysis.

1.5 Key performance indicators (KPI)

ID	Name	Description	Reference to mentioned use case objectives
OB1	Different types of IoT/edge devices to be exploited in Demo Areas e.g., Smart Meter, HEMS, Sensors, inverter	The IoT/edge devices to be used within this SUC	Obj,1 Obj.3
OB4	Users involved in the piloting	Number of users part of the Greek Demo, based on the installations of edge/IoT devices	Obj.1, Obj.2
KPI3	% Of planned usage of HEDGE-IoT tools/data services (e.g., transactions, periodicity) in field demos	Number of HEDGE-IoT tools and data services used within this SUC	Obj.1, Obj. 2, Obj.3, Obj.4
KPI7	Increased RES and IoT deployment for providing flexibility services	Amount of RES and IoT devices available in this SUC	Obj.1, Obj. 2, Obj. 3
KPI12	Faster application response times	Edge vs cloud response times performing forecasts and being available in the users	Obj.1, Obj. 3
KPI21	Cross-energy flexibility enabled by HEDGE-IoT solution	The ability to identify grid issues and procure flexibility by better forecasting LV demand	Obj.1, Obj. 2, Obj. 4

1.6 Use case conditions

Use case conditions

Assumptions

- Availability and installation of Edge IoT devices in households
- Availability in historical consumer data
- Data quality and accessibility/availability
- Participation and consent of consumers/prosumers

Prerequisites

- Consumers/Prosumers should have IoT devices in selected homes and buildings.
- Weather conditions and forecasts should be available (electricity demand forecast and PV forecast for prosumers)
- Prosumers/consumers are willing to provide the data from the IoT devices via the energy supplier
- Adequate flexibility offers from the local flexibility market (BUC-GR-03) are available (via the grid operators) to conduct the experiment

1.7 Further Information to the use case for classification / mapping

Classification Information

Relation to other use cases

Linked to SUC-GR-01.01:

- Providing forecasts of demand

Linked to SUC-GR-01.04:

- Ability to acquire data through several actors

Linked to SUC-GR-02.01:

- Ability to identify grid issues

Linked to SUC-GR-01.05:

• Ability to acquire accurate real-time data in edge level • Ability to perform edge processing and operations in residential level (e.g., scripting optimisation modules, identification of quick changes in appliance levels, validate the flexibility actions)
Level of depth
High
Prioritisation
High
Generic, regional, or national relation
National
Nature of the use case
System Use Case: Technical specifications to perform energy demand forecasting to predict the customer demand
Further keywords for classification

1.8 General Remarks

General Remarks

2 Diagrams of use case

Diagram(s) of use case

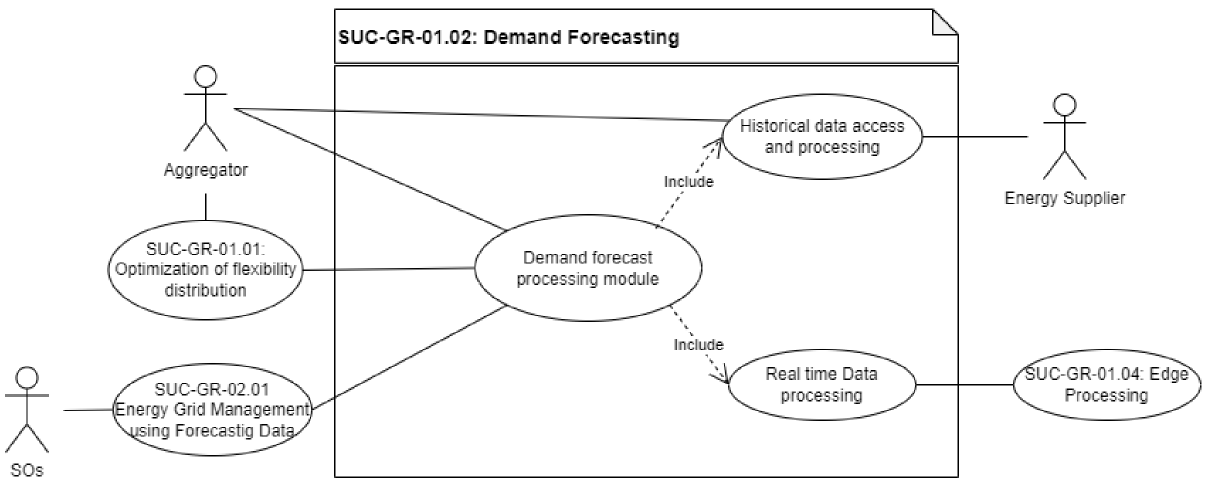


FIGURE 6: UML USE CASE DIAGRAM

3 Technical details

3.1 Actors

Actors			
Actor Name	***Actor Type***	***Actor Description***	***Further information specific to this use case***
Aggregator	Business Actor	An entity processing, analysing, and monitoring energy consumption/production data, operating the AI algorithms for demand/production forecasts, and performing the optimisation algorithms for the flexibility offers	Public Power Corporation
Energy Supplier	Business Actor	Collects consumer and prosumers data and is responsible for invoicing the consumers.	Public Power Corporation
SOs	Business Actor	Collect the forecasting data and identify any potential grid issues	Hellenic Electricity Distribution Network Operator (HEDNO), Independent Power Transmission Operator (IPTO)

3.2 References

References						
No.	***Reference Type***	***Reference***	***Status***	***Impact on use case***	***Originator / organisation***	***Link***

4 Step by step analysis of use case

4.1 Overview of scenarios

Scenario conditions						
No.	**Scenario name**	**Scenario description**	**Primary actor**	**Triggering event**	**Pre-condition**	**Post-condition**
Sc.1	Data Collection and Processing	Gather and preprocess real-time and historical energy consumption data from residential customers.	SUC-GR-01.04: Edge Processing	Scheduled data collection cycle or real-time data transmission from smart meters and residential devices.	Smart meters and residential devices are installed and operational	The data are collected and ready for processing
Sc.2	Demand Forecasting for Optimizatio n of the Aggregator	Analyse the collected data to forecast customer demand and optimize the decision of the aggregator	Aggregator	Completion of data collection and preprocessing	Real-time and historical energy consumption data is available.	Accurate short-to-middle term and long-term demand forecasts are available, and the aggregator has decided

Sc.3	Demand Forecasting for Grid Issue Detection	Demand forecasts and flexibility data are available and validated; system operators monitor and analyse grid conditions.	SOs	Availability of validated demand forecasts and flexibility assessments.	Demand forecasts and flexibility data are available and validated; system operators are ready to monitor and analyse grid conditions.	The SOs identify grid issues

4.2 Steps – Scenarios

Scenario								
Scenario name:		Sc.1 Data Collection and Processing						
Step No.	Event	Name of process/ activity	Description of process/ activity	Service	Information producer (actor)	Information receiver (actor)	Information Exchanged (IDs)	Requirement, R-IDs
St. 1	The meter operator sends the processed real-time data to the aggregator	Real-time Data to Aggregator	The meter operator sends the real-time consumption data to the aggregator	GET	SUC-GR-01.04: Edge Processing	Aggregator	Inf.1	Qos.1, Qos.2, Qos.3, Qos.4, Sec.1, Sec.2, Sec.3, Sec.4, Sec.5. D.1, D.3, D.5, Conf.3, Conf.4, Conf.5, Conf.6, O.1, O.2, O.3
St. 2	The aggregator requests the historical consumption data from the energy supplier	Historical Data Request	Historical data is requested	GET	Aggregator	Energy Supplier	Inf.2	Qos.2, Qos.3, Sec.1, Sec.5, Conf.3
St. 3	The energy supplier returns the historical data to the aggregator	Historical Data Retrieval	Historical data is acquired	GET	Energy Supplier	Aggregator	Inf.3	Qos.2, Qos.3, Sec.1, Sec.2, Sec.3, Sec.4, Sec.5, D.2, D.3, D.4, D.5, D.6, D.8, Conf.3, Conf.4, Conf.5, Conf.6, O.1, O.2, O.3

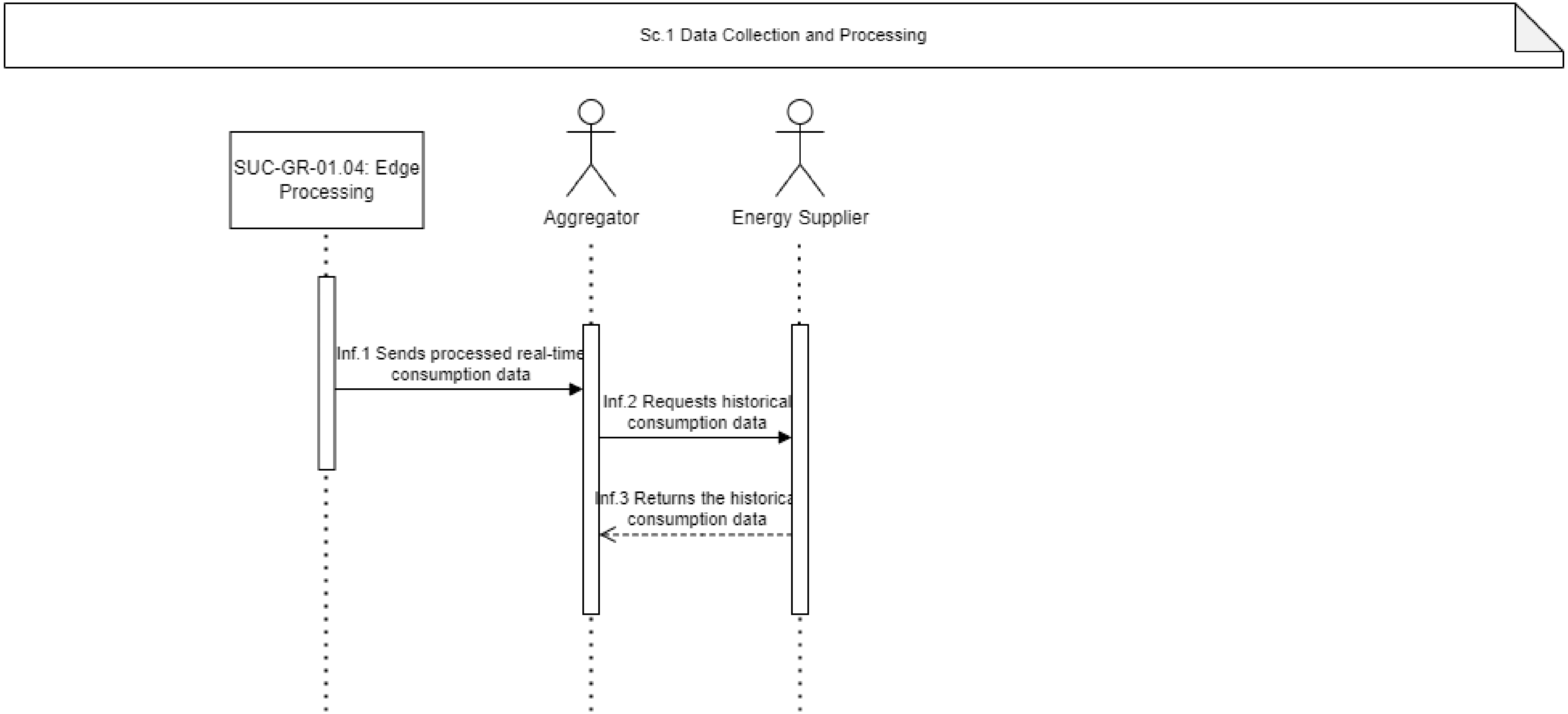


FIGURE 7: SUC-GR-01.02 SC.1 SEQUENCE DIAGRAM

Scenario								
Scenario name:		Sc.2 Demand Forecasting for Optimization of the Aggregator						
Step No.	Event	Name of process/ activity	Description of process/ activity	Service	Information producer (actor)	Information receiver (actor)	Information Exchanged (IDs)	Requirement, R-IDs
St. 1	Scheduled forecasting cycle or need for updated forecasts	Short-to-Middle Term Forecasting	Generate short-to-middle term demand forecasts.	EXECUTE	Aggregator	Aggregator	-	Qos.1, Qos.2, Qos.4
St. 2	The aggregator integrates the forecasted data into the optimization system	Integration of the forecasted data	The aggregator integrates the forecasted data into the optimization system	REPORT	Aggregator	SUC-GR-01.01: Optimization of flexibility distribution	Inf.4	Qos.2, Qos.3, Sec.5, D.1, D.3, D.5, D.6, D.7, O.1, O.2, O.3

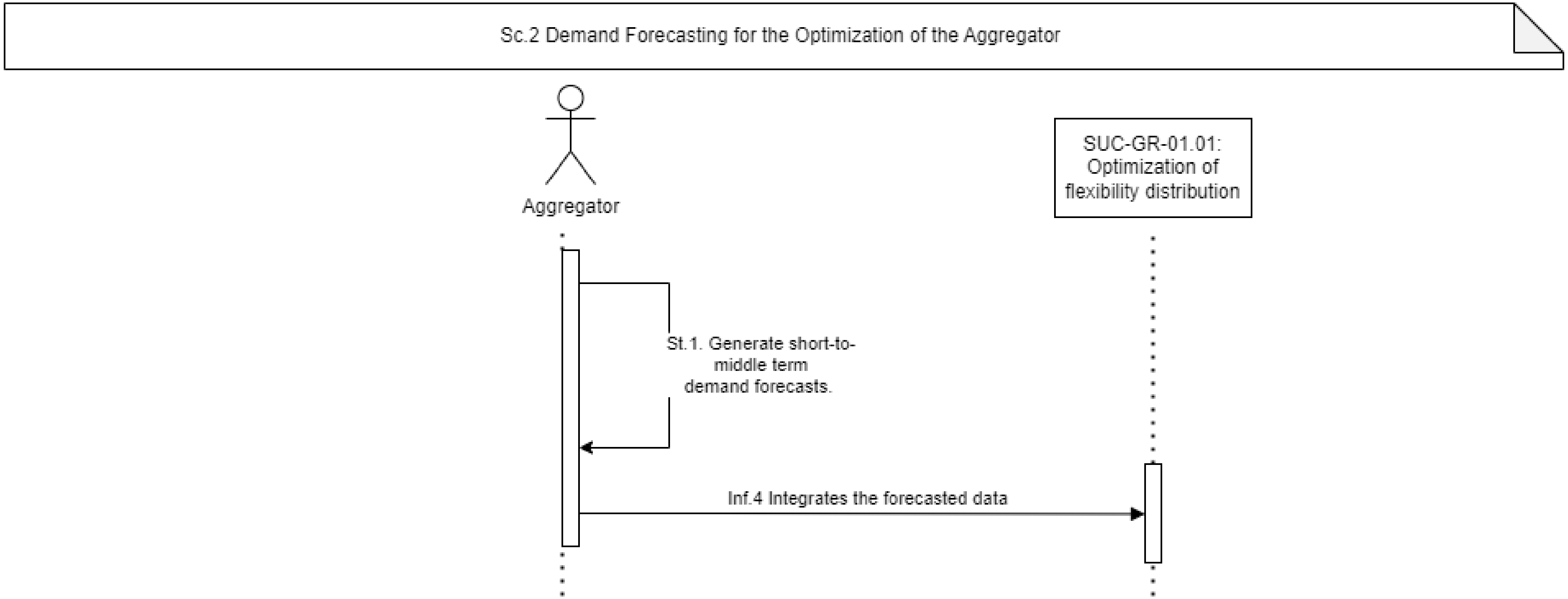


FIGURE 8: SUC-GR-01.02 SC.2 SEQUENCE DIAGRAM

Scenario								
Scenario name:		Sc.3 Demand Forecasting for Grid Issue Detection						
Step No.	**Event**	**Name of process/ activity**	**Description of process/ activity**	**Service**	**Information producer (actor)**	**Information receiver (actor)**	**Information Exchanged (IDs)**	**Requirement, R-IDs**
St. 1	Scheduled forecasting cycle or need for updated forecasts	Short-to-Middle Term Forecasting	Generating demand forecasts for short-to-middle term periods.	EXECUTE	Aggregator	Aggregator	-	Qos.1, Qos.2, Qos.4
St. 2	Request of the forecasted data	Request of the forecasted data	The system operators request the forecasted data from the aggregator to run the grid analysis process	GET	SOs	Aggregator	Inf.5	Qos.1, Qos.2, Qos.4, Sec.1, Sec.5
St. 3	Return of the forecasted data	Return of the forecasted data	Aggregator provides the forecasted data to the system operators	GET	Aggregator	SOs	Inf.6	Qos.2, Qos.3, Sec.1, Sec.2, Sec.3, Sec.4, Sec.5, D.2, D.3, D.4, D.5, D.6, D.8, Conf.3, Conf.4, Conf.5, O.1, O.2, O.3
St. 4	The System Operators kick off the grid analysis process	Grid analysis	The System Operators kick off the grid analysis process to identify any possible grid issues	GET	SOs	SUC-GR-02.01 Energy Grid Management using Forecasting Data	Inf.7	Qos.2, Qos.3, Conf.1, Conf.2, Conf.3, Conf.4, Conf.5, Conf.6, Conf.7, Conf.8

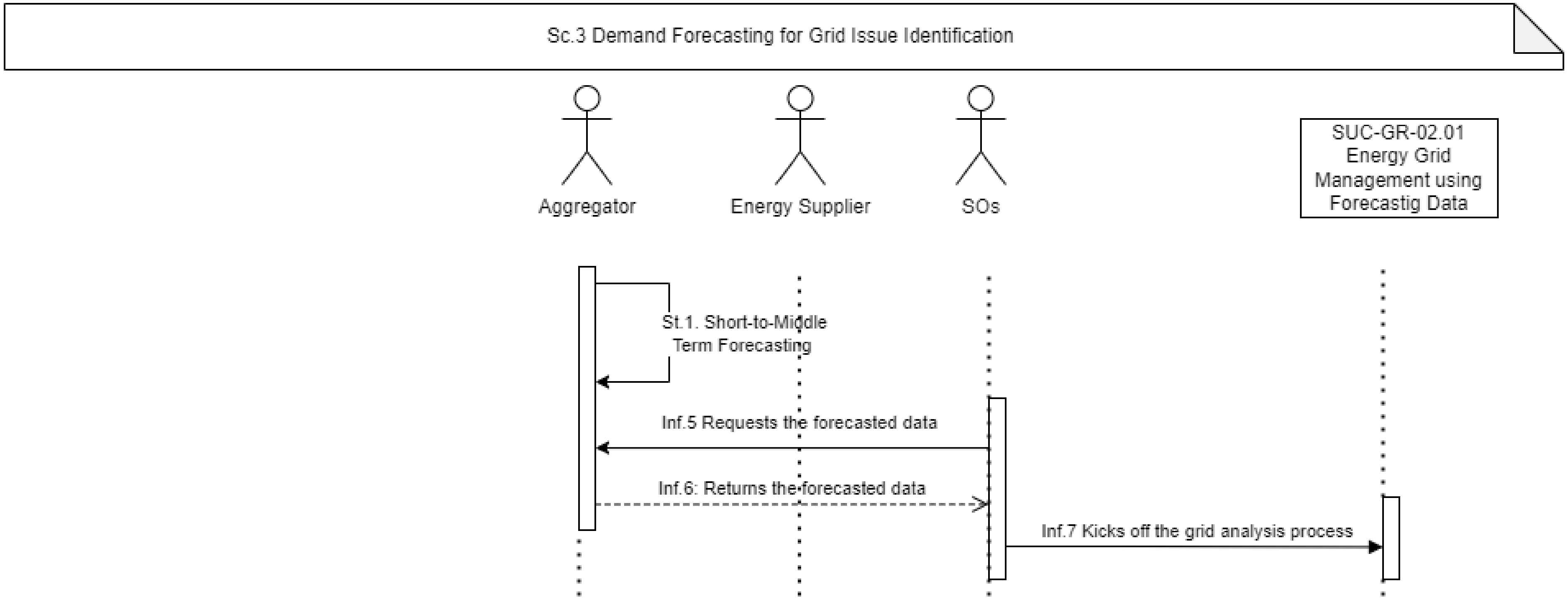


FIGURE 9: SUC-GR-01.02 SC.3 SEQUENCE DIAGRAM

5 Information exchanged

Information exchanged			
Information exchanged (ID)	**Name of information**	**Description of information exchanged**	**Requirement, R-IDs**
Inf.1	Real-time Data to Aggregator	The meter operator sends the real-time consumption data to the aggregator	Qos.1, Qos.2, Qos.3, Qos.4, Sec.1, Sec.2, Sec.3, Sec.4, Sec.5. D.1, D.3, D.5, Conf.3, Conf.4, Conf.5, Conf.6, O.1, O.2, O.3
Inf.2	Historical Data Request	Historical data is requested	Qos.2, Qos.3, Sec.1, Sec.5, Conf.3
Inf.3	Historical Data Retrieval	Historical data is acquired	Qos.2, Qos.3, Sec.1, Sec.2, Sec.3, Sec.4, Sec.5, D.2, D.3, D.4, D.5, D.6, D.8, Conf.3, Conf.4, Conf.5, Conf.6, O.1, O.2, O.3
Inf.4	Integration of the forecasted data	The aggregator integrates the forecasted data into the optimization system	Qos.2, Qos.3, Sec.5, D.1, D.3, D.5, D.6, D.7, O.1, O.2, O.3
Inf.5	Request of the forecasted data	The system operators request the forecasted data from the aggregator to run the grid analysis process	Qos.1, Qos.2, Qos.4, Sec.1, Sec.5
Inf.6	Return of the forecasted data	Aggregator provides the forecasted data to the system operators	Qos.2, Qos.3, Sec.1, Sec.2, Sec.3, Sec.4, Sec.5, D.2, D.3, D.4, D.5, D.6, D.8, Conf.3, Conf.4, Conf.5, O.1, O.2, O.3
Inf.7	Grid analysis	The System Operators kick off the grid analysis process to identify any grid issues	Qos.2, Qos.3, Conf.1, Conf.2, Conf.3, Conf.4, Conf.5, Conf.6, Conf.7, Conf.8

6 Requirements

Quality of Service Requirements		
Categories ID	**Category name for requirements**	**Category description**
QoS	Quality of Service	Generic properties that service/SUC should provide – quality attributes.
Requirement R-ID	**Requirement name**	**Requirement description**
QoS.1	Elapsed time response requirements for exchanging data	Pending the forecast horizons
QoS.2	Availability of information flows	99.9% availability
QoS.3	Accuracy of data requirements	Adequate accuracy can be assumed
QoS.4	Frequency of data exchanges	Upon request

Security Requirements		
Categories ID	**Category name for requirements**	**Category description**

Sec	Security	Authentication of user, confidentiality, integrity, prevention of denial of service, non-repudiation or accountability, error management.
Requirement R-ID	**Requirement name**	**Requirement description**
Sec.1	Information theft	Ensuring that data cannot be stolen or deleted by an unauthorized entity is crucial
Sec.2	Information integrity violation	Ensuring that data is not changed or destroyed is quite important
Sec.3	Replay	Ensuring that data cannot be resent by an unauthorized source is quite important
Sec.4	Denial of service	Ensuring unimpeded access to data is quite important
Sec.5	Authentication	Ensuring that data comes from the stated source or goes to authenticated receiver is crucial

Data Management Requirements		
Categories ID	**Category name for requirements**	**Category description**
D	Data Management	Type of source of data, correctness or validity of data, timeliness or time stamping of data, volume of data, synchronization, or consistency of data across systems, timely access to data, validation of data across organizational boundaries, transaction management, data naming, identification, formats across disparate systems, maintenance of data and databases.
Requirement R-ID	**Requirement name**	**Requirement description**
D.1	Type of source data	Source data was directly measured
D.2	Correctness of data	Source data is always correct
D.3	Up-to-date management	Received data must be up to date within minutes of source data changing
D.4	Management of large volumes of data that are being exchanged	Some part of step involves handling large volumes of data
D.5	Data consistency and synchronization management across systems	Minute-by-minute synchronization
D.6	Management of accessing different types of data to be exchanged	Numbers or types of data being exchanged are rarely changed or updated
D.7	Transaction integrity required (backup and rollback capability)	Data exchanges require backup of crucial data for "cold" failover
D.8	Management of data formats in data exchanges	Conversion of data formats is handled by a "converter" at Information Receiver site

Discovery and Configuration Requirements		
Categories ID	**Category name for requirements**	**Category description**
Conf	Configuration	Locations, distances, communication layout, commonly used communication protocol media, network bandwidth, existing

		protocols, number of devices, systems, volume of data items, expected growth, etc.
Requirement R-ID	**Requirement name**	**Requirement description**
Conf.1	Number of Information Producers	Two to a few
Conf.2	Number of Information Receivers	Two to a few
Conf.3	Distance between entities	Up until many kilometres
Conf.4	Data exchange methods	Edge and Cloud enabled communication protocols
Conf.5	Data exchange pattern	Data flows patterns basically even
Conf.6	Existence of legacy systems	Many legacy systems
Conf.7	Operation mode of Information Producer	Manual & Automatic
Conf.8	Operation mode of Information Receiver	Manual & Automatic

Other Requirements		
Categories ID	**Category name for requirements**	**Category description**
O	Regulatory obligation related to privacy	2016/679 GDPR (General Data Protection Regulation)
Requirement R-ID	**Requirement name**	**Requirement description**
O.1	Personal data processing	Personal data may not be processed unless there is at least one legal basis to do so.
O.2	Right to access, rectify, erasure, restriction	Data retention policy outlines the specific sensitive time period which data can be retained, plus how it will be disposed of when the time to do so comes.
O.3	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.

7 Common Terms and Definitions

Common Terms and Definitions	
Term	**Definition**
LFM	Local Flexibility Market
SO	System Operator
PPC	Public Power Corporation
HEDNO	Hellenic Electricity Distribution Network Operator
IPTO	Independent Power Transmission Operator
GDPR	General Data Protection Regulation

3 SUC-GR-01.03 – PRODUCTION FORECASTING

1 Description of the use case

1.1 Name of the use case

ID	Area / Domain(s) / Zones(s)	Name of Use Case
SUC-GR-01.03	Local Flexibility Market (LFM) / Demand Response Programs / IoT Integration	**Production Forecasting**

1.2 Version management

Version Management			
Version No.	**Date**	**Name of Author(s)**	**Changes0.**
0.1	28.06.2024	Nickie Gkolia - ICCS	1st Draft
0.2	16.07.2024	Nickie Gkolia - ICCS	Extended Version
0.3	26.07.2024	Nickie Gkolia - ICCS	Correcting diagrams and typos
0.4	27.08.2024	Nickie Gkolia - ICCS	Modifications to comply with the template provided

1.3 Scope and objectives of use case

Scope and Objectives of Use Case	
Scope	To forecast the production of the prosumers to identify their ability to offer flexibility. The aggregator will use this information to run the optimization algorithm and decide if it can bid for a flexibility market product.
Objective(s)	The main objectives are: 1. To predict the energy production of prosumers (households with PV systems) over a specified period. This involves collecting and analysing historical data, weather forecasts, and predicting future production trends. 2. To determine the ability of prosumers to offer flexibility based on their predicted production as well as identify the surplus energy that can be potentially used for flexibility services. 3. To provide the aggregator with timely and reliable production forecasts so it can use this information to run optimization algorithms effectively. 4. To help the system operators to identify grid issues and request flexibility
Related business case(s)	BUC-GR-01: Flexibility management through active prosumers/consumers engagement BUC-GR-02: Leveraging data exchange and ai edge algorithms for energy forecasting and prevention of critical grid events

1.4 Narrative of use case

Narrative of Use Case
Short description
The system forecasts the energy production of residential PV systems to assess the ability of prosumers to offer flexibility. The aggregator uses these forecasts to run optimisation algorithms and determine whether they can bid for flexibility market products to improve grid stability and maximise

economic benefits. By integrating accurate production forecasts with an optimisation algorithm, the system supports informed decisions. It ensures scalability, reliability and regulatory compliance while protecting customer data. Grid operators also use the forecast data to identify potential grid problems and ensure grid stability.

Complete description

This use case describes a system developed for real-time monitoring and forecasting of energy production of prosumers, especially households equipped with photovoltaic (PV) systems. The system continuously monitors production data using specialised equipment and combines it with historical data from energy suppliers and weather forecasts to improve forecasting accuracy. These forecasts are important to assess the ability of prosumers to provide flexibility services such as energy storage and demand response to the grid.

The forecasting process integrates real-time production data, historical production information and weather forecasts to provide accurate predictions for prosumer energy production. The system also includes battery storage management that optimises charging and discharging times to support flexibility procurement. This integration ensures that the flexibility offered by prosumers is reliable and meets grid requirements.

The aggregator uses these detailed forecasts together with battery management insights and historical data to run optimisation algorithms. These algorithms help to decide whether to bid for flexibility market products and ensure that the bids are economically favourable and technically feasible. In addition, grid operators use the forecast data to identify and resolve potential grid problems by submitting bids for flexibility measures to the market operator.

The SUC comprises the following steps:

1. Data from household appliances and smart metres is collected in real time
2. Historical data is provided by the energy supplier.
3. All data is pre-processed.
4. The aggregator uses both real-time and historical data to forecast customer production.
5. The system operators (SOs) use the forecast data to recognise potential grid problems.

Main technologies used:

1. **Photovoltaic (PV) systems and** smart metres: for real-time data collection of energy production and consumption from residential prosumers.
2. **Edge** c**omputing:** Processes data locally at the edge of the grid, reducing latency and enabling faster analyses and decisions.
3. **Machine** learning models**:** For accurate production forecasts based on historical data, real-time data and weather forecasts.
4. **Data** analytics platforms**:** For pre-processing data, forecasting and integrating results into decision-making processes

Hardware:

1. **Photovoltaic** s**ystems and** smart metres: Used in private households to record energy production and consumption data in real time.
2. **Edge servers:** Are set up close to the data sources for initial data processing and rapid analysis.
3. **Battery storage systems:** Used to store energy generated by PV systems and provide flexibility to the grid.

The SUC includes the following scenarios:

1. **Data collection and processing:** the system collects real-time data from photovoltaic (PV) systems and smart metres in private households, as well as historical data from energy suppliers. This data is then pre-processed to ensure it is clean, organised and ready for use in forecasting models.
2. **Production forecast for aggregator optimisation:** The system uses the pre-processed data together with weather forecasts to predict prosumer energy production. These forecasts are integrated into optimisation algorithms that help the aggregator decide whether to bid on the flexibility markets to ensure that the bids are economically advantageous and technically feasible.

3. **Production forecasts to recognise grid problems:** Grid operators use forecast production data to identify potential grid problems, such as imbalances between supply and demand or possible congestion. They analyse this information to proactively manage grid stability and decide whether to submit bids for flexibility measures to the market operator.	

1.5 Key performance indicators (KPI)

ID	Name	Description	Reference to mentioned use case objectives
OB1	Different types of IoT/edge devices to be exploited in Demo Areas e.g., Smart Meter, HEMS, Sensors, inverter	The IoT/edge devices to be used within this SUC	Obj,1 Obj.2, Obj. 3
OB4	Users involved in the piloting	Number of users part of the Greek Demo, based on the installations of edge/IoT devices	Obj.1, Obj.2, Obj. 3
KPI3	% Of planned usage of HEDGE-IoT tools/data services (e.g., transactions, periodicity) in field demos	Number of HEDGE-IoT tools and data services used within this SUC	Obj.1, Obj. 2, Obj.3, Obj.4
KPI7	Increased RES and IoT deployment for providing flexibility services	Amount of RES and IoT devices available in this SUC	Obj.1, Obj. 2, Obj. 3
KPI12	Faster application response times	Edge vs cloud response times performing forecasts and being available in the users	Obj.1, Obj. 3, Obj. 3
KPI21	Cross-energy flexibility enabled by HEDGE-IoT solution	The ability to identify grid issues and procure flexibility by better forecasting LV DER production	Obj.1, Obj. 2, Obj. 4

1.6 Use case conditions

Use case conditions
Assumptions
• Availability and installation of Edge IoT devices in households • Availability in historical production data • Data quality and accessibility/availability • Consumer participation and consent
Prerequisites
• Consumers/Prosumers should have IoT devices in selected homes and buildings. • Weather conditions and forecasts should be available (electricity demand forecast and PV forecast for prosumers) • Prosumers/consumers are willing to provide the data from the IoT devices via the energy supplier • Adequate flexibility offers from the local flexibility market (BUC-GR-03) are available (via the grid operators) to conduct the experiment

1.7 Further Information to the use case for classification / mapping

Classification Information
Relation to other use cases
Linked to SUC-GR-01.01: • Provision of production forecasts Linked to SUC-GR-02.01: • Ability to recognise grid problems Linked to SUC-GR-01.05: • Ability to capture accurate real-time data at the edge level • Ability to perform edge processing and operations at the residential level (e.g. scripting of optimisation modules, identification of rapid changes in appliance levels, validation of flexibility actions) Linked to SUC-GR-01.04: • Ability to capture accurate real-time data at the edge level • Ability to perform edge processing and operations at the household level (e.g. scripting of optimisation modules, identification of rapid changes in appliance levels, validation of flexibility actions)
Level of depth
High
Prioritisation
High
Generic, regional, or national relation
National
Nature of the use case
System Use Case: Technical specifications to perform energy production forecasting to predict the prosumers production
Further keywords for classification

1.8 General Remarks

General Remarks

2 Diagrams of use case

Diagram(s) of use case

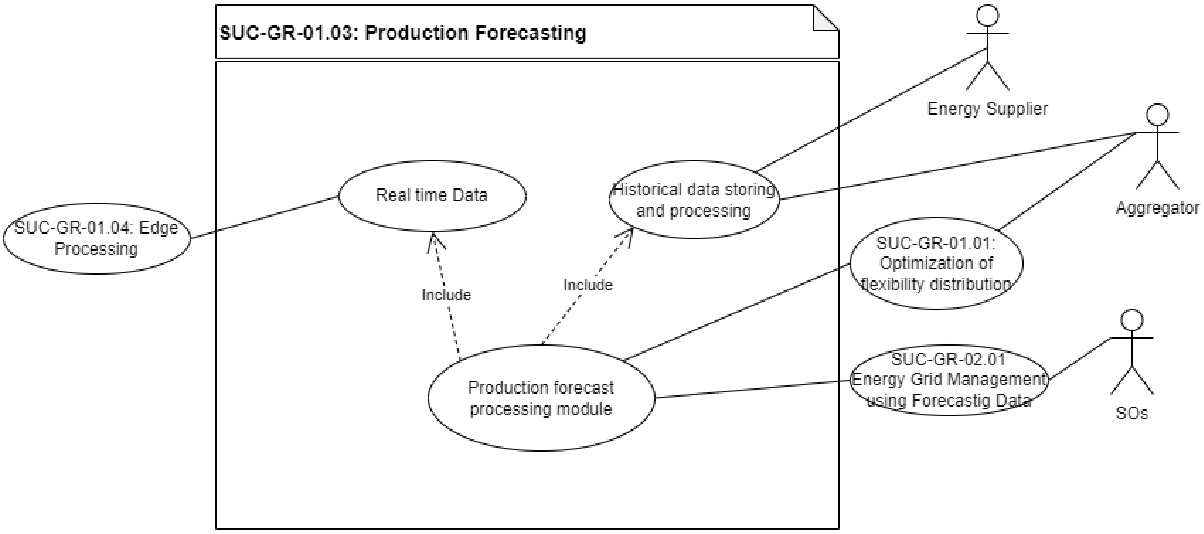


FIGURE 10: UML USE CASE DIAGRAM

3 Technical details

3.1 Actors

Actors			
Actor Name	***Actor Type***	***Actor Description***	***Further information specific to this use case***
Aggregator	Business Actor	An entity that processes, analyses and monitors energy consumption/generation data, runs AI algorithms for demand/generation forecasting and performs optimisation algorithms for the flexibility offers	Public Power Corporation
Energy Supplier	Business Actor	Collects consumer and prosumers data and is responsible for invoicing the consumers.	Public Power Corporation
SOs	Business Actor	Collect the prediction data and identify possible network problems	Hellenic Electricity Distribution Network Operator (HEDNO), Independent Power Transmission Operator (IPTO)

3.2 References

References						
No.	***Reference Type***	***Reference***	***Status***	***Impact on use case***	***Originator / organisation***	***Link***

4 Step by step analysis of use case

4.1 Overview of scenarios

Scenario conditions						
No.	**Scenario name**	**Scenario description**	**Primary actor**	**Triggering event**	**Pre-condition**	**Post-condition**
Sc.1	Data Collection and Processing	Gather and preprocess real-time and historical energy production data from residential prosumers.	SUC-GR-01.04: Edge Processing	Scheduled data collection cycle or real-time data transmission from smart metres and residential devices.	Smart meters and residential devices are installed and operational	The data are collected and ready for processing
Sc.2	Production Forecasting for Optimization of the Aggregator	Analyse the collected data to forecast customer production and optimise the aggregator's decision	Aggregator	Completion of data collection and preprocessing	Real-time and historical energy production data is available.	Accurate short-term to medium-term and long-term production forecasts are available
Sc.3	Production Forecasting for Grid Issue Detection	Production forecasts and flexibility data are available and validated; grid operators monitor and analyse grid conditions.	SOs	Availability of validated production forecasts and flexibility assessments.	Production forecasts and flexibility data are available and validated; grid operators are ready to monitor and analyse grid conditions.	The SOs identify grid issues

4.2 Steps – Scenarios

Scenario								
Scenario name:		Sc.1 Data Collection and Processing						
Step No.	**Event**	**Name of process/ activity**	**Description of process/ activity**	**Service**	**Information producer (actor)**	**Information receiver (actor)**	**Information Exchanged (IDs)**	**Requirement, R-IDs**
St. 1	The edge processing system sends the pre-processed data to the aggregator	Production Data to aggregator	The edge processing system sends the pre-processed data to the aggregator	GET	SUC-GR-01.04: Edge Processing	Aggregator	Inf.1	Qos.1, Qos.2, Qos.3, Qos.4, Sec.1, Sec.2, Sec.3, Sec.4, Sec.5. D.1, D.3, D.5, Conf.3, Conf.4, Conf.5, Conf.6, O.1, O.2, O.3
St. 2	Historical energy production data from the energy supplier is requested.	Historical Data Request	The aggregator requests historical data from the energy supplier.	GET	Aggregator	Energy Supplier	Inf.2	Qos.2, Qos.3, Sec.1, Sec.5, Conf.3
St. 3	Historical energy production data from the energy supplier is returned.	Historical Data Return	The energy supplier returns the historical production data to the aggregator.	GET	Energy Supplier	Aggregator	Inf.3	Qos.2, Qos.3, Sec.1, Sec.2, Sec.3, Sec.4, Sec.5, D.2, D.3, D.4, D.5, D.6, D.8, Conf.3, Conf.4, Conf.5, Conf.6, O.1, O.2, O.3

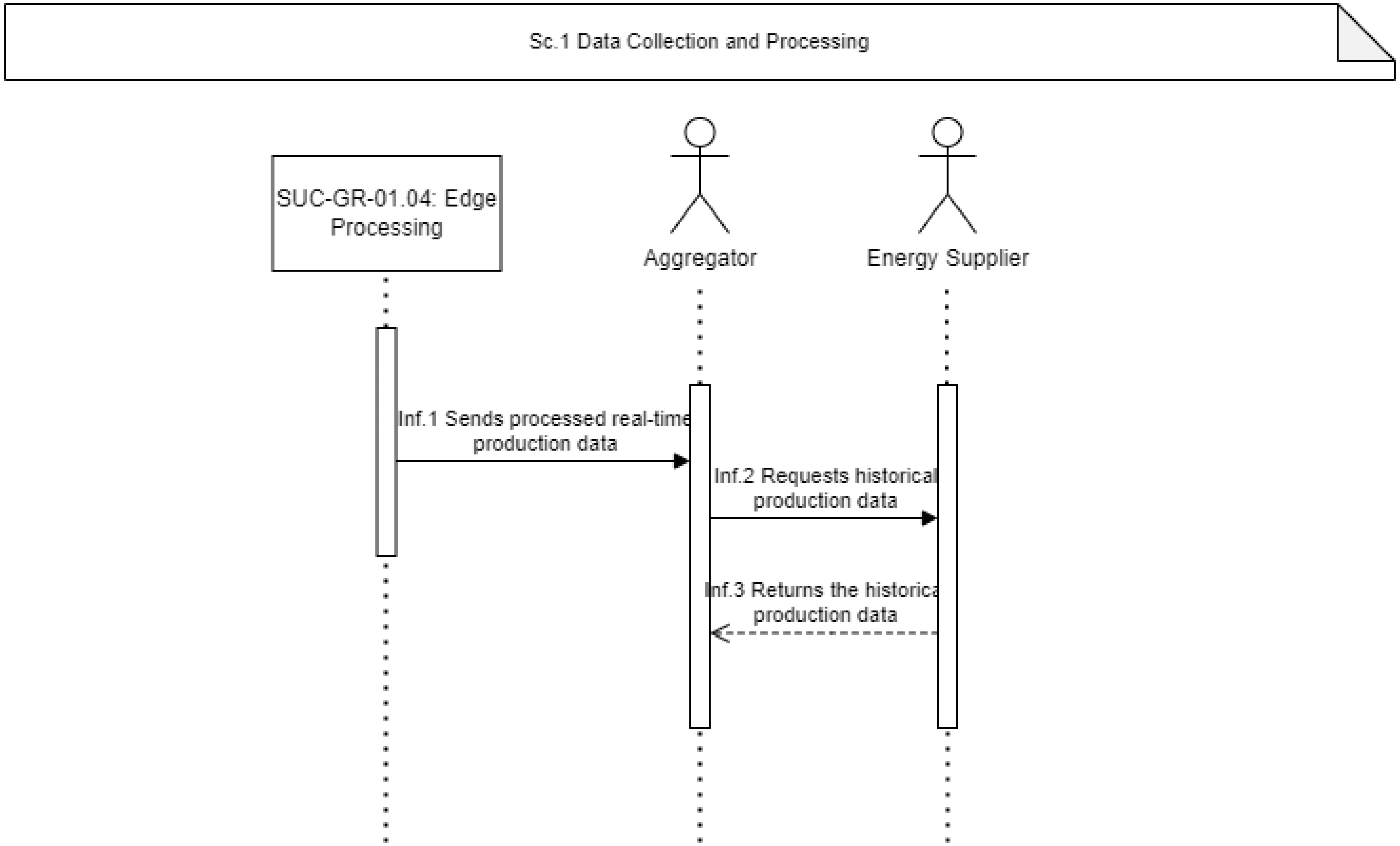


FIGURE 11: SUC-GR-01.03 SC.1 SEQUENCE DIAGRAM

Scenario								
Scenario name:		Sc.2 Production Forecasting for Optimization of the Aggregator						
Step No.	**Event**	**Name of process/ activity**	**Description of process/ activity**	**Service**	**Information producer (actor)**	**Information receiver (actor)**	**Information Exchanged (IDs)**	**Requirement, R-IDs**
St. 1	Scheduled forecasting cycle or need for updated forecasts	Short-to-Middle Term Forecasting	Generate short-to-middle term production forecasts.	EXECUTE	Aggregator	Aggregator	-	Qos.1, Qos.2, Qos.4
St. 2	The aggregator integrates the forecasted data into the optimization system	Integration of the forecasted data	The aggregator integrates the forecasted data into the optimization system	REPORT	Aggregator	SUC-GR-01.01: Optimization of flexibility distribution	Inf.4	Qos.2, Qos.3, Sec.5, D.1, D.3, D.5, D.6, D.7, O.1, O.2, O.3

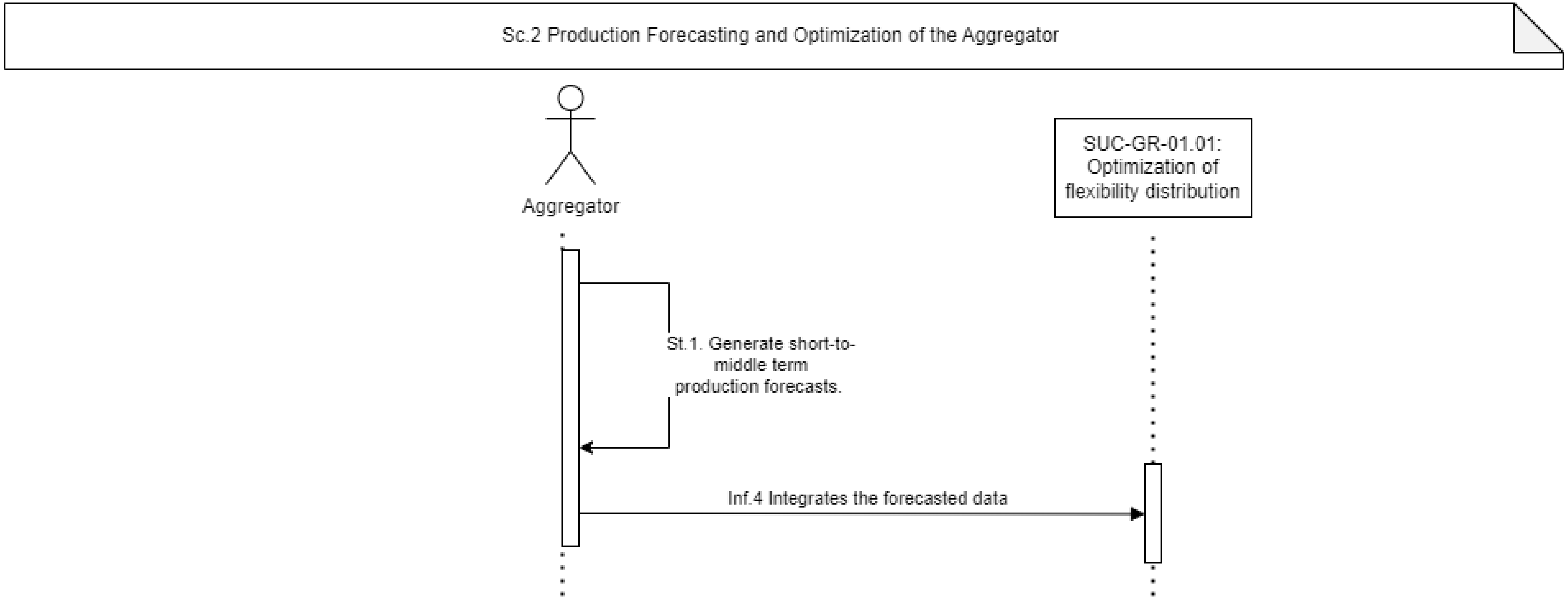


FIGURE 12: SUC-GR-01.03 SC.2 SEQUENCE DIAGRAM

Scenario								
Scenario name:		Sc.3 Production Forecasting for Grid Issue Detection						
Step No.	**Event**	**Name of process/ activity**	**Description of process/ activity**	**Service**	**Information producer (actor)**	**Information receiver (actor)**	**Information Exchanged (IDs)**	**Requirement, R-IDs**
St. 1	Scheduled forecasting cycle or need for updated forecasts	Short-to-Middle Term Forecasting	Generating demand forecasts for short-to-middle term periods.	EXECUTE	Aggregator	Aggregator	-	Qos.1, Qos.2, Qos.4
St. 2	Request of the forecasted data	Request of the forecasted data	The system operators request the forecasted data from the aggregator to run the grid analysis process	GET	SOs	Aggregator	Inf.5	Qos.1, Qos.2, Qos.4, Sec.1, Sec.5
St. 3	Return of the forecasted data	Return of the forecasted data	Aggregator provides the forecasted data to the system operators	GET	Aggregator	SOs	Inf.6	Qos.2, Qos.3, Sec.1, Sec.2, Sec.3, Sec.4, Sec.5, D.2, D.3, D.4, D.5, D.6, D.8, Conf.3, Conf.4, Conf.5, O.1, O.2, O.3
St. 4	The System Operators kick off the grid analysis process	Grid analysis	The System Operators kick off the grid analysis process to identify any possible grid issues	GET	SOs	SUC-GR-02.01 Energy Grid Management using Forecasting Data	Inf.7	Qos.2, Qos.3, Conf.1, Conf.2, Conf.3, Conf.4, Conf.5, Conf.6, Conf.7, Conf.8

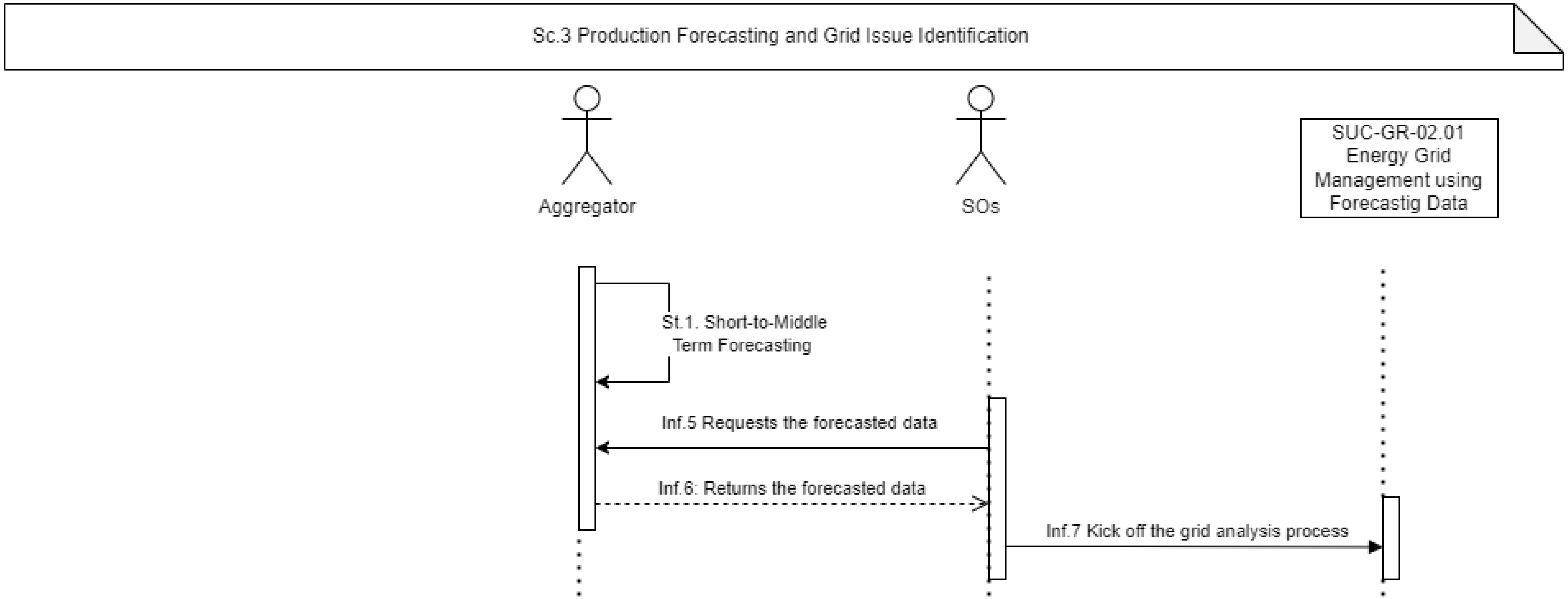


FIGURE 13: SUC-GR-01.03 SC.3 SEQUENCE DIAGRAM

5 Information exchanged

Information exchanged			
Information exchanged (ID)	***Name of information***	***Description of information exchanged***	***Requirement, R-IDs***
Inf.1	Real-time Data to Aggregator	The meter operator sends the real-time production data to the aggregator.	Qos.1, Qos.2, Qos.3, Qos.4, Sec.1, Sec.2, Sec.3, Sec.4, Sec.5. D.1, D.3, D.5, Conf.3, Conf.4, Conf.5, Conf.6, O.1, O.2, O.3
Inf.2	Historical Data Request	Historical data is requested	Qos.2, Qos.3, Sec.1, Sec.5, Conf.3
Inf.3	Historical Data Retrieval	Historical data is acquired	Qos.2, Qos.3, Sec.1, Sec.2, Sec.3, Sec.4, Sec.5, D.2, D.3, D.4, D.5, D.6, D.8, Conf.3, Conf.4, Conf.5, Conf.6, O.1, O.2, O.3
Inf.4	Integration of the forecasted data	The aggregator integrates the forecasted data into the optimization system	Qos.2, Qos.3, Sec.5, D.1, D.3, D.5, D.6, D.7, O.1, O.2, O.3
Inf.5	Request of the forecasted data	The system operators request the forecasted data from the aggregator to run the grid analysis process	Qos.1, Qos.2, Qos.4, Sec.1, Sec.5
Inf.6	Return of the forecasted data	Aggregator provides the forecasted data to the system operators	Qos.2, Qos.3, Sec.1, Sec.2, Sec.3, Sec.4, Sec.5, D.2, D.3, D.4, D.5, D.6, D.8, Conf.3, Conf.4, Conf.5, O.1, O.2, O.3
Inf.7	Grid analysis	The System Operators kick off the grid analysis process to identify any possible grid issues	Qos.2, Qos.3, Conf.1, Conf.2, Conf.3, Conf.4, Conf.5, Conf.6, Conf.7, Conf.8

6 Requirements

Quality of Service Requirements		
Categories ID	**Category name for requirements**	**Category description**
QoS	Quality of Service	Generic properties that service/SUC should provide – quality attributes.
Requirement R-ID	**Requirement name**	**Requirement description**
QoS.1	Elapsed time response requirements for exchanging data	Pending the forecast horizons
QoS.2	Availability of information flows	99.9% availability
QoS.3	Accuracy of data requirements	Adequate accuracy can be assumed
QoS.4	Frequency of data exchanges	Upon request

Security Requirements		
Categories ID	**Category name for requirements**	**Category description**
Sec	Security	Authentication of user, confidentiality, integrity, prevention of denial of service, non-repudiation or accountability, error management.
Requirement R-ID	**Requirement name**	**Requirement description**
Sec.1	Information theft	Ensuring that data cannot be stolen or deleted by an unauthorized entity is crucial
Sec.2	Information integrity violation	Ensuring that data is not changed or destroyed is quite important
Sec.3	Replay	Ensuring that data cannot be resent by an unauthorized source is quite important
Sec.4	Denial of service	Ensuring unimpeded access to data is quite important
Sec.5	Authentication	Ensuring that data comes from the stated source or goes to authenticated receiver is crucial

Data Management Requirements		
Categories ID	**Category name for requirements**	**Category description**
D	Data Management	Type of source of data, correctness or validity of data, timeliness or time stamping of data, volume of data, synchronization, or consistency of data across systems, timely access to data, validation of data across organizational boundaries, transaction management, data naming, identification, formats across disparate systems, maintenance of data and databases.
Requirement R-ID	**Requirement name**	**Requirement description**
D.1	Type of source data	Source data was directly measured
D.2	Correctness of data	Source data is always correct
D.3	Up-to-date management	Received data must be up to date within minutes of source data changing
D.4	Management of large volumes of data that are being exchanged	Some part of step involves handling large volumes of data
D.5	Data consistency and synchronization management across systems	Minute-by-minute synchronization
D.6	Management of accessing different types of data to be exchanged	Numbers or types of data being exchanged are rarely changed or updated
D.7	Transaction integrity required (backup and rollback capability)	Data exchanges require backup of crucial data for "cold" failover
D.8	Management of data formats in data exchanges	Conversion of data formats is handled by a "converter" at Information Receiver site

Discovery and Configuration Requirements		
Categories ID	**Category name for requirements**	**Category description**
Conf	Configuration	Locations, distances, communication layout, commonly used communication protocol media, network bandwidth, existing protocols, number of devices, systems, volume of data items, expected growth, etc.
Requirement R-ID	**Requirement name**	**Requirement description**
Conf.1	Number of Information Producers	Two to a few
Conf.2	Number of Information Receivers	Two to a few
Conf.3	Distance between entities	Up until many kilometres
Conf.4	Data exchange methods	Edge and Cloud enabled communication protocols
Conf.5	Data exchange pattern	Data flows patterns basically even
Conf.6	Existence of legacy systems	Many legacy systems
Conf.7	Operation mode of Information Producer	Manual & Automatic
Conf.8	Operation mode of Information Receiver	Manual & Automatic

Other Requirements		
Categories ID	**Category name for requirements**	**Category description**
O	Regulatory obligation related to privacy	2016/679 GDPR (General Data Protection Regulation)
Requirement R-ID	**Requirement name**	**Requirement description**
O.1	Personal data processing	Personal data may not be processed unless there is at least one legal basis to do so.
O.2	Right to access, rectify, erasure, restriction	Data retention policy outlines the specific sensitive time period which data can be retained, plus how it will be disposed of when the time to do so comes.
O.3	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.

7 Common Terms and Definitions

Common Terms and Definitions	
Term	**Definition**
LFM	Local Flexibility Market
SO	System Operator
PPC	Public Power Corporation
HEDNO	Hellenic Electricity Distribution Network Operator
IPTO	Independent Power Transmission Operator
GDPR	General Data Protection Regulation

4 SUC-GR-01.04 – EDGE PROCESSING

1 Description of the use case

1.1 Name of the use case

ID	*Area / Domain(s) / Zones(s)*	*Name of Use Case*
SUC-GR-01.04	Local Flexibility Market / Demand Response Programs / IoT integration	Edge Processing

1.2 Version management

Version Management			
Version No.	*Date*	*Name of Author(s)*	*Changes0.*
0.1	03.07.2024	Nickie Gkolia - ICCS	1st Draft
0.2	16.07.2024	Nickie Gkolia - ICCS	Extended Version
0.3	26.07.2024	Nickie Gkolia - ICCS	Refinement
0.4	28.08.2024	Nickie Gkolia - ICCS	Modifications to comply with the template provided
1.0	15.10.2024	Nickie Gkolia - ICCS	Final first version

1.3 Scope and objectives of use case

Scope and Objectives of Use Case	
Scope	The edge processing system will focus on real-time monitoring and analysis of residential energy consumption using IoT devices. It aims to provide actionable insights and facilitate efficient energy management to support consumer participation in the Local Flexibility Market (LFM).
Objective(s)	The main objectives are: 1. To continuously monitor and calculate key energy metrics such as average voltage, instant consumption, and total energy usage 2. To identify unusual patterns or potential issues in energy consumption to enable proactive management and maintenance 3. To provide detailed visualizations and customized insights on energy consumption patterns to help users optimize their energy usage 4. To enable the Aggregator to leverage real-time data and insights to make informed decisions about flexibility offers and incentivize consumer participation in the LFM
Related business case(s)	BUC-GR-01: Flexibility management through active prosumers/consumers engagement

1.4 Narrative of use case

Narrative of Use Case
Short description
The edge processing system monitors and analyses real-time energy consumption and production data from IoT devices used in residential areas. This system calculates key metrics, performs data

validation and quality checks, and aggregates data to provide actionable insights. By processing consumption and production data on site, the system supports the aggregator and consumers in optimising flexibility procurement and participation in the local flexibility market (LFM).

Complete description

The Edge Processing system is designed to improve the procurement of flexibility by enabling real-time monitoring and analysis of residential energy consumption and generation by IoT devices. This system collects and processes a variety of energy metrics, such as average voltage, instantaneous consumption, total cumulative energy, current frequency, active power and power factor. It also calculates statistical measures, including the median and standard deviation, and performs anomaly detection to recognise irregularities in the data. In addition, the system performs data validation and quality checks to ensure the accuracy and reliability of the collected data.

In addition to monitoring energy consumption, the system also tracks prosumer energy generation data, such as yields from photovoltaic systems. This comprehensive monitoring provides a holistic view of energy dynamics in residential buildings and allows the system to pay attention to specific conditions, such as values that exceed set points and occupancy status (e.g. whether someone is at home). These findings help with planning and energy management and thus contribute to more efficient energy utilisation.

The edge processing system supports data aggregation by day and month, which facilitates visualisation and provides users with insights into their energy consumption and production patterns. It stores daily consumption and production data for up to five days, enabling historical analysis and identification of trends. This historical perspective is crucial to understanding long-term energy behaviour and making informed energy management decisions.

By processing the data on site, the system provides timely and localised insights that enable consumers to optimise their energy use and production. It also helps aggregators make informed decisions about flexibility offers and incentivise consumers to participate in the local flexibility market (LFM). By integrating real-time data analytics, data validation and actionable intelligence, the Edge Processing System plays a critical role in promoting a responsive and efficient energy market.

The SUC includes the following steps:

1. Deployment of IoT devices in residential areas to monitor energy consumption and production data.
2. Continuously collect key metrics such as average voltage, instantaneous consumption, total cumulative energy, prosumer production data, current frequency, active power and power factor.
3. Perform data validation to ensure the accuracy and reliability of the collected data.
4. Analyse real-time data to calculate statistical metrics.
5. Aggregate data by day and month for comprehensive visualisations and insights into energy consumption and production patterns

Main technologies used:

1. **IoT devices:** sensors and smart metres that monitor and collect real-time energy consumption and production data.
2. **Edge computing:** processes data locally at the edge of the network, reducing latency and enabling faster analyses and decisions
3. **Machine learning models:** For anomaly detection and predictive analyses based on the collected energy data.
4. **Data analysis platforms:** For data validation, statistical analysis and visualisation of energy consumption and production patterns.

The SUC includes the following scenario:

1. **Edge** p**rocessing of** real-time data: The system processes data collected from smart metres and other IoT devices at the edge of the grid. This includes validating data accuracy, analysing data in real time to calculate statistical measures, detecting anomalies and aggregating data for visualisation. The processed data provides insights into energy consumption and production patterns that can be used to optimise energy

usage and support flexibility procurement. Hardware: **IoT devices and sensors:** Installed in homes to monitor energy consumption and production, including smart metres and PV systems.

1.5 Key performance indicators (KPI)

ID	*Name*	*Description*	*Reference to mentioned use case objectives*
OB1	Different types of IoT/edge devices to be exploited in Demo Areas e.g., Smart Meter, HEMS, Sensors, inverter	Different types of IoT/edge devices to be exploited in Demo Areas e.g., Smart Meter, HEMS, Sensors, inverter	Obj.3, Obj.4
KPI3	% Of planned usage of HEDGE-IoT tools/data services (e.g., transactions, periodicity) in field demos	Number of HEDGE-IoT tools and data services used within this SUC	Obj.1, Obj. 2, Obj. 3, Obj. 4
KPI4	Real-time data sharing among stakeholders	Amount of real-time data exchanged between consumers and aggregator/service providers	Obj.4
KPI7	Increased RES and IoT deployment for providing flexibility services	Amount of RES and IoT devices available in this SUC	Obj.1, Obj. 2, Obj.3, Obj. 4
KPI8	IoT/Edge/Fog sites uptime and availability	Availability of IoT/Edge level sites for data operations and services	Obj.1, Obj. 4
KPI12	Faster application response times	Edge vs cloud response times performing data operations and being available to users	Obj.1, Obj. 4
KPI13	Savings in network bandwidth and lower latency	Data usage and time reduction of performing edge operations	Obj. 1, Obj. 4

1.6 Use case conditions

Use case conditions
Assumptions
• Availability and installation of Edge IoT Devices in households • Data Quality and Accessibility/Availability • Prosumers Participation and Consent • Stable Connectivity for data exchange
Prerequisites
• Consumers/Prosumers should possess IoT devices at selected homes and buildings. • A data infrastructure should be in place to collect, store, and process the real-time data generated by the IoT devices. • Prosumers/consumers are willing/agree to provide the data from the IoT devices through the energy supplier • The edge processing hardware and software should be set up and configured to handle real-time data analysis

1.7 Further Information to the use case for classification / mapping

Classification Information
Relation to other use cases

Linked to SUC-GR-01.01: • Support the Aggregator in making informed decisions about flexibility offers in the Local Flexibility Market (LFM) by leveraging the analysed data and insights. Linked to SUC-GR-01.02: • Provide accurate real-time data that will be used in the demand forecasting Linked to SUC-GR-01.03: • Provide accurate real-time data that will be used in the production forecasting Linked to SUC-GR-01.05: • Enable the insights provided to customers through the user interface so they can optimize their energy management
Level of depth
High
Prioritisation
High
Generic, regional, or national relation
National
Nature of the use case
System Use Case: Technical specifications to perform real-time monitoring and analysis of residential energy consumption
Further keywords for classification

1.8 General Remarks

General Remarks

2 Diagrams of use case

Diagram(s) of use case

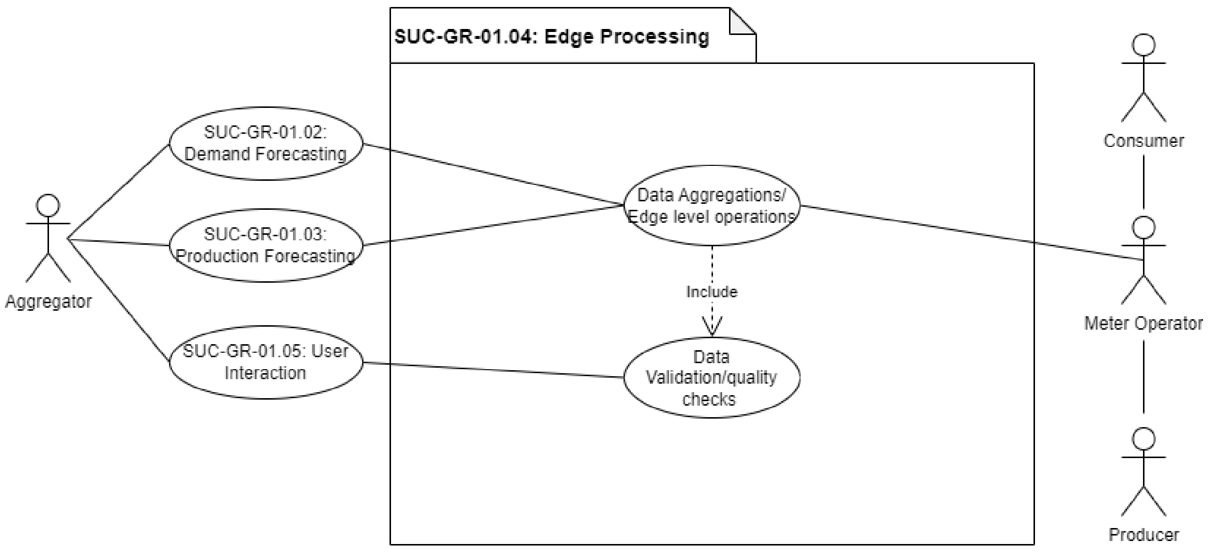


FIGURE 14: UML USE CASE DIAGRAM

3 Technical details

3.1 Actors

Actors			
Actor Name	***Actor Type***	***Actor Description***	***Further information specific to this use case***
Consumer	Business Actor	Residential consumers, possessing IoT devices monitoring their consumption.	Residential Consumers/ Public Power Corporation Customers
Producer	Business Actor	Small residential PV owners, promoting self-consumption (mostly under net-metering schemes	Residential Prosumers/ Public Power Corporation Customers
Meter Operator	Logical Actor	An entity providing IoT submetering devices (smart plugs, smart meters, gateways, etc.)	Public Power Corporation, ICCS
Aggregator	Business Actor	An entity processing, analysing, and monitoring energy consumption/production data, operating the AI algorithms for demand/production forecasts, and performing the optimisation algorithms for the flexibility offers	Public Power Corporation

3.2 References

References						
No.	***Reference Type***	***Reference***	***Status***	***Impact on use case***	***Originator / organisation***	***Link***

4 Step by step analysis of use case

4.1 Overview of scenarios

Scenario conditions						
No.	**Scenario name**	**Scenario description**	**Primary actor**	**Triggering event**	**Pre-condition**	**Post-condition**
Sc.1	Edge Processing of real-time data	Process the collected data from smart meters at the edge	Meter Operator	Collection of real-time data	Raw real-time data are collected by smart meters at the edge level in the households	Pre-processed data are available at the edge

4.2 Steps – Scenarios

Scenario								
Scenario name:		Sc.1 Edge Processing of real-time data						
Step No.	**Event**	**Name of process/ activity**	**Description of process/ activity**	**Service**	**Information producer (actor)**	**Information receiver (actor)**	**Information Exchanged (IDs)**	**Requirement, R-IDs**
St. 1	Real-Time Data Collection	Deploy IoT Devices	Install IoT devices in residential settings to monitor both energy consumption and production data from prosumers	GET	Prosumers	Meter Operator	Inf.1	QoS.1, QoS.2, QoS.4, Sec.1, Sec.2, Sec.3, Sec.4, Sec.5, Sec.6, Conf.1, Conf.2, Conf.3, Conf.4, Conf.5, Conf.6, Conf.7, Conf.8, O.1, O.2, O.3
St. 2	Data Validation, aggregation, analysis, and Quality Checks	Perform Data Validation	Validate the collected data to ensure accuracy and reliability Analyse real-time data to calculate statistical measures such as median, standard deviation, and detect anomalies.	EXECUTE	Meter Operator	Meter Operator	-	QoS.2, QoS.3, Sec.6, Sec.7, D.1, D.2, D.3, D.4, D.5, D.6, D.7, O.1, O.2, O.3
St. 3	Meter Operator sends the validated data to the UI (User Interface)	Validated data to the UI	Meter Operator sends the validated data to the UI	REPORT	Meter Operator	SUC-GR-01.05: User Interaction	Inf.2	Sec.1, Sec.2, Sec.3, Sec.4, Sec.5, Sec.6, D.2, D.3, D.4, D.5, D.6, D.7, Conf.7, Conf.8
St. 4	Validated data to aggregator	The aggregator gets the validated data	Send the validated data to aggregator to gain insights for the consumption or production of each prosumer	GET	SUC-GR-01.05: User Interaction	Aggregator	Inf.3	QoS.2, QoS.4, Sec.1, Sec.2, Sec.3, Sec.4, Sec.5, Sec.6, D.2, D.3, D.4, D.5, D.6, D.7, Conf.7, Conf.8
St. 5	Validated data to	Validated data to	The aggregator sends the validated data for production forecasting	REPORT	Aggregator	SUC-GR-01.03:	Inf.4	QoS.2, QoS.4, Sec.1, Sec.2, Sec.3, Sec.4, Sec.5, Sec.6, D.2, D.3,

	production forecasting	production forecasting				Production Forecasting		D.4, D.5, D.6, D.7, Conf.7, Conf.8
St. 6	Validated data for demand forecasting	Validated data for demand forecasting	The aggregator sends the validated data for demand forecasting	REPORT	Aggregator	SUC-GR-01.02: Demand Forecasting	Inf.5	QoS.2, QoS.4, Sec.1, Sec.2, D.2, D.3, D.4, D.5, D.6, D.7Sec.3, Sec.4, Sec.5, Sec.6
St. 7	The aggregator performs data analysis	Data analysis	The aggregator performs data analysis to provide feedback to the customers	EXECUTE	Aggregator	Aggregator	-	QoS.2, QoS.4, D.2, D.3, D.4, D.5, O.1, O.2, O.3
St. 8	Personalized feedback to the prosumers from aggregator	The aggregator sends personalized feedback through the UI	The aggregator sends personalized feedback to the prosumers through the UI	REPORT	Aggregator	SUC-GR-01.05: User Interaction	Inf.6	QoS.2, QoS.4, Sec.1, Sec.2, Sec.3, Sec.4, Sec.5, Sec.6, D.2, D.3, D.4, D.5, Conf.7, Conf.8
St. 9	UI returns aggregator's feedback to the prosumers	Personalized feedback to the prosumers	UI returns aggregator's feedback to the prosumers	GET	SUC-GR-01.05: User Interaction	Prosumers	Inf.7	QoS.2, QoS.4, Sec.1, Sec.2, Sec.3, Sec.4, Sec.5, Sec.6, D.2, D.3, D.4, D.5, Conf.7, Conf.8

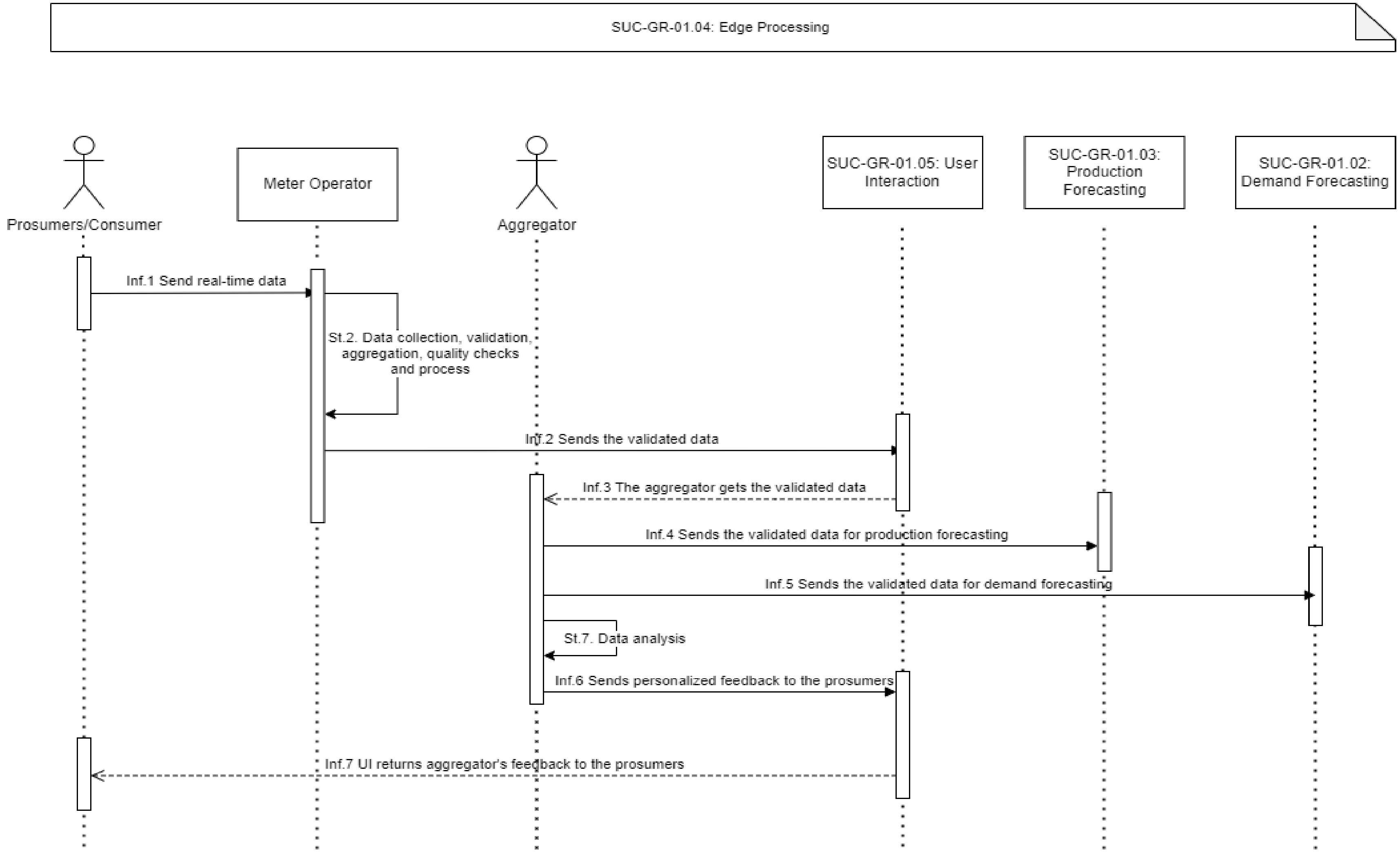


FIGURE 15: SUC-GR-01.04 SC.1 SEQUENCE DIAGRAM

5 Information exchanged

Information exchanged			
Information exchanged (ID)	***Name of information***	***Description of information exchanged***	***Requirement, R-IDs***
Inf.1	Real-time data	All the consumption and production real-time data that are collected from the IoT devices at the edge	QoS.1, QoS.2, QoS.4, Sec.1, Sec.2, Sec.3, Sec.4, Sec.5, Sec.6, Conf.1, Conf.2, Conf.3, Conf.4, Conf.5, Conf.6, Conf.7, Conf.8, O.1, O.2, O.3
Inf.2	Validated data to the UI	Meter Operator sends the validated data to the UI	Sec.1, Sec.2, Sec.3, Sec.4, Sec.5, Sec.6, D.2, D.3, D.4, D.5, D.6, D.7, Conf.7, Conf.8
Inf.3	The aggregator gets the validated data	Send the validated data to aggregator to gain insights for the consumption or production of each prosumer	QoS.2, QoS.4, Sec.1, Sec.2, Sec.3, Sec.4, Sec.5, Sec.6, D.2, D.3, D.4, D.5, D.6, D.7, Conf.7, Conf.8
Inf.4	Validated data to production forecasting	The aggregator sends the validated data for production forecasting	QoS.2, QoS.4, Sec.1, Sec.2, Sec.3, Sec.4, Sec.5, Sec.6, D.2, D.3, D.4, D.5, D.6, D.7, Conf.7, Conf.8
Inf.5	Validated data for demand forecasting	The aggregator sends the validated data for demand forecasting	QoS.2, QoS.4, Sec.1, Sec.2, D.2, D.3, D.4, D.5, D.6, D.7Sec.3, Sec.4, Sec.5, Sec.6
Inf.6	The aggregator sends personalized feedback through the UI	The aggregator sends personalized feedback to the prosumers through the UI	QoS.2, QoS.4, Sec.1, Sec.2, Sec.3, Sec.4, Sec.5, Sec.6, D.2, D.3, D.4, D.5, Conf.7, Conf.8
Inf.7	UI returns aggregator's feedback to the prosumers	UI returns aggregator's feedback to the prosumers	QoS.2, QoS.4, Sec.1, Sec.2, Sec.3, Sec.4, Sec.5, Sec.6, D.2, D.3, D.4, D.5, Conf.7, Conf.8

6 Requirements

Quality of Service Requirements		
Categories ID	**Category name for requirements**	**Category description**
QoS	Quality of Service	Generic properties that service/SUC should provide – quality attributes.
Requirement R-ID	**Requirement name**	**Requirement description**
QoS.1	Elapsed time response requirements for exchanging data	1-2 seconds
QoS.2	Availability of information flows	99.9% + availability - Allowed outage: 9 hours per year
Qos.3	Accuracy of data requirements	Age of data needs to be knowable
Qos.4	Frequency of data exchanges	Every few seconds

Security Requirements		
Categories ID	**Category name for requirements**	**Category description**

Sec	Security	Authentication of user, confidentiality, integrity, prevention of denial of service, non-repudiation or accountability, error management.
Requirement R-ID	**Requirement name**	**Requirement description**
Sec.1	Eavesdropping	Ensuring confidentiality, avoiding illegitimate use of data, and preventing unauthorized reading of data is crucial.
Sec.2	Information integrity violation	Ensuring that data is not changed or destroyed is crucial.
Sec.3	Authentication	Ensuring that data comes from the stated source or goes to authenticated receiver is crucial.
Sec.4	Repudiation	Ensuring that the source cannot deny sending the data or that the receiver cannot deny receiving the data is crucial.
Sec.5	Information theft	Ensuring that data cannot be stolen or deleted by an unauthorized entity is crucial.
Sec.6	Denial of Service	Ensuring unimpeded access to data is crucial
Sec.7	Procedural security measures commonly used with this data exchange	Audits

Data Management Requirements		
Categories ID	**Category name for requirements**	**Category description**
D	Data Management	Type of source of data, correctness or validity of data, timeliness or time stamping of data, volume of data, synchronization, or consistency of data across systems, timely access to data, validation of data across organizational boundaries, transaction management, data naming, identification, formats across disparate systems, maintenance of data and databases.
Requirement R-ID	**Requirement name**	**Requirement description**
D.1	Type of source data	Source data was directly measured
D.2	Correctness of source data	Source data is always correct (e.g. by definition)
D.3	Up-to-date management	Received data must be up-to-date within minutes of source data changing
D.4	Management of large volumes of data that are being exchanged	Major part of step involves handling large volumes of data
D.5	Data consistency and synchronization management across systems	Minute-by-minute synchronization
D.6	Validation of data exchanges	Data can be assumed as valid (or validity checking is handled elsewhere)
D.7	Management of data formats in data exchanges	Conversion of data formats is automatically handled by each application

Discovery and Configuration Requirements		
Categories ID	**Category name for requirements**	**Category description**

Conf	Configuration	Locations, distances, communication layout, commonly used communication protocol media, network bandwidth, existing protocols, number of devices, systems, volume of data items, expected growth, etc.
Requirement R-ID	**Requirement name**	**Requirement description**
Conf.1	Number of Information Producers	One
Conf.2	Number of Information Receivers	Two to a few
Conf.3	Location of Information Producer	Building
Conf.4	Location of Information Receiver	Commercial customer site
Conf.5	Communication configuration	WLAN
Conf.6	Communication media	Wireless
Conf.7	Operation mode of Information Producer	Automatic
Conf.8	Operation mode of Information Receiver	Automatic

Other Requirements		
Categories ID	**Category name for requirements**	**Category description**
O	Regulatory obligation related to privacy	2016/679 GDPR (General Data Protection Regulation)
Requirement R-ID	**Requirement name**	**Requirement description**
O.1	Personal data processing	Personal data may not be processed unless there is at least one legal basis to do so.
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.
O.3	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.

7 Common Terms and Definitions

Common Terms and Definitions	
Term	**Definition**
PPC	Public Power Corporation
LFM	Local Flexibility Market
DR	Demand Response

5 SUC-GR-01.05 – USER INTERACTION

1 Description of the use case

1.1 Name of the use case

ID	Area / Domain(s) / Zones(s)	Name of Use Case
SUC-GR-01.05	Local Flexibility Market / Demand Response Programs / IoT Integration	**User Interaction**

1.2 Version management

Version Management			
Version No.	Date	Name of Author(s)	Changes0.
0.1	01.07.2024	Nickie Gkolia (ICCS)	1st Draft
0.2	26.07.2024	Nickie Gkolia (ICCS)	Refinement
0.3	28.08.2024	Nickie Gkolia (ICCS)	Modifications to comply with the template provided
1.0	15.10.2024	Nickie Gkolia - ICCS	Final first version

1.3 Scope and objectives of use case

Scope and Objectives of Use Case	
Scope	To enable active participation of consumers/prosumers in the flexibility market facilitated by an interactive user interface (UI). It includes functionalities for consumers/prosumers to receive, review, and respond to flexibility requests from the aggregator, while also providing insights into energy consumption patterns and offering economic incentives based on participation.
Objective(s)	The main objectives are: 1. To enable consumers/prosumers to actively engage in the flexibility market 2. To provide a user-friendly interface for reviewing and responding to flexibility requests from the aggregator 3. To offer insights into energy consumption patterns to optimize usage and maximize economic incentives.
Related business case(s)	BUC-GR-01: Flexibility management through active prosumers/consumers engagement

1.4 Narrative of use case

Narrative of Use Case
Short description
This use case is about the development of an interactive user interface (UI) that enables active participation of consumers and prosumers in the flexibility market. The UI enables users to receive, review and respond to flexibility requests from the aggregator and provides detailed insights into their energy consumption behaviour as well as economic incentives for their participation.
Complete description
The system is designed to enable consumers and prosumers to actively participate in the flexibility market through an intuitive and interactive user interface (UI). This UI enables users to receive flexibility

requests in real time from the aggregator, review these requests and respond according to their willingness to adjust their energy consumption or production patterns.

The user interface provides detailed energy consumption data aggregated every 5 minutes, allowing users to closely monitor their daily energy consumption. Users can view their average daily consumption based on historical data and track daily consumption over the last few days. The interface also provides insights into weekly, monthly and yearly consumption trends that help users understand their energy consumption patterns over different time periods.

Each household has access to personalised analytics that provide deeper insights into their energy consumption behaviour and highlight areas for potential energy savings and efficiency improvements. In addition, the user interface offers economic incentives linked to the user's participation in the flexibility market. Users can see potential savings and revenues based on their responses to flexibility requests and their overall engagement in the programme.

In parallel, the aggregator has its own user interface to monitor and manage each household's energy consumption and generation. This interface provides comprehensive tracking tools to monitor real-time energy data, analyse consumption and production trends and ensure efficient management of the flexibility market by using the insights from the aggregated data. The system aims to create a collaborative and dynamic environment for the flexibility market by encouraging active user engagement through transparent data presentation and meaningful economic incentives.

The SUC comprises the following steps:

1. The system notifies the consumer/user of a new flexibility request from the aggregator via the user interface (UI).
2. The consumer accesses the UI to review the details of the flexibility request, including possible economic incentives, and decides whether to accept or reject the request.
3. The system records the response from the consumer/customer and sends it to the aggregator.
4. The system provides ongoing feedback on efficiency improvements in electrical appliances and updates on earned economic incentives.
5. Users can monitor their energy consumption data, which is aggregated every 5 minutes, to understand their consumption behaviour and identify opportunities for improvement.
6. The consumer can opt out of receiving future flexibility requests or customise their preferences via the user interface.
7. The aggregator uses the interface to monitor real-time and historical energy data, analyse consumption and production trends and optimise flexibility requests accordingly

Main technologies used:

1. **User interface (UI) design and development:** The user interface for both consumers and the aggregator is developed using modern web technologies such as HTML, CSS, JavaScript and frameworks such as React or Angular to provide a responsive and user-friendly experience.
2. **IoT devices and smart metres:** Used in households to continuously collect real-time energy consumption and production data.
3. **Data analysis and visualisation tools:** Used to analyse energy data, calculate statistics and present findings and trends in a visually appealing and understandable format.

The SUC includes the following scenarios:

1. **Flexibility offers via the** user interface: the user interface notifies consumers and prosumers of flexibility requests from the aggregator and displays possible economic incentives. Users can view the details of these requests and decide whether they want to participate by adjusting their energy consumption or production.
2. **Monitoring of energy consumption and production by users:** Users access the interface to monitor their energy consumption and production data. The interface provides aggregated data every 5 minutes as well as historical insights and personalised analytics that enable users to understand their energy consumption patterns and identify areas for improvement.
3. **Aggregator monitoring dashboard:** The aggregator uses a dedicated dashboard to monitor real-time and historical energy data from individual households. The dashboard provides tools

to analyse consumption and production trends and optimise flexibility requests based on user responses and aggregated data insights. Hardware: 1. **IoT devices and smart metres:** Installed in residential areas to continuously monitor energy consumption and production data. 2. **User devices:** Smartphones, tablets or computers used by consumers, prosumers and aggregators to access the user interfaces and dashboards.

1.5 Key performance indicators (KPI)

ID	Name	Description	Reference to mentioned use case objectives
OB1	Different types of IoT/edge devices to be exploited in Demo Areas e.g., Smart Meter, HEMS, Sensors, inverter	The IoT/edge devices to be used within this SUC	Obj. 1, Obj. 3
OB4	Users involved in the piloting	Number of users part of the Greek Demo, based on the installations of edge/IoT devices	Obj.1, Obj.3
KPI3	% Of planned usage of HEDGE-IoT tools/data services (e.g., transactions, periodicity) in field demos	Number of HEDGE-IoT tools and data services used within this SUC	Obj. 1, Obj. 2, Obj. 3
KPI4	Real-time data sharing among stakeholders	Amount of real-time data exchanged between consumers and aggregator/service providers	Obj. 1, Obj. 2, Obj. 3
KPI8	IoT/Edge/Fog sites uptime and availability	Availability of IoT/Edge level sites for data operations and services	Obj.1, Obj. 2, Obj. 3
KPI10	Number of consumers engaged with flexibility services	Number of consumers that receive flexibility requests	Obj. 1, Obj. 2, Obj. 3
KPI12	Faster application response times	Edge vs cloud response times performing data operations and being available to users	Obj. 1, Obj. 2, Obj. 3

1.6 Use case conditions

Use case conditions
Assumptions
• Availability and installation of Edge IoT devices in households • Availability in historical consumer data • Aggregator sends flexibility requests to consumers/prosumers based on real-time market signals • Participation and consent of consumers/prosumers • The user interface provided by the aggregator is accessible via the devices used by the consumers/prosumers (e.g. smartphones, tablets, computers)
Prerequisites
• Consumers/Prosumers should own IoT devices in selected homes and buildings. • Availability of historical energy consumption data stored and accessible for analyses. • Prosumers/consumers are willing to provide the data from the IoT devices via the energy supplier • Appropriate flexibility offers from the local flexibility market (BUC-GR-03) are available (via the grid operators) to conduct the experiment

1.7 Further Information to the use case for classification / mapping

Classification Information
Relation to other use cases
Linked to SUC-GR-01.01: • Ability of the customers to accept or reject flexibility offers
Level of depth
High
Prioritisation
High
Generic, regional, or national relation
National
Nature of the use case
System Use Case: Technical specifications to enable the active participation of consumers/prosumers in the flexibility market
Further keywords for classification

1.8 General Remarks

General Remarks

2 Diagrams of use case

Diagram(s) of use case

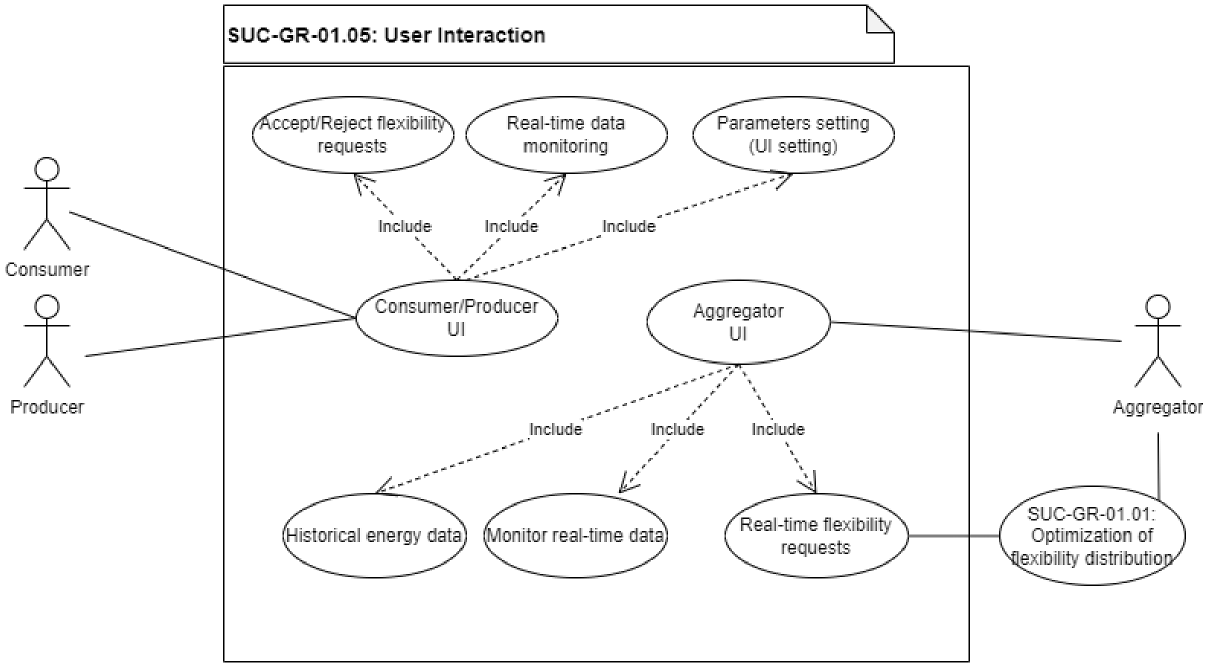


FIGURE 16: UML USE CASE DIAGRAM

3 Technical details

3.1 Actors

Actors			
Actor Name	***Actor Type***	***Actor Description***	***Further information specific to this use case***
Consumer	Business Actor	Residential consumers, possessing IoT devices monitoring their consumption.	Residential Consumers/PPC Customers
Producer	Business Actor	Small residential PV owners, promoting self-consumption (mostly under net-metering schemes	Residential Prosumers/PPC Customers
Aggregator	Business Actor	An entity processing, analysing, and monitoring energy consumption/production data, operating the AI algorithms for demand/production forecasts, and performing the optimisation algorithms for the flexibility offers	PPC
UI	Logical Actor	The platform used by the aggregator and prosumers for exchanging data	-

3.2 References

References						
No.	***Reference Type***	***Reference***	***Status***	***Impact on use case***	***Originator / organisation***	***Link***

4 Step by step analysis of use case

4.1 Overview of scenarios

Scenario conditions						
No.	**Scenario name**	**Scenario description**	**Primary actor**	**Triggering event**	**Pre-condition**	**Post-condition**
Sc.1	Flexibility Offers through the UI	Generating, notify, review, and respond to flexibility requests from the aggregator to the users	Aggregator	System generates a new flexibility request based on market conditions and user data	The customers are registered and logged into the system	Customers' response to the flexibility request is recorded and acknowledged by the system
Sc.2	Energy Consumption and Production Monitoring by Users	Customers' interaction with the interface to monitor their energy consumption and production, view detailed data, and access household analytics	Residential Customers	Customers log into the interactive user interface (UI)	The customers are registered and has access to the system.	The customers view their energy consumption data and analytics
Sc.3	Monitoring Dashboard of the Aggregator	How the aggregator uses the dedicated interface to monitor real-time data, analyse trends, manage flexibility requests, and ensure efficient market management.	Aggregator	Aggregator logs into the dedicated user interface	Aggregator has the appropriate dashboard set on its side and the residential customers has IoT devices deployed	Aggregator has monitored real-time data, analysed trends, and ensured efficient market operations based on insights.

4.2 Steps – Scenarios

Scenario								
Scenario name:		Sc.1 Flexibility Offers through the UI						
Step No.	**Event**	**Name of process/ activity**	**Description of process/ activity**	**Service**	**Information producer (actor)**	**Information receiver (actor)**	**Information Exchanged (IDs)**	**Requirement, R-IDs**
St. 1	Flexibility Request Generation	Generate Flexibility Request	The system generates a flexibility request based on market conditions and user data.	REPORT	SUC-GR-01.01: Optimization of flexibility distribution	Aggregator	Inf.1	QoS.1, QoS.2, QoS.4, Sec.2, Sec.4, D.4, D.5, D.6
St. 2	Flexibility Request Notification	Notify Customers of Flexibility Request	The system sends a notification to the user interface about a new flexibility request.	REPORT	Aggregator	UI	Inf.2	QoS.2, QoS.4, Sec.1, Sec.2, Sec.4, D.4, D.5, D.6, Conf.1, Conf.2
St. 3	User Reviews Request	Review Flexibility Request	The customer logs in to the UI and reviews the details of the flexibility request.	GET	UI	Customers	Inf.3	QoS.1, QoS.2, QoS.3, Sec.1, Sec.2, Sec.3, Sec.4, Sec.5, D.2, D.4, Conf.1, Conf.2, O.1, O.2, O.3
St. 4	Customer Responds to Request	Respond to Flexibility Request	Customer decides to accept or decline the flexibility request and submits the response.	REPORT	Customer	UI	Inf.4	QoS.1, QoS.2, QoS.3, Sec.1, Sec.2, Sec.3, Sec.4, Sec.5, D.2, Conf.1, Conf.2, Conf.4

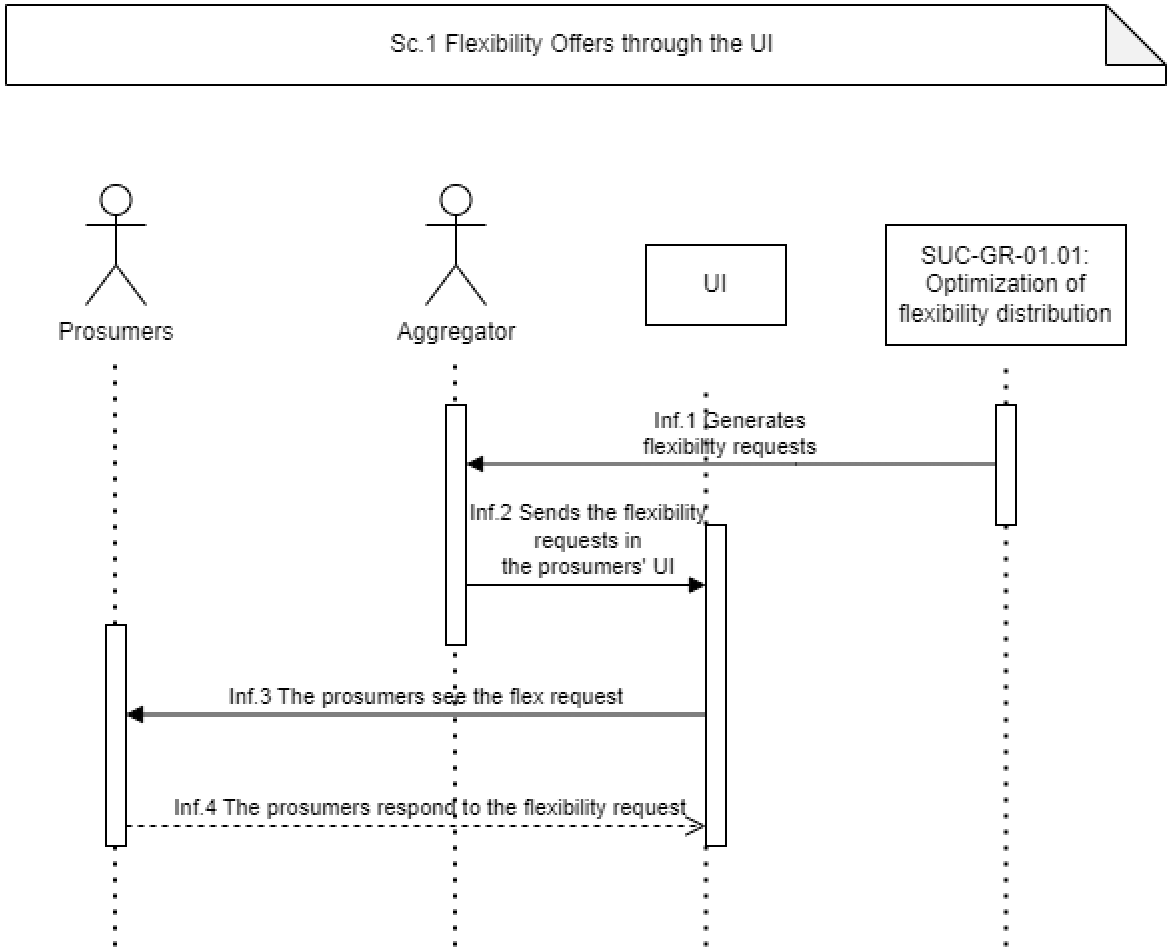


FIGURE 17: SUC-GR-01.05 SC.1 SEQUENCE DIAGRAM

Scenario								
Scenario name:		Sc.2 Energy Consumption and Production Monitoring by Users						
Step No.	**Event**	**Name of process/ activity**	**Description of process/ activity**	**Service**	**Information producer (actor)**	**Information receiver (actor)**	**Information Exchanged (IDs)**	**Requirement, R-IDs**
St. 1	User Logs In	User Login	User logs in to the interactive user interface (UI)	EXECUTE	Customers	UI	Inf.5	QoS.1, QoS.2, Sec.5, Conf.1, Conf.2, O.1, O.2, O.3
St. 2	Dashboard Overview Displayed	Display Dashboard Overview	The system displays an overview of the user's energy consumption data	GET	UI	Customers	Inf.6	QoS.1, QoS.2, QoS.3, QoS.4, Sec.2, Sec.3, Sec.4, D.1, D.2, D.3, D.4, D.5, D.6, Conf.1, Conf.2, Conf.3, Conf.4
St. 3	Detailed Consumption Data Access Request	Request for Access to the Detailed Consumption Data	User requests to view the detailed energy consumption data aggregated every 5 minutes	GET	Customers	UI	Inf.7	QoS.2, QoS.4, Sec.2, Sec.3, Sec.4, D.1, D.2, D.3, D.4, D.5, D.6, Conf.1, Conf.2, Conf.3, Conf.4
St. 4	Detailed Consumption Data Access Return	Provide Access the Detailed Consumption Data	The UI displays the detailed energy consumption data aggregated every 5 minutes	REPORT	UI	Customers	Inf.8	QoS.1, QoS.2, QoS.3, QoS.4, Sec.2, Sec.3, Sec.4, D.1, D.2, D.3, D.4, D.5, D.6, Conf.1, Conf.2, Conf.3, Conf.4
St. 5	Personal Analytics of Consumption	Request for Access to the Personal Analytics of Consumption	User requests for Access to the Personal Analytics of Consumption	GET	Customers	UI	Inf.9	QoS.2, QoS.4, Sec.2, Sec.3, Sec.4, D.5, Conf.1, Conf.2, Conf.3, Conf.4

St. 6	Access Household Analytics	View Household Analytics	The UI returns the personalized analytics for the household energy consumption	REPORT	UI	Customers	Inf.10	QoS.1, QoS.2, QoS.3, QoS.4, Sec.1, Sec.2, Sec.3, Sec.4, D.1, D.2, D.3, D.4, D.5, D.6, Conf.1, Conf.2, Conf.3, Conf.4

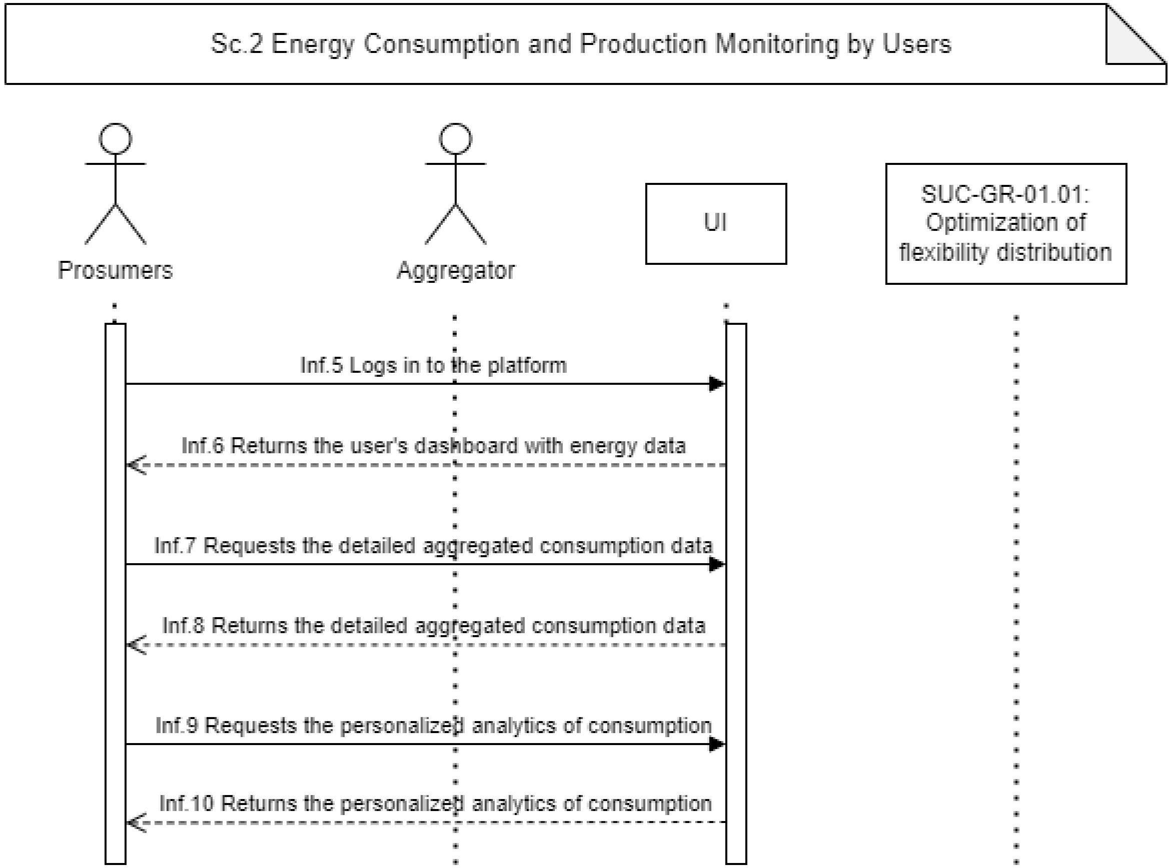


FIGURE 18: SUC-GR-01.05 SC.2 SEQUENCE DIAGRAM

Scenario								
Scenario name:		Sc.3 Monitoring Dashboard of the Aggregator						
Step No.	**Event**	**Name of process/ activity**	**Description of process/ activity**	**Service**	**Information producer (actor)**	**Information receiver (actor)**	**Information Exchanged (IDs)**	**Requirement, R-IDs**
St. 1	Aggregator Logs In	Aggregator Login	Aggregator logs in to the dedicated user interface	EXECUTE	Aggregator	UI	Inf.11	QoS.1, Sec.5, Conf.1, Conf.2, Conf.3, O.1, O.2, O.3
St. 2	Consumption and Production data display	Consumption and Production data display	The UI returns consumption and production data from all customers	REPORT	UI	Aggregator	Inf.12	QoS.1, QoS.2, QoS.3. QoS.4, Sec.1, Sec.2, Sec.3, Sec.4, D.1, D.2, D.3, D.4, D.5, D.6, Conf.1, Conf.2, Conf.3
St. 3	Production and Consumption forecasting	The aggregator performs production and consumption forecasting	The aggregator performs production and consumption forecasting	EXECUTE	Aggregator	UI	Inf.13	QoS.1, QoS.2, QoS.3, Sec.1, Sec.2, Sec.3, Sec.4, D.1, D.2, D.3, D.4, D.5, D.6, Conf.1, Conf.2, Conf.3
St. 4	Production and Consumption forecasting results	The aggregator gets the results from production and consumption forecasting	The aggregator gets the results from production and consumption forecasting	GET	UI	Aggregator	Inf.14	QoS.1, QoS.2, QoS.3, Sec.1, Sec.2, Sec.3, Sec.4, D.1, D.2, D.3, D.4, D.5, D.6, Conf.1, Conf.2, Conf.3
St. 5	PV Management Dashboard Request	Request to Manage PVs of the prosumers	The aggregator requests the dashboard to manage community-owned PV systems and user participation	GET	Aggregator	UI	Inf.15	QoS.1, QoS.2, QoS.3, QoS.4, Sec.1, Sec.2, Sec.3, Sec.4, Conf.1, Conf.2, Conf.3
St. 6	PV Management Dashboard Return	Return of the PV management dashboard	The UI returns the PV management dashboard	REPORT	UI	Aggregator	Inf.16	QoS.1, QoS.2, QoS.3, QoS.4, Sec.1, Sec.2, Sec.3, Sec.4, D.1, D.2, D.3, D.4, D.5, D.6, Conf.1, Conf.2, Conf.3
St. 7	Energy Prices Monitoring Dashboard Request	Energy Prices Monitoring Dashboard Request	The aggregator requests the dashboard with the real-time and historical price monitoring	GET	Aggregator	UI	Inf.17	QoS.1, QoS.2, Sec.1, Sec.2, Sec.3, Sec.4, D.1, D.2, D.3, D.4, D.5, D.6, Conf.1, Conf.2, Conf.3

St. 8	Energy Prices Monitoring Dashboard Return	Energy Prices Monitoring Dashboard Return	The UI returns the dashboard with the real-time and historical price monitoring	REPORT	UI	Aggregator	Inf.18	QoS.1, QoS.2, QoS.3, QoS.4, Sec.1, Sec.2, Sec.3, Sec.4, D.1, D.2, D.3, D.4, D.5, D.6, Conf.1, Conf.2, Conf.3
St. 9	Personalized Tips to the UI	Provide recommendations for prosumers to the UI	The aggregator provides recommendations through the UI to prosumers for optimizing energy usage	REPORT	Aggregator	UI	Inf.19	QoS.1, QoS.2, QoS.3, QoS.4, Sec.1, Sec.2, Sec.3, Sec.4, D.1, D.2, D.3, D.4, D.5, D.6, Conf.1, Conf.2, Conf.3
St. 10	Personalized Tips to Prosumers	Get the personalized tips	The prosumers get the recommendations for optimizing energy usage	GET	UI	Prosumers	Inf.20	QoS.1, QoS.2, QoS.3, QoS.4, Sec.1, Sec.2, Sec.3, Sec.4, D.1, D.2, D.3, D.4, D.5, D.6, Conf.1, Conf.2, Conf.3

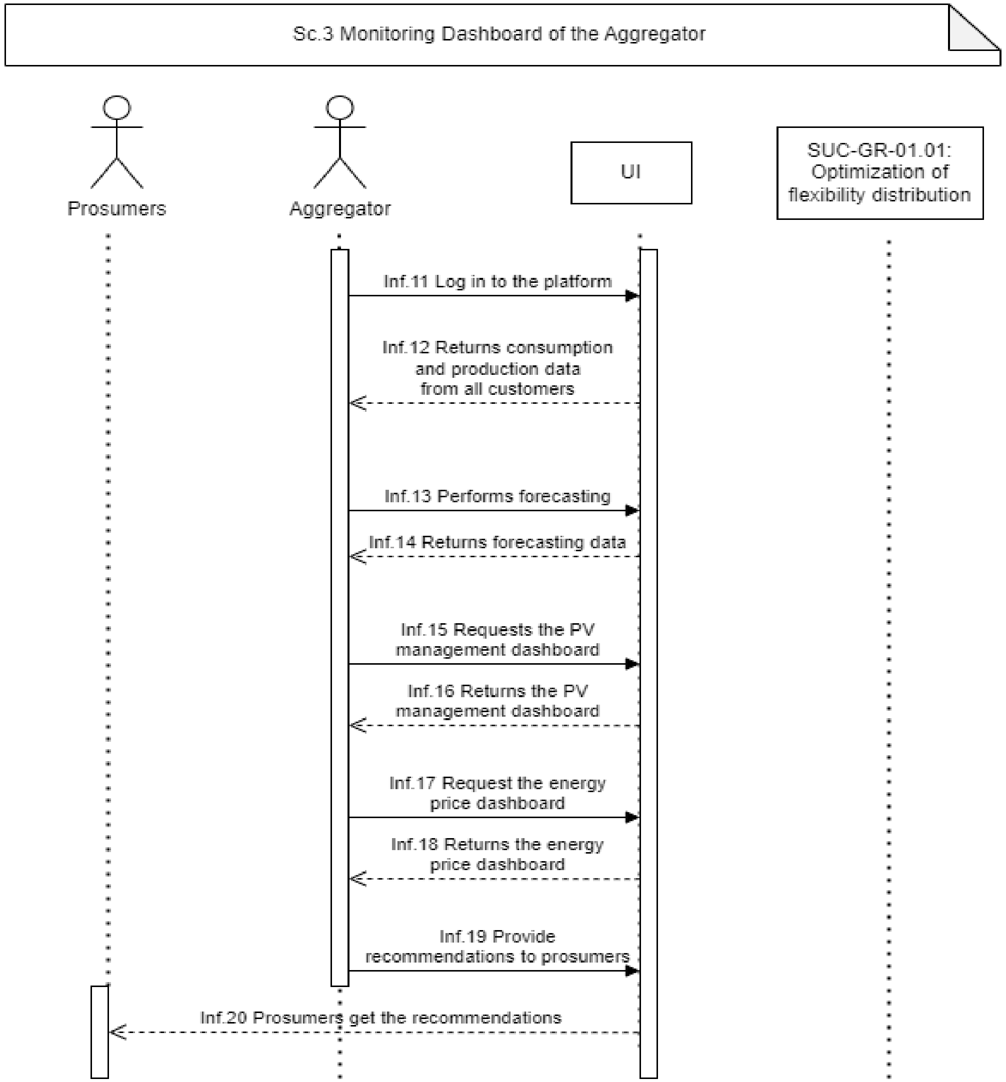


FIGURE 19: SUC-GR-01.05 SC.3 SEQUENCE DIAGRAM

5 Information exchanged

Information exchanged			
Information exchanged (ID)	***Name of information***	***Description of information exchanged***	***Requirement, R-IDs***
Inf.1	Generate Flexibility Request	The system generates a flexibility request based on market conditions and user data.	QoS.1, QoS.2, QoS.4, Sec.2, Sec.4, D.4, D.5, D.6
Inf.2	Notify Customers of Flexibility Request	The system sends a notification to the user interface about a new flexibility request.	QoS.2, QoS.4, Sec.1, Sec.2, Sec.4, D.4, D.5, D.6, Conf.1, Conf.2
Inf.3	Review Flexibility Request	The customer logs in to the UI and reviews the details of the flexibility request.	QoS.1, QoS.2, QoS.3, Sec.1, Sec.2, Sec.3, Sec.4, Sec.5, D.2, D.4, Conf.1, Conf.2, O.1, O.2, O.3
Inf.4	Respond to Flexibility Request	Customer decides to accept or decline the flexibility request and submits the response.	QoS.1, QoS.2, QoS.3, Sec.1, Sec.2, Sec.3, Sec.4, Sec.5, D.2, Conf.1, Conf.2, Conf.4
Inf.5	User Login	User logs in to the interactive user interface (UI) to see the household analytics	QoS.1, QoS.2, Sec.5, Conf.1, Conf.2, O.1, O.2, O.3
Inf.6	Display Dashboard Overview	The system displays an overview of the user's energy consumption data	QoS.1, QoS.2, QoS.3, QoS.4, Sec.2, Sec.3, Sec.4, D.1, D.2, D.3, D.4, D.5, D.6, Conf.1, Conf.2, Conf.3, Conf.4
Inf.7	Request for Access to the Detailed Consumption Data	User requests to view the detailed energy consumption data aggregated every 5 minutes	QoS.2, QoS.4, Sec.2, Sec.3, Sec.4, D.1, D.2, D.3, D.4, D.5, D.6, Conf.1, Conf.2, Conf.3, Conf.4
Inf.8	Provide Access the Detailed Consumption Data	The UI displays the detailed energy consumption data aggregated every 5 minutes	QoS.1, QoS.2, QoS.3, QoS.4, Sec.2, Sec.3, Sec.4, D.1, D.2, D.3, D.4, D.5, D.6, Conf.1, Conf.2, Conf.3, Conf.4
Inf.9	Request for Access to the Personal Analytics of Consumption	User requests for Access to the Personal Analytics of Consumption	QoS.2, QoS.4, Sec.2, Sec.3, Sec.4, D.5, Conf.1, Conf.2, Conf.3, Conf.4
Inf.10	View Household Analytics	The UI returns the personalized analytics for the household energy consumption	QoS.1, QoS.2, QoS.3, QoS.4, Sec.1, Sec.2, Sec.3, Sec.4, D.1, D.2, D.3, D.4, D.5, D.6, Conf.1, Conf.2, Conf.3, Conf.4
Inf.11	Aggregator Login	Aggregator logs in to the dedicated user interface	QoS.1, Sec.5, Conf.1, Conf.2, Conf.3, O.1, O.2, O.3
Inf.12	Consumption and Production data display	The UI returns consumption and production data from all customers	QoS.1, QoS.2, QoS.3. QoS.4, Sec.1, Sec.2, Sec.3, Sec.4, D.1, D.2, D.3, D.4, D.5, D.6, Conf.1, Conf.2, Conf.3
Inf.13	The aggregator performs production and consumption forecasting	The aggregator performs production and consumption forecasting	QoS.1, QoS.2, QoS.3, Sec.1, Sec.2, Sec.3, Sec.4, D.1, D.2, D.3, D.4, D.5, D.6, Conf.1, Conf.2, Conf.3

Inf.14	The aggregator gets the results from production and consumption forecasting	The aggregator gets the results from production and consumption forecasting	QoS.1, QoS.2, QoS.3, Sec.1, Sec.2, Sec.3, Sec.4, D.1, D.2, D.3, D.4, D.5, D.6, Conf.1, Conf.2, Conf.3
Inf.15	Request to Manage PVs of the prosumers	The aggregator requests the dashboard to manage community-owned PV systems and user participation	QoS.1, QoS.2, QoS.3, QoS.4, Sec.1, Sec.2, Sec.3, Sec.4, Conf.1, Conf.2, Conf.3
Inf.16	Return of the PV management dashboard	The UI returns the PV management dashboard	QoS.1, QoS.2, QoS.3, QoS.4, Sec.1, Sec.2, Sec.3, Sec.4, D.1, D.2, D.3, D.4, D.5, D.6, Conf.1, Conf.2, Conf.3
Inf.17	Energy Prices Monitoring Dashboard Request	The aggregator requests the dashboard with the real-time and historical price monitoring	QoS.1, QoS.2, Sec.1, Sec.2, Sec.3, Sec.4, D.1, D.2, D.3, D.4, D.5, D.6, Conf.1, Conf.2, Conf.3
Inf.18	Energy Prices Monitoring Dashboard Return	The UI returns the dashboard with the real-time and historical price monitoring	QoS.1, QoS.2, QoS.3, QoS.4, Sec.1, Sec.2, Sec.3, Sec.4, D.1, D.2, D.3, D.4, D.5, D.6, Conf.1, Conf.2, Conf.3
Inf.19	Provide recommendations for prosumers to the UI	The aggregator provides recommendations through the UI to prosumers for optimizing energy usage	QoS.1, QoS.2, QoS.3, QoS.4, Sec.1, Sec.2, Sec.3, Sec.4, D.1, D.2, D.3, D.4, D.5, D.6, Conf.1, Conf.2, Conf.3
Inf.20	Get the personalized tips	The prosumers get the recommendations for optimizing energy usage	QoS.1, QoS.2, QoS.3, QoS.4, Sec.1, Sec.2, Sec.3, Sec.4, D.1, D.2, D.3, D.4, D.5, D.6, Conf.1, Conf.2, Conf.3

6 Requirements

Quality of Service Requirements		
Categories ID	**Category name for requirements**	**Category description**
QoS	Quality of Service	Generic properties that service/SUC should provide – quality attributes.
Requirement R-ID	**Requirement name**	**Requirement description**
QoS.1	Elapsed time response requirements for exchanging data	1-2 seconds
QoS.2	Availability of information flows	99.9% + availability - Allowed outage: 9 hours per year
QoS.3	Accuracy of data requirements	Time skew of data must be known
QoS.4	Frequency of data exchanges	Essentially continuous

Security Requirements		
Categories ID	**Category name for requirements**	**Category description**
Sec	Security	Authentication of user, confidentiality, integrity, prevention of denial of service, non-repudiation or accountability, error management.

Requirement R-ID	Requirement name	Requirement description
Sec.1	Eavesdropping	Ensuring confidentiality, avoiding illegitimate use of data, and preventing unauthorized reading of data is crucial.
Sec.2	Authentication	Ensuring that data comes from the stated source or goes to an authenticated receiver is crucial.
Sec.3	Information theft	Ensuring that data cannot be stolen or deleted by an unauthorized entity is crucial.
Sec.4	Denial of Service	Ensuring unimpeded access to data is crucial.
Sec.5	This data exchange has the following requirements with respect to proof of conformance and/or non-repudiation with contractual agreements:	Logging of the source, destination, requesting application, and requesting user of information exchanges is required, but not the data itself

Data Management Requirements		
Categories ID	**Category name for requirements**	**Category description**
D	Data Management	Type of source of data, correctness or validity of data, timeliness or time stamping of data, volume of data, synchronization, or consistency of data across systems, timely access to data, validation of data across organizational boundaries, transaction management, data naming, identification, formats across disparate systems, maintenance of data and databases.
Requirement R-ID	**Requirement name**	**Requirement description**
D.1	Type of source data	Source data was previously automatically stored in a database
D.2	Correctness of source data	Source data is always correct
D.3	Management of large volumes of data that are being exchanged	Some part of step involves handling large volumes of data
D.4	Data consistency and synchronization management across systems	Minute-by-minute synchronization
D.5	Management of data across organizational boundaries	Data exchanges go across organizational boundaries
D.6	Management across different implementations	Types of data being exchanged can vary significantly in different implementations

Discovery and Configuration Requirements		
Categories ID	**Category name for requirements**	**Category description**
Conf	Configuration	Locations, distances, communication layout, commonly used communication protocol media, network bandwidth, existing protocols, number of devices, systems, volume of data items, expected growth, etc.
Requirement R-ID	**Requirement name**	**Requirement description**

Conf.1	Operation mode of Information Producer	Automatic
Conf.2	Operation mode of Information Receiver	Automatic
Conf.3	Relative maturity of current implementation	Very mature and widely implemented
Conf.4	Distance between entities	Many kilometres

Other Requirements		
Categories ID	**Category name for requirements**	**Category description**
O	Regulatory obligation related to privacy	2016/679 GDPR (General Data Protection Regulation)
Requirement R-ID	**Requirement name**	**Requirement description**
O.1	Personal data processing	Personal data may not be processed unless there is at least one legal basis to do so.
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.
O.3	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.

7 Common Terms and Definitions

Common Terms and Definitions	
Term	**Definition**
PPC	Public Power Corporation
LFM	Local Flexibility Market
DR	Demand Response
UI	User Interface
GDPR	General Data Protection Regulation

6 SUC-GR-02.01 – ENERGY GRID MANAGEMENT USING FORECASTING DATA

1 Description of the use case

1.1 Name of the use case

ID	*Area / Domain(s) / Zones(s)*	*Name of Use Case*
SUC-GR-02.01	Grid load management, Demand Forecasts, Grid Issues Identification, Flexibility Calculation	Energy Grid Management using forecasting data

1.2 Version management

Version Management			
Version No.	*Date*	*Name of Author(s)*	*Changes.*
0.1	19.06.2024	Maria Koutsoupidou, Nikolaos Fesakis	1st Draft
0.2	05.07.2024	Maria Koutsoupidou, Nikolaos Fesakis	Extended version
0.3	22.07.2024	Maria Koutsoupidou, Nikolaos Fesakis	Corrections after review
0.4	30.08.2024	Nikolaos Fesakis, Maria Koutsoupidou	Corrections after guidelines
0.5	18.09.2024	Nikolaos Fesakis, Maria Koutsoupidou	Corrections after last review
1.0	02.10.2024	Nikolaos Fesakis, Maria Koutsoupidou	Final first version

1.3 Scope and objectives of use case

Scope and Objectives of Use Case	
Scope	Through the strategic use of forecasting data, the system operator (SO) and the energy service company (ESCO) work together to utilise production and demand forecasts for proactive grid load management, problem identification and flexibility calculation.
Objective(s)	The most important goals are: Objective **1:** Regularly analyse the current state of the energy network and assess its performance and efficiency. Objective **2**: Proactively identify potential problems or inefficiencies within the grid using data-driven insights from production and demand forecasts to improve grid management, decision-making and operational responsiveness. Objective **3**: To determine the necessary flexibility in grid operation to balance fluctuations in energy production and demand and ensure stability and efficiency.
Related business case(s)	BUC-GR-01: Flexibility management through active involvement of prosumers/consumers

	BUC-GR-02: Energy forecasting BUC-GR-03: Flexibility trading platform to mitigate problems in the T&D grids

1.4 Narrative of use case

Narrative of Use Case
Short description
This use case utilises advanced production and demand forecasting to improve network management. Through strategic collaboration between the system operator (SO) and the energy service company (ESCO), the system uses real-time and historical data to forecast demand and production, identify potential grid problems and calculate the necessary operational flexibility if problems occur.
Complete description
The process begins with the SO receiving parameterised energy demand and generation forecasts from the ESCO and carrying out data aggregation. These measures are necessary in order to structure the forecast data in a suitable format for the grid analysis. In order to assess the grid status and identify upcoming critical events based on the received forecast data, the SO uploads the data for grid analysis and load optimisation. The SO can then calculate the flexibility required to adapt to the forecast energy demand and generation, thus ensuring the stability and efficiency of the grid. The list of scenarios for this SUC is as follows: 1. Energy grid management with forecast data In this SUC, the SO utilises the forecast data from the ESCO to effectively manage the energy grid. The SO uses this data to perform a grid analysis using energy flow analysis software, which generates a report on the grid status and load optimisation. The required flexibility is then calculated based on the optimisation results. The SUC comprises the following steps 1. The ESCO parameterises the demand/generation forecast data according to the predefined specifications. 2. The ESCO sends the energy forecast data to the SO. 3. The SO aggregates the received forecast data. 4. The forecast data is loaded for the grid analysis. 5. The grid analysis results in a report that defines the status and load optimisation. 6. The SO calculates the required flexibility based on the status and load optimisation.

1.5 Key performance indicators (KPI)

ID	*Name*	*Description*	*Reference to mentioned use case objectives*
KPI 4	Real-time data sharing among stakeholders	Amount of data shared within the SUC	Obj. 2
KPI 17	Increased flexibility incorporation enabled by IoT/Edge technologies for grid security	Amount of increased flexibility within the SUC	Obj. 1, Obj. 3

1.6 Use case conditions

Use case conditions
Assumptions
• The data for the forecasts is accurate and reliable. • The IT infrastructure is robust and fully functional. • There are effective channels for data exchange between the ESCO and the SO. • All processes comply with the relevant regulations.
Prerequisites

- The forecasting models are correctly calibrated for accuracy.
- Grid Analysis System is available.
- The network topology is available.
- Forecasts of related SUCs are available and integrated into the process.

1.7 Further Information to the use case for classification / mapping

Classification Information
Relation to other use cases
Linked to SUC-GR-01.02: • Providing forecasts of demand Linked to SUC-GR-01.03: • Providing forecasts of production Linked to SUC-GR-03.02: • Ability to forward the calculated Flexibility to the Flexibility Trading platform.
Level of depth
High
Prioritisation
High
Generic, regional or national relation
National
Nature of the use case
System Use Case: Technical specifications to perform energy grid management in order to calculate the required flexibility.
Further keywords for classification

1.8 General Remarks

General Remarks

2 Diagrams of use case

Diagram(s) of use case

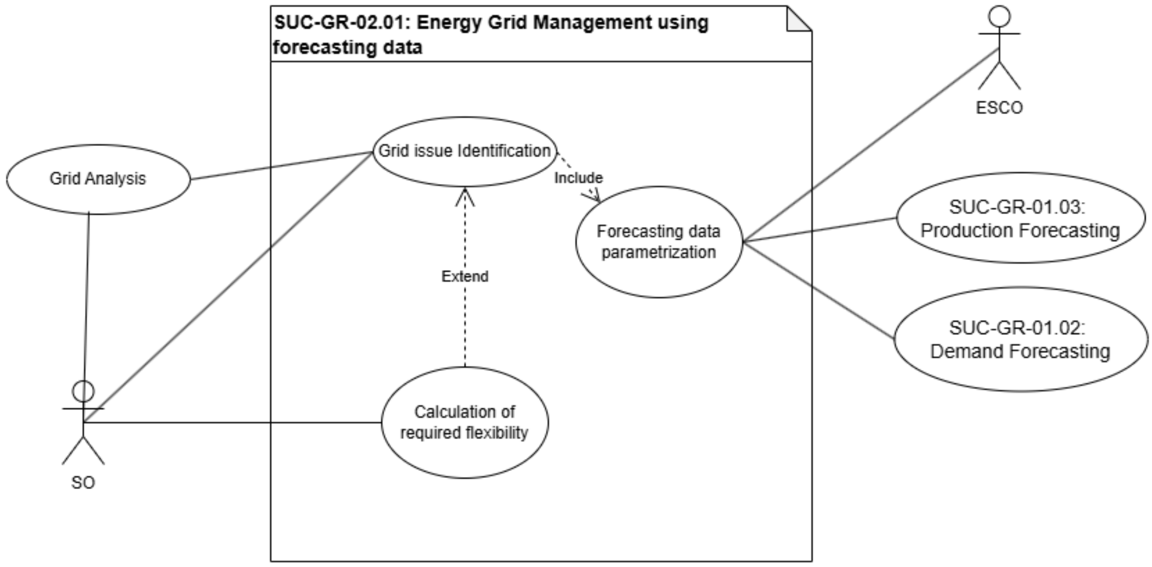


FIGURE 20: UML USE CASE DIAGRAM

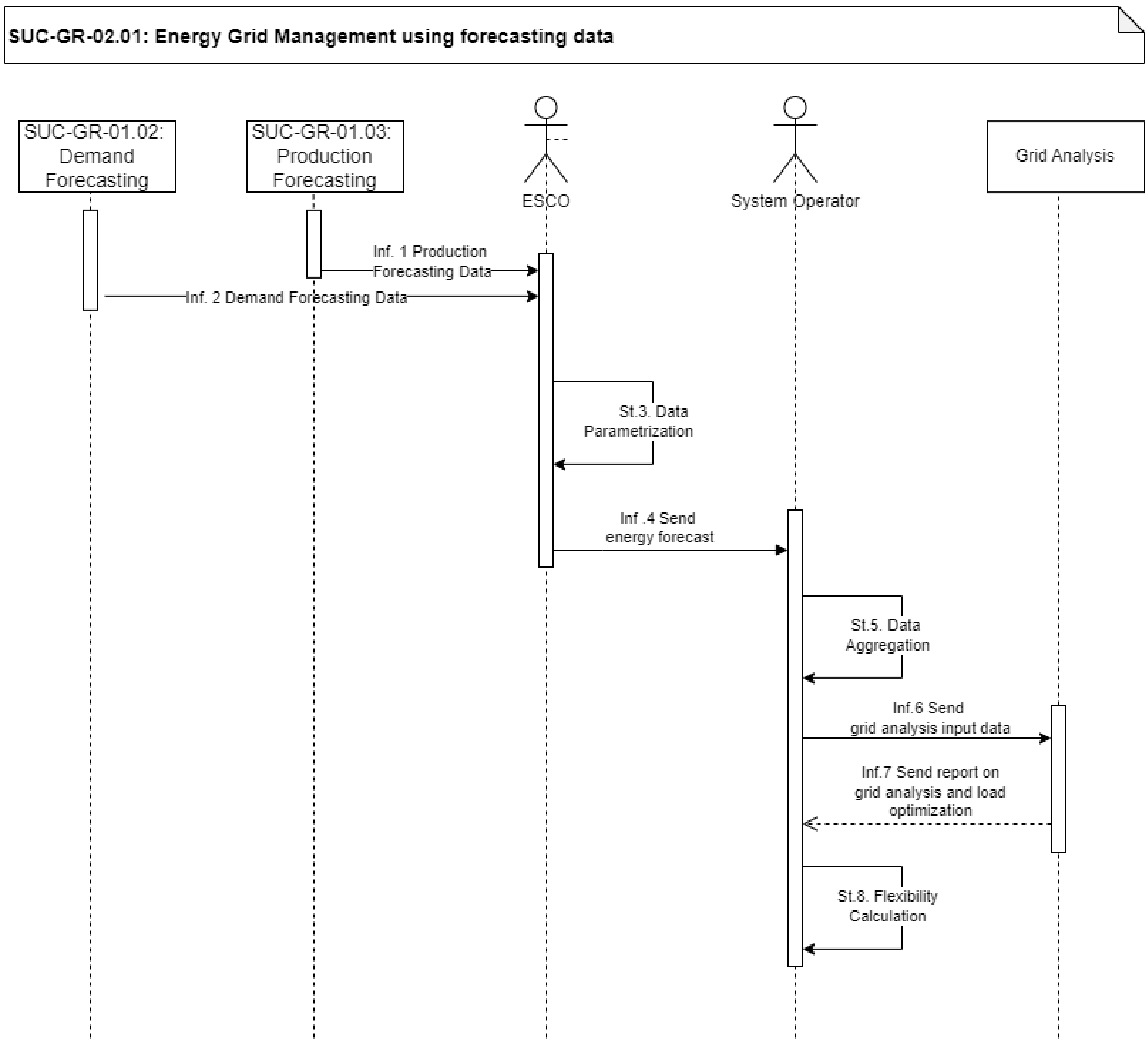


FIGURE 21. 1 SUC-GR-O2.01: ENERGY GRID MANAGEMENT USING FORECASTING DATA SEQUENCE DIAGRAM

3 Technical details

3.1 Actors

Actors			
Actor Name	***Actor Type***	***Actor Description***	***Further information specific to this use case***
System Operator	Business Actor	A party responsible for operating, maintaining and, if necessary, developing the network in a given area and, if applicable, its interconnections with other networks, and for ensuring the long-term ability of the network to meet reasonable demand for the distribution or transmission of electricity.	HEDNO (Hellenic Electricity Distribution Network Operator S.A.)
Energy Service Company	Business Actor	A party that provides energy-related services to the party connected to the grid but is not directly involved in the energy value chain or the physical infrastructure itself. The energy service company (ESCO) can offer both insight services and energy management services.	PPC (Public Power Corporation SA)
Grid Analysis	Logical Actor	A system that analyzes grid state and exports report about grid analysis and load optimization.	HEDNO

3.2 References

References						
No.	***Reference Type***	***Reference***	***Status***	***Impact on use case***	***Originator / organisation***	***Link***

4 Step by step analysis of use case

4.1 Overview of scenarios

Scenario conditions						
No.	**Scenario name**	**Scenario description**	**Primary actor**	**Triggering event**	**Pre-condition**	**Post-condition**

Sc.1	Energy Grid Management using forecasting data	The SO uses forecasting data to manage the energy grid, identify potential issues, and calculate required flexibility.	SO (System Operator)	Receipt of energy forecast from ESCO.	Data for demand and production forecasting is collected and parametrized by ESCO.	Report on grid analysis and load optimization is sent to SO and the required flexibility is calculated.

4.2 Steps – Scenarios

Scenario								
Scenario name:		Energy Grid Management using forecasting data						
Step No.	**Event**	**Name of process/ activity**	**Description of process/ activity**	**Service**	**Information producer (actor)**	**Information receiver (actor)**	**Information Exchanged (IDs)**	**Requirement, R-IDs**
St. 1	Production Data Availability	Production Forecasting Data	Production Forecasting Data exported from SUC-GR-01.03 is collected from ESCO	REPORT	SUC-GR-01.03	ESCO	Inf.1	Sec.1, D.1, D.2
St. 2	Demand Data Availability	Demand Forecasting Data	Demand Forecasting Data exported from SUC-GR-01.02 is collected from ESCO	REPORT	SUC-GR-01.02	ESCO	Inf.2	Sec.1, D.1, D.2
St. 3	Data Availability	Data Parametrization	Parametrization of the energy forecasting data for demand and production	CHANGE	ESCO	ESCO	x	
St. 4	Data parametrization	Send Energy Forecast	ESCO sends energy demand and production forecasts to the SO	REPORT	ESCO	SO	Inf.4	Conf.1, D.1, Sec.1, O.1
St. 5	Receipt of energy forecast	Data Aggregation	System Operator aggregates data for grid analysis	EXECUTE	SO	SO	x	
St. 6	Completion of data preprocessing	Send Grid Analysis Input Data	SO sends the forecasting data for detailed grid analysis to Grid Analysis	REPORT	SO	Grid Analysis	Inf.6	Sec.1
St. 7	Completion of Grid Analysis	Send Grid Analysis Report	Grid Analysis sends report on grid analysis and load optimization	REPORT	Grid Analysis	SO	Inf.7	Sec.1
St. 8	Report Receipt	Flexibility Calculation	Calculation of grid flexibility based on grid analysis	EXECUTE	SO	SO	x	

5 Information exchanged

Information exchanged			
Information exchanged (ID)	*Name of information*	*Description of information exchanged*	*Requirement, R-IDs*
Inf.1	Production Forecasting Data	Production Forecasting data extracted from SUC-GR-01.03	D.1, D.2
Inf.2	Demand Forecasting Data	Demand Forecasting data extracted from SUC-GR-01.02	D.1, D.2
Inf.4	Data from forecasts	The parametrized energy forecasting data generated using the respective SUCs.	D.1, D.2
Inf.6	Grid analysis input data	The essential aggregated data to perform grid analysis.	D.1
Inf.7	Report data	A report on grid analysis and load optimization.	D.1

6 Requirements

Quality of Service Requirements		
Categories ID	**Category name for requirements**	**Category description**
QoS	Quality of Service	Generic properties that service/SUC should provide – quality attributes.
Requirement R-ID	**Requirement name**	**Requirement description**
QoS.1	Frequency of data exchanges	Upon request

Security Requirements		
Categories ID	**Category name for requirements**	**Category description**
Sec	Security	Authentication of user, confidentiality, integrity, prevention of denial of service, non-repudiation or accountability, error management.
Requirement R-ID	**Requirement name**	**Requirement description**
Sec.1	Authentication and Access Control mechanisms commonly used with this data exchange	Private (secret) key encryption

Data Management Requirements		
Categories ID	**Category name for requirements**	**Category description**
D	Data Management	Type of data source, accuracy or validity of data, timeliness or timestamping of data, volume of data, synchronisation or consistency of data across different systems, timely access to data, validation of data across organisational boundaries, transaction management, naming, identification and formatting of data across different systems, maintenance of data and databases.
Requirement R-ID	**Requirement name**	**Requirement description**

D.1	Correctness of source data	Source data is usually correct
D.2	Up-to-date management	Received data must be up-to-date within hours of source data changing

Discovery and Configuration Requirements		
Categories ID	**Category name for requirements**	**Category description**
Conf	Configuration	Locations, distances, communication layout, commonly used communication protocol media, network bandwidth, existing protocols, number of devices, systems, data volume, expected growth, etc.
Requirement R-ID	**Requirement name**	**Requirement description**
Conf.1	Data exchange methods	Client-server Through database

Other Requirements		
Categories ID	**Category name for requirements**	**Category description**
O	Regulatory obligation related to privacy	2016/679 GDPR (General Data Protection Regulation)
Requirement R-ID	**Requirement name**	**Requirement description**
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.

7 Common Terms and Definitions

Common Terms and Definitions	
Term	**Definition**
SUC	System Use Case
BUC	Business Use Case
SO	System Operator
ESCO	Energy Service Company
HEDNO	Hellenic Energy Distribution Network Operator
PPC	Public Power Corporation
RES	Renewable Energy Source
IoT	Internet of Things

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

1 Description of the use case

1.1 Name of the use case

ID	Area / Domain(s) / Zones(s)	Name of Use Case
SUC-GR-03.01	Flexibility Market	Registration & Prequalification on Local Flexibility Market

1.2 Version management

Version Management			
Version No.	Date	Name of Author(s)	Changes0.
0.1	02.07.2024	HENEX	1st Draft
0.2	26.08.2024	HENEX	Changes based on guidelines
0.3	09.09.2024	HENEX	Changes based on review
1.0	02.10.2024	HENEX	Final first version

1.3 Scope and objectives of use case

Scope and Objectives of Use Case	
Scope	The scope of the SUC is the description of the authorisation process for users of the Local Flexibility Market (LFM) platform. The LFM platform offers various registration and pre-qualification procedures that are tailored to the respective role of the user and ensure a personalised and efficient process for access to the functions and possibilities of the platform.
Objective(s)	The aim of this use case is to outline the comprehensive authorisation process for users accessing the LFM platform. This process includes registration and pre-qualification steps to ensure that users are granted access to the platform's features and capabilities based on their specific roles. The authorisation process aims to achieve the following: 1. **Ensure secure access:** implement a robust and secure user registration and authentication mechanism to protect sensitive information and prevent unauthorised access. 2. **Role-specific tailoring**: Provide different registration and pre-qualification procedures for different user roles, e.g. for SOs and FSPs, to ensure that each user has appropriate access rights and capabilities. 3. **Optimised user experience**: Design an efficient and user-friendly process that minimises the time and effort required to register and pre-qualify users, thus increasing overall user satisfaction. 4. **Accurate role assignment**: Ensure users are accurately categorised and assigned roles based on the information and prequalification criteria they submit to enable effective and appropriate use of the platform. 5. **Effective communication:** Ensure clear and timely communication with users throughout the registration and prequalification process, including

	confirmation emails, status updates and notifications of approval or requests for additional information. 6. **Transparent and continuous access:** Provide users with continuous access to and a clear overview of the registration steps so that they are always informed of their progress. 7. **Synchronised communication:** Ensure synchronised communication between the user and the platform so that users are always aware of their current status and any actions required to complete the registration and pre-qualification process. By achieving these goals, the LFM platform can maintain a secure, efficient and user-centric environment that supports the diverse needs and roles of its users and fosters a productive and collaborative market ecosystem.
Related business case(s)	BUC-GR-03: Flexibility trading platform for mitigating problems of the T&D networks

1.4 Narrative of use case

Narrative of Use Case
Short description
Various flexible resources can qualify for the flexibility market. Flexibility service providers (FSPs) must apply for qualification if their resources fulfil the market access requirements set by the SOs and the market operator (MO). If the pre-qualification is successful, the FSP becomes a qualified participant for the relevant assets and can bid on the flexibility market. If the prequalification is not successful, the FSP cannot register the assets or make offers. At this stage, SOs are expected to register on the market platform as traders of flexibility, but only FSPs need to go through the prequalification process.
Complete description
Different types of flexible resources may qualify for participation in the flexibility market. To ensure compliance, Flexibility Service Providers (FSPs) must provide pre-qualification information if their assets fulfil the market access criteria set by both System Operators (SOs) and the Market Operator (MO). The process is as follows: 1. **Registration**: both the SO and the FSP must complete the registration process to gain access to the platform. In this phase, they provide important information about their role and company. **Prequalification of assets:** Only the FSP must go through the prequalification process. This means that the FSP must submit detailed information about their assets to the MO. The MO then forwards this information to the SO for assessment and prequalification. **Prequalification Answer:** The SO is responsible for carrying out the prequalification test, with the platform acting as an intermediary. The outcome of this process determines whether the FSP's assets fulfil the standards required for market participation. This process can be illustrated using two scenarios: 1. **FSP Registration and Prequalification: t**he FSP must complete both registration and prequalification of assets in order to participate in the market. 2. **SO registration:** The SO must register on the platform as a buyer of flexibility services**,** but does not have to pre-qualify the assets. This structured approach ensures that only qualified FSPs can participate, maintaining high standards and reliability within the flexibility market.

1.5 Key performance indicators (KPI)

ID	Name	Description	Reference to mentioned use case objectives
KPI 8	IoT/Edge/Fog Sites Uptime and Availability	Uptime and availability percentage of cloud-based Authorization/Authentication service	6, 7

1.6 Use case conditions

Use case conditions
Assumptions
1. **System availability**: ○ The \Authorisation/Authentication service is always fully functional and accessible to users. 2. **User competence**: ○ FSPs and SOs are familiar with the platform's registration and prequalification procedures and have the necessary technical competence to operate the system. 3. **Accurate information**: ○ FSPs provide accurate and complete information during the registration and prequalification process. ○ The information provided by FSPs about their assets complies with the market access requirements set by the SOs and the MO. 4. **Regulatory compliance**: ○ The LFM platform operates within the legal and regulatory framework that governs the flexibility markets. ○ FSPs adhere to all applicable regulations and standards during registration and pre-qualification. 5. **Timely communication**: ○ There is efficient and timely communication between the FSPs, MOs and SOs. ○ Confirmation emails, status updates and notifications are sent and received without significant delays. 6. **Availability of roles**: ○ Role-specific administrators and SOs are available to review and process prequalification requests without significant delays. ○ SOs actively register on the market platform as buyers of flexibility. 7. **Security measures**: ○ The LFM platform employs robust security measures to protect user data and ensure the integrity of the registration and prequalification processes. 8. **System integration**: ○ The LFM platform is integrated with the relevant external systems and databases required to validate registration and pre-qualification information. By ensuring these assumptions are met, the registration and prequalification process can function smoothly and effectively, maintaining the reliability and efficiency of the LFM Platform.
Prerequisites
1. **System setup:** The LFM platform is fully developed, tested and ready for use, and the necessary infrastructure is in place 2. **User training:** The FSPs and SOs have completed the necessary training to use the platform effectively. 3. **Regulatory compliance:** The platform and FSPs fulfil all relevant legal and regulatory requirements. 4. **Documentation:** Comprehensive guidelines and user documentation are available for registration and prequalification.

5. **Data preparation**: The FSPs have accurate and up-to-date information for registration and prequalification.
6. **Communication channels**: Reliable channels (e.g. email) are established for support during the process.
7. **Approval workflows:** Defined workflows and assigned roles for reviewing and approving applications are implemented.
8. **Security measures:** Security protocols such as data encryption and user authentication are implemented.
9. **MO readiness:** The MO is prepared to manage registration and pre-qualification processes.

1.7 Further Information to the use case for classification / mapping

Classification Information
Relation to other use cases
Linked to SUC-GR-03.02
Level of depth
High
Prioritisation
High
Generic, regional or national relation
National
Nature of the use case
Further keywords for classification

1.8 General Remarks

General Remarks

2 Diagrams of use case

Diagram(s) of use case

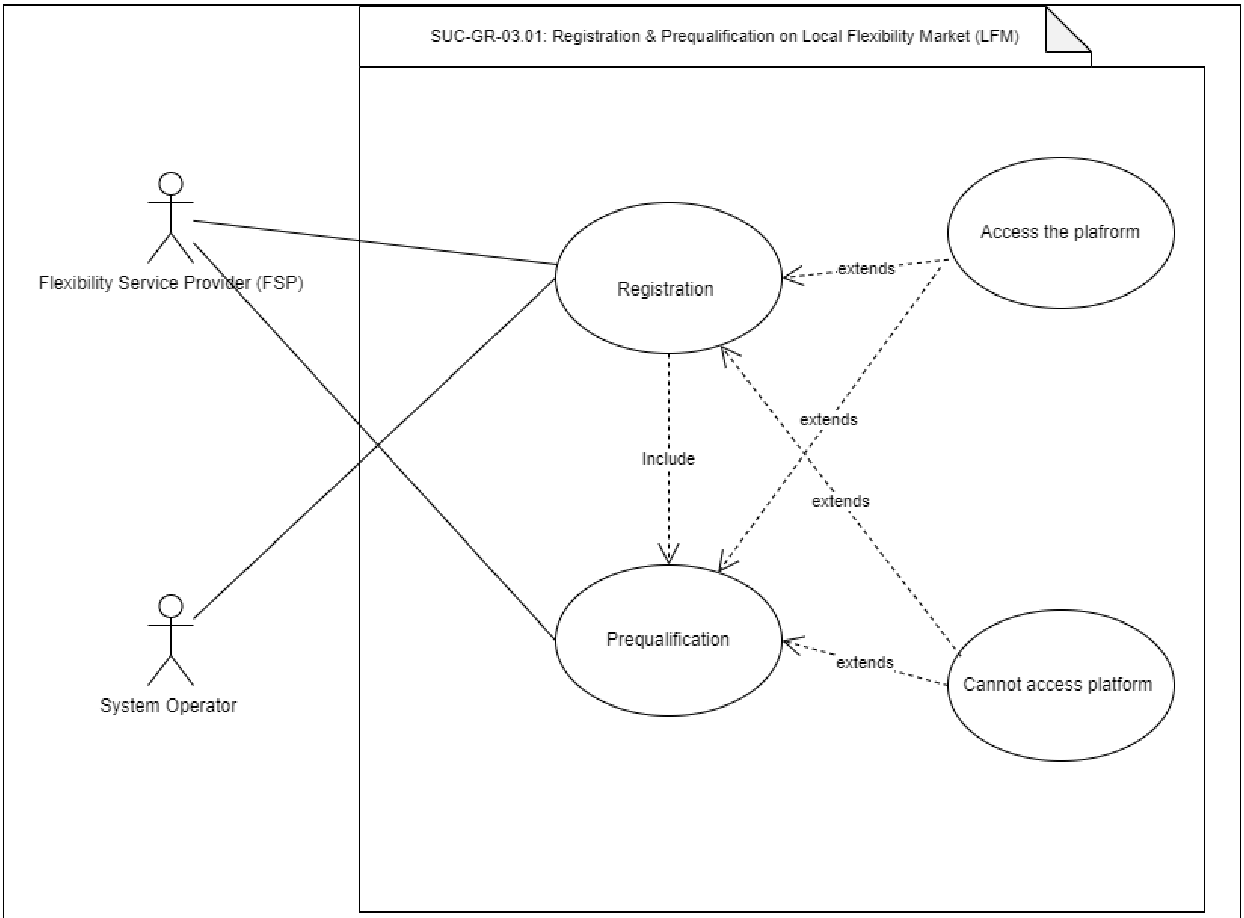


FIGURE 22: UML USE CASE DIAGRAM

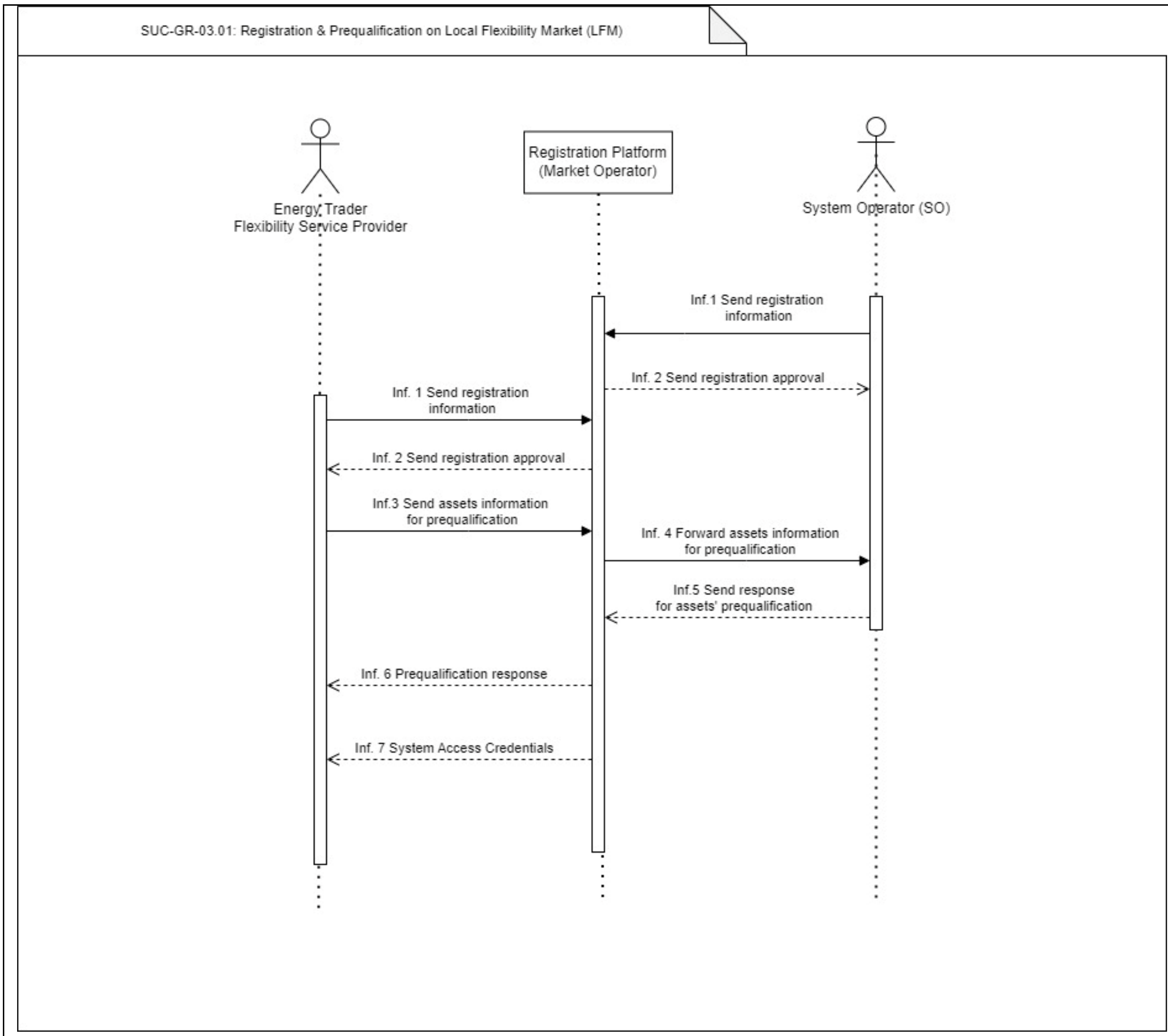


FIGURE 23: SUC-GR-03.1 SEQUENCE DIAGRAM

3 Technical details

3.1 Actors

Actors			
Actor Name	***Actor Type***	***Actor Description***	***Further information specific to this use case***
Flexibility Service Provider (FSP)	Business Actor	Initiates the registration process. Provides asset information for prequalification. You receive feedback on the status of registration and prequalification.	PPC
Registration Platform (Market Operator)	Operator	Manages the registration process. Approves the initial registration information. Forwards asset information to the SO for prequalification. Submits prequalification results to the FSP.	HENEX

System Operator (SO)	Business Actor	Distribution System Operator (DSO / Transmission System Operator (TSO)): Receives information on installations from the MO for prequalification. Checks and evaluates the installations on the basis of the market access requirements. Sends the answers to the prequalification (approval or rejection) to the MO.	HEDNO, IPTO

3.2 References

References						
No.	***Reference Type***	***Reference***	***Status***	***Impact on use case***	***Originator / organisation***	***Link***

4 Step by step analysis of use case

4.1 Overview of scenarios

Scenario conditions						
No.	**Scenario name**	**Scenario description**	**Primary actor**	**Triggering event**	**Pre-condition**	**Post-condition**
Sc.1	FSP Registers and Prequalifies	This scenario describes the complete process where a FSP successfully registers and prequalifies their assets on the LFM Platform.	FSP	FSP decides to join the LFM Platform and initiates the registration process.	The LFM Platform is operational and accessible. The FSP has all necessary information and documentation ready for registration and prequalification.	The FSP's account is registered and activated. The FSP's assets are prequalified. The FSP can create offers in the flexibility market.
Sc. 2	SO Registers	This scenario describes the process where a SO registers on the LFM Platform to become a buyer of flexibility.	SO	SO, decides to participate in the flexibility market and initiates the registration process.	The LFM Platform is operational and accessible. The SO has all necessary information and documentation ready for registration.	The SO's account is registered and activated. The SO is designated as a buyer of flexibility. The SO can browse and select flexibility offers on the market

4.2 Steps – Scenarios

Scenario								
Scenario name:	FSP Registers and Prequalifies							
Step No.	**Event**	**Name of process/ activity**	**Description of process/ activity**	**Service**	**Information producer (actor)**	**Information receiver (actor)**	**Information Exchanged (IDs)**	**Requirement, R-IDs**
St. 1	FSP Registers and Prequalifies	FSP Navigates to Registration Page	The FSP navigates to the registration page on the LFM Platform to begin the registration process.	Web Interface	FSP	MO	Inf. 1	QoS.1, QoS.2, QoS.3 Sec. 1, Sec. 2, D.2, Conf.1, Conf.2, Conf. 3, Conf. 4, Conf 5, O.X
St. 2	Submit Registration Information	FSP Submits Registration Form	The FSP fills out and submits the registration form with the required company and contact details.	Registration Service	FSP	MO	Inf. 1	QoS.1, QoS.2, QoS.3 Sec. 1, Sec. 2, D.2, Conf.1, Conf.2, Conf. 3, Conf. 4, Conf 5, O.X
St. 3	Approval of Registration	MO Approves Registration	The MO reviews the registration details, approves the registration, and notifies the FSP.	Notification Service	MO	FSP	Inf. 2	QoS.1, QoS.2, QoS.3 Sec. 2, Sec.3 Conf.1, Conf.2,
St.4	Asset Information Submission	FSP Submits Asset Information	The FSP logs into the LFM Platform and submits information about their assets for prequalification.	Asset Submission Service	FSP	MO	Inf. 3	QoS.1, QoS.2, QoS.3 Sec. 1, Sec. 2, D.2, Conf.1, Conf.2, Conf. 3, Conf. 4, Conf 5, O.X
St. 5	Forward Asset Information for Prequalification	LFM Platform Forwards Asset Information	The LFM Platform forwards the asset information to the SO for evaluation.	Data Forwarding Service	MO	SO	Inf. 4	QoS.1, QoS.2, QoS.3 Sec. 1, Sec. 2, Sec.3, D.1, D.2, Conf.1, Conf.2, Conf. 3, Conf. 4, Conf 5, O.X
St. 6	Evaluation by SO	SO Evaluates Assets	The SO reviews the asset information and evaluates whether the assets meet market	Evaluation Service	SO	MO	Inf. 5	QoS.1, QoS.2, QoS.3 Sec. 2, Sec.3 Conf.1, Conf.2,

			access requirements.					
St. 7	Response from SO	SO Sends Prequalification Response	SO Sends Prequalification Response	Notification Service	SO	MO	Inf. 5	QoS.1, QoS.2, QoS.3 Sec. 2, Sec.3 Conf.1, Conf.2,
St. 8	Notification of Prequalification Result	MO Notifies FSP	The MO notifies the FSP of the prequalification outcome.	Notification Service	MO	FSP	Inf. 6	QoS.1, QoS.2, QoS.3 Sec. 2, Sec.3 Conf.1, Conf.2,

Scenario								
Scenario name:		System Operator Registers						
Step No.	***Event***	***Name of process/ activity***	***Description of process/ activity***	***Service***	***Information producer (actor)***	***Information receiver (actor)***	***Information Exchanged (IDs)***	***Requirement, R-IDs***
St. 1	Initiate Registration	SO Navigates to Registration Page	The SO navigates to the registration page on the LFM Platform to begin the registration process.	Web Interface	SO	MO	Inf. 1	QoS.1, QoS.2, QoS.3 Sec. 1, Sec. 2, D.2, Conf.1, Conf.2, Conf. 3, Conf. 4, Conf 5, O.X
St. 2	Submit Registration Information	SO Submits Registration Form	The SO fills out and submits the registration form with the required organization and contact details.	Registration Service	SO	MO	Inf. 1	QoS.1, QoS.2, QoS.3 Sec. 1, Sec. 2, D.2, Conf.1, Conf.2, Conf. 3, Conf. 4, Conf 5, O.X
St. 3	Approval of Registration	MO Approves Registration	The MO reviews the registration details, approves the registration, and notifies the FSP.	Notification Service	MO	SO	Inf. 2	QoS.1, QoS.2, QoS.3 Sec. 2, Sec.3 Conf.1, Conf.2,
St. 4	System Access	SO Logs into Platform	The SO logs into the LFM Platform, sets up their profile, and specifies their requirements and preferences for buying flexibility.	Access Service	MO	SO	Inf. 7	QoS.1, QoS.2, QoS.3 Sec. 1, Sec. 2, Sec.3, D.1, D.2, Conf.1, Conf.2, Conf. 3, Conf. 4, Conf 5, O.X

5 Information exchanged

Information exchanged			
Information exchanged (ID)	***Name of information***	***Description of information exchanged***	***Requirement, R-IDs***
Inf. 1	Registration Form	Contains company/organization information and contact details required for registration (FSP/SO).	QoS.1, QoS.2, QoS.3 Sec. 1, Sec. 2, D.2, Conf.1, Conf.2, Conf. 3, Conf. 4, Conf 5, O.X
Inf. 2	Registration Approval Notification	Confirmation that the registration has been approved by the MO (FSP/SO).	QoS.1, QoS.2, QoS.3 Sec. 2, Sec.3 Conf.1, Conf.2,
Inf .3	Asset Information	Details about the FSP's assets, including type, capacity, and other relevant data for prequalification.	QoS.1, QoS.2, QoS.3 Sec. 1, Sec. 2, D.2, Conf.1, Conf.2, Conf. 3, Conf. 4, Conf 5, O.X
Inf. 4	Forwarded Asset Information	Asset information sent by the MO to the SO for evaluation.	QoS.1, QoS.2, QoS.3 Sec. 1, Sec. 2, Sec.3, D.1, D.2, Conf.1, Conf.2, Conf. 3, Conf. 4, Conf 5, O.X
Inf. 5	Prequalification Evaluation	Evaluation results from the SO determining if the assets meet market access requirements.	QoS.1, QoS.2, QoS.3 Sec. 2, Sec.3 Conf.1, Conf.2,
Inf. 6	Prequalification Response Notification	Notification sent by the MO to the FSP regarding the outcome of the prequalification process.	QoS.1, QoS.2, QoS.3 Sec. 2, Sec.3 Conf.1, Conf.2,
Inf. 7	System Access Credentials	Login credentials provided to the SO for accessing the LFM Platform.	QoS.1, QoS.2, QoS.3 Sec. 1, Sec. 2, Sec.3, D.1, D.2, Conf.1, Conf.2, Conf. 3, Conf. 4, Conf 5, O.X

6 Requirements

Quality of Service Requirements		
Categories ID	**Category name for requirements**	**Category description**
QoS	Quality of Service	Generic properties that service/SUC should provide – quality attributes.
Requirement R-ID	**Requirement name**	**Requirement description**
QoS.1	Availability of information flows	Continuous availability not required but must be available at specific times or under specific conditions
QoS.2	Accuracy of data requirements	Adequate accuracy can be assumed
QoS.3	Frequency of data exchanges	Upon event
QoS.4	Frequency of data exchanges	Random

Security Requirements	

Categories ID	Category name for requirements	Category description
Sec	Security	Authentication of user, confidentiality, integrity, prevention of denial of service, non-repudiation or accountability, error management.
Requirement R-ID	**Requirement name**	**Requirement description**
Sec.1	Eavesdropping: Ensuring confidentiality, avoiding illegitimate use of data, and preventing unauthorized reading of data, is:	Quite important
Sec.2	Information integrity violation: Ensuring that data is not changed or destroyed is:	Crucial
Sec.3	Authentication and Access Control mechanisms commonly used with this data exchange	API Key / Access Token

Data Management Requirements		
Categories ID	**Category name for requirements**	**Category description**
D	Data Management	Type of source of data, correctness or validity of data, timeliness or time stamping of data, volume of data, synchronization, or consistency of data across systems, timely access to data, validation of data across organizational boundaries, transaction management, data naming, identification, formats across disparate systems, maintenance of data and databases.
Requirement R-ID	**Requirement name**	**Requirement description**
D.1	Correctness of source data	Source data is always correct (e.g. by definition)
D.2	Up-to-date management	Received data must be up-to-date within seconds of source data changing

Discovery and Configuration Requirements		
Categories ID	**Category name for requirements**	**Category description**
Conf	Configuration	Locations, distances, communication layout, commonly used communication protocol media, network bandwidth, existing protocols, number of devices, systems, volume of data items, expected growth, etc.
Requirement R-ID	**Requirement name**	**Requirement description**
Conf.1	Number of Information Producers	Two to a few
Conf.2	Number of Information Receivers	Two to a few
Conf.3	Data exchange methods	Client-server
Conf.4	Communication access services requirements	Request-response

Conf.5	Commonly used communication protocol	Include here the communication protocols used for the information exchange.

Other Requirements		
Categories ID	**Category name for requirements**	**Category description**
O	Regulatory obligation related to privacy	2016/679 GDPR (General Data Protection Regulation)
Requirement R-ID	**Requirement name**	**Requirement description**
O.1	A name of the requirement.	Description of the requirement (this might be populated automatically from the repository, if the requirement has already been described in the external document before).
O.2	All constraints also apply.	Personal data may not be processed unless there is at least one legal basis to do so.
O.3	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.
O.4	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.
O.5	Data retention policy	Personal data may not be transferred to a third-party if the data subject did not agree and the third party provide appropriate safeguard.
O.X	All constraints also apply.	All requirements in this category.

7 Common Terms and Definitions

Common Terms and Definitions	
Term	**Definition**
FSP	Flexibility Service Provider
MO	Market Operator
SO	System Operator
LFM	Local Flexibility Marker

8 SUC-GR-03.02 – FLEXIBILITY TRADING

1 Description of the use case

1.1 Name of the use case

ID	Area / Domain(s) / Zones(s)	Name of Use Case
SUC-GR-03.02	Flexibility Market	Flexibility Trading

1.2 Version management

Version Management			
Version No.	**Date**	**Name of Author(s)**	**Change(s)**
0.1	02.07.2024	HENEX	1st Draft
0.2	26.08.2024	HENEX	Changes based on guidelines
0.3	09.09.2024	HENEX	Changes based on review
1.0	02.10.2024	HENEX	Final first version

1.3 Scope and objectives of use case

Scope and Objectives of Use Case	
Scope	This use case covers the process of trading flexibility services to maintain grid stability and ensure efficient market operation. The main focus is on the interactions between system operators (SO), market operators (MO) and flexibility service providers (FSP) in the context of a flexibility market. This includes a number of processes such as the submission of flexibility requests and offers to assess the feasibility of transactions and market clearing – the settlement of the results. The above processes are based on the exchange of information and coordination mechanisms between the FSPs, MOs and SOs.
Objective(s)	The main objectives of this use case are: 1. Ensure grid stability and optimize market operations by effectively managing and trading flexibility services. 2. Facilitate seamless interactions between System Operators, Market Operators, and Flexibility Service Providers. 3. Promote real-time data sharing and execute financially and technically viable flexibility offers. 4. Leverage advanced IoT and AI technologies to improve grid performance and provide economic benefits to end-users.
Related business case(s)	BUC-GR-03: Flexibility trading platform for mitigating problems of the T&D networks

1.4 Narrative of use case

Narrative of Use Case
Short description
In the "Flexibility Trading" use case, SOs request grid flexibility in the Local Flexibility Market (LFM) run by the Market Operator (MO). Notifications are sent by the LFM to the FSPs, who evaluate the request and submit flexibility offers. Financial and network feasibility checks are conducted by the MO and SOs respectively. Feasible orders lead to market clearing and order nomination, while infeasible

orders are rejected. The process ensures efficient grid management and proper market operations, with settlement and remuneration following the clearing of trades.
Complete description

The "flexibility trading" use case describes the process by which SOs, MOs and FSPs interact to manage grid stability and optimise market operation. The use case focuses on the sequence of events from the initial request for flexibility services to billing and remuneration after the services have been provided.
 	
The key steps in the flexibility trading process:
1. **Submit flexibility request:**
  o The SO identifies a need for grid flexibility due to potential grid issues and submits a flexibility request to the LFM, which is operated by the MO.
2. **Review request:**
  o The MO notifies qualified FSPs of the SO's flexibility request.
  o The qualified FSPs evaluate the SO's request using AI and other decision support tools and decide whether to offer their flexibility services.
3. **Submission of the flexibility offer:**
  o The FSPs submit their flexibility offers to the LFM operated by the MO.
4. **Feasibility checks:**
  o The MO conducts financial audits of the orders received to ensure economic feasibility
  o The MO forwards the results of the financial feasibility check to the SOs.
  o The SOs coordinate and conduct the network feasibility assessment to ensure that the trade mitigates or solves the identified network problem(s).
  o Alternative path: If either feasibility check fails, rejection and error messages are sent by the LFM (MO) to the involved partners (FSPs and SOs).
5. **Market clearing:**
  o If the feasibility checks are passed, the MO sends the results of the market clearing to the involved partners (FSPs and SOs)
6. **Settlement:**
  o Once the flexibility services have been provided, settlement is done by the trading platform after receiving data from the SOs and smart metres. The next step is to pay the FSP for the services provided to the system
 	
This use case captures the comprehensive process and interactions required for efficient flexibility trading that ensures grid stability and economic efficiency.

1.5 Key performance indicators (KPI)

ID	*Name*	*Description*	*Reference to mentioned use case objectives*
KPI 3	Planned Usage of HEDGE-IoT Tools	Percentage of planned usage of HEDGE-IoT tools/data services (e.g., transactions, periodicity) in field demos.	1,2,3,4
KPI 6	End-users' Bill Reduction	Percentage reduction in end-users' bills by offering flexibility services. This will be anticipated by measuring the end-users' revenues from flexibility trading	4

KPI 8	IoT/Edge/Fog Sites Uptime and Availability	Uptime and availability percentage of cloud-based flexibility trading platform.	3
KPI 9	Flexibility Unlocked and Transacted in Markets	Quantity of flexibility unlocked and transacted in markets.	1,2,3,4
KPI 10	Number of Consumers Engaged with Flexibility Services	Number of consumers engaged with flexibility services. Engaged consumers are considered consumers/end-users that accept to change their production in consumptions, as a response to a flexibility request.	4

1.6 Use case conditions

Use case conditions
Assumptions

9. **System availability**:
   - The LFM platform is always fully functional and accessible to users.
10. **User Expertise**:
    - FSPs and SOs are familiar with the platform's registration and prequalification procedures and have the necessary technical expertise to operate the system.
11. **Accurate information**:
    - FSPs provide accurate and complete information during the registration and prequalification process.
    - The information provided by the FSPs about their assets complies with the market access requirements set by the SOs and the MO.
12. **Regulatory compliance**:
    - The LFM platform operates within the legal and regulatory framework that governs the flexibility markets.
    - FSPs adhere to all applicable regulations and standards during registration and pre-qualification.
13. **Timely communication**:
    - There is efficient and timely communication between the FSPs, MOs and SOs.
    - Confirmation emails, status updates and notifications are sent and received promptly and without major delays.
14. **Availability of roles**:
    - Role-specific administrators and SOs are available to review and process prequalification requests without significant delays.
    - SOs actively register on the market platform as buyers of flexibility.
15. **Security measures**:
    - The LFM platform employs robust security measures to protect user data and ensure the integrity of the registration and prequalification processes.
16. **System integration**:
    - The LFM platform is integrated with the relevant external systems and databases required to validate registration and prequalification information.

By ensuring these requirements, the flexibility trading process can function smoothly and effectively and maintain the reliability and efficiency of the LFM.
Prerequisites
1. **Authentication and authorisation:** All actors are properly authenticated and authorised to perform their respective roles within the LFM. 2. **Compliance with legal requirements:** The flexibility market operates within the regulatory and legal framework applicable to the region or country. 3. **Infrastructure and communication:** The necessary infrastructure and communication channels are in place to support real-time interactions and transactions between system operators, market operators and flexibility service providers. 4. **Data accuracy:** The data used to assess financial and grid feasibility is accurate and up-to-date to ensure reliable decision-making. 5. **Technology readiness:** The technologies (including AI tools) used to assess, offer and validate flexibility services are fully functional and reliable. 6. **Market participation:** There are sufficient and willing market participants (FSPs) that respond to flexibility requests. 7. **Grid condition monitoring:** SOs are able to accurately monitor grid conditions and predict grid stability needs. 8. **Timeliness: Feasibility** checks and market clearing are completed within a timeframe that enables timely decision making and grid management. 9. **Privacy and security:** Privacy and security measures are in place and adhered to in order to ensure the confidentiality and integrity of transaction data. 10. **Economic viability:** Market conditions are such that the provision and use of flexibility services is economically viable for all parties involved.

1.7 Further Information to the use case for classification / mapping

Classification Information
Relation to other use cases
Linked to SUC-GR-03.01
Level of depth
High
Prioritisation
High
Generic, regional or national relation
National
Nature of the use case
Further keywords for classification

1.8 General Remarks

General Remarks

2 Diagrams of use case

Diagram(s) of use case

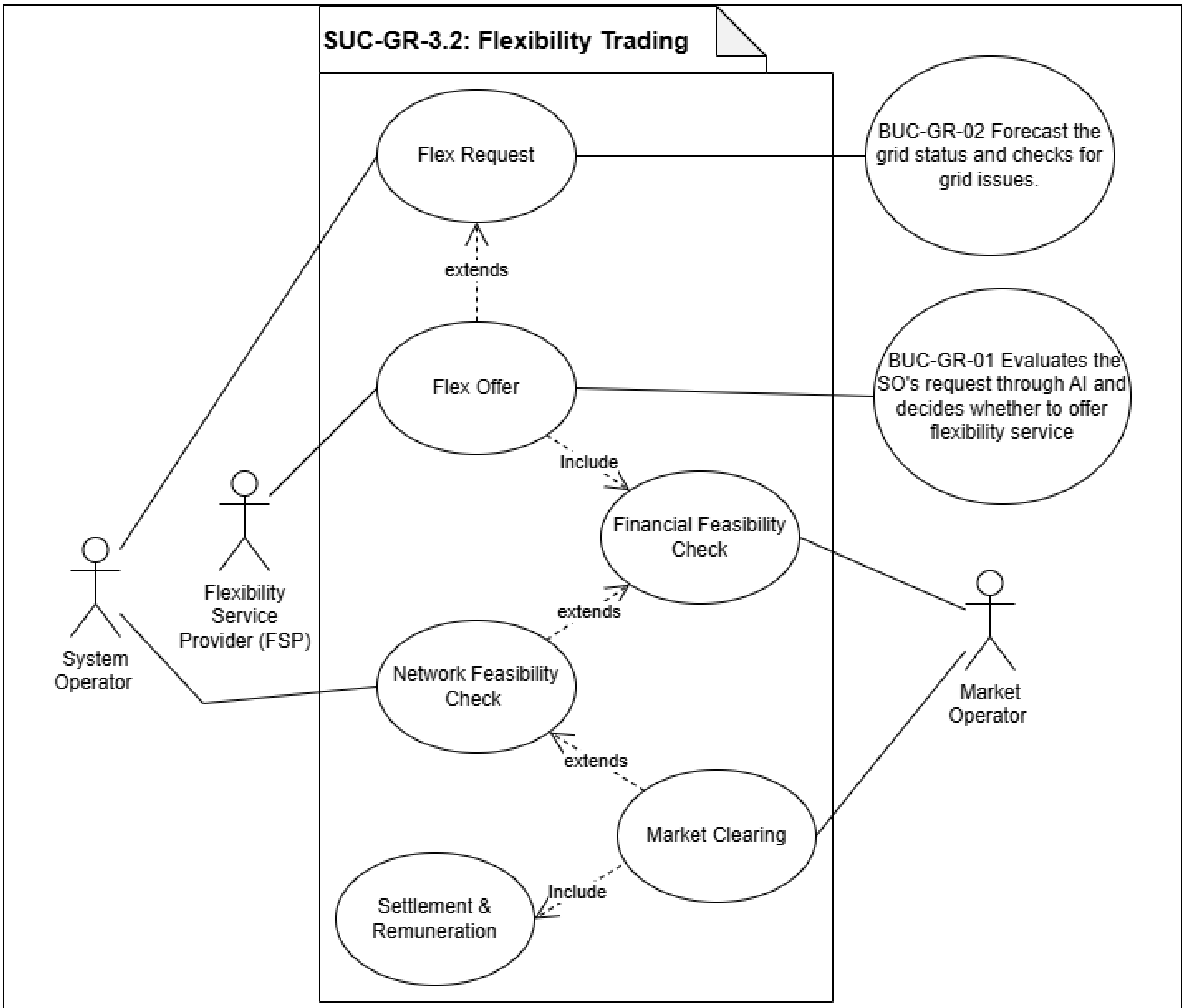


FIGURE 24: UML USE CASE DIAGRAM

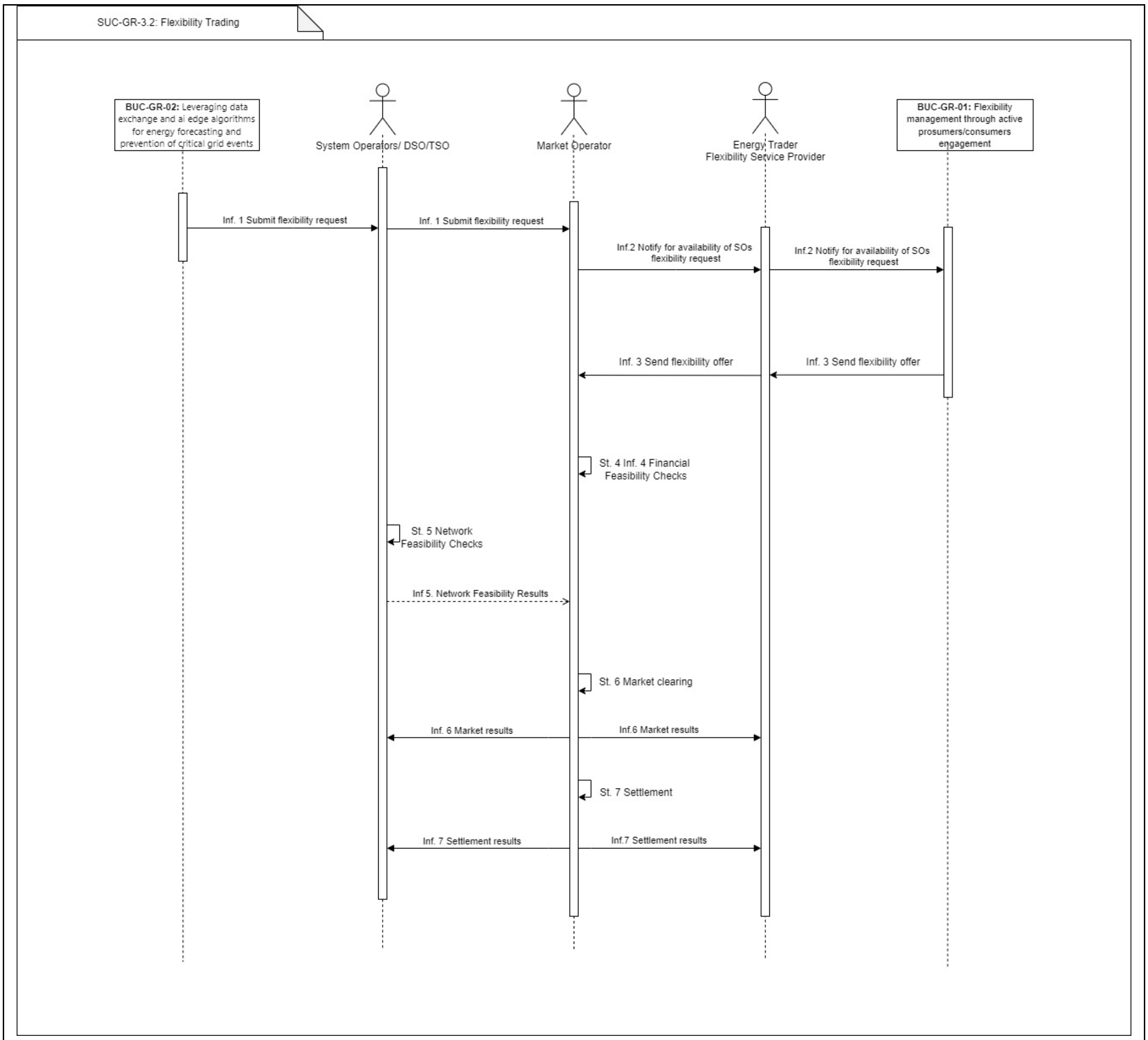


FIGURE 25: SUC-GR-03.2 SEQUENCE DIAGRAM

3 Technical details

3.1 Actors

Actors			
Actor Name	***Actor Type***	***Actor Description***	***Further information specific to this use case***
Flexibility Service Provider (FSP)	Business Actor	Receives notifications for flexibility requests Submits flexibility offers Receives market results Provides flexibility in the system Receives settlement and remuneration information	PPC
Market Operator (MO)	Operator	Operates all processes of the LFM Platform Provides interfaces for the transactions Is responsible for the data exchanges between the actors	HENEX

System Operator (SO)	Business Actor	A Distribution System Operator (DSO) or Transmission System Operator (TSO) joins the local flexibility market to request and purchase flexibility from flexibility providers. They: • Send flexibility requests when a grid imbalance is detected. • Perform network feasibility checks for flexibility offers based on market outcomes. • Provide data about settlement and remuneration.	HEDNO, IPTO

3.2 References

References						
No.	***Reference Type***	***Reference***	***Status***	***Impact on use case***	***Originator / organisation***	***Link***

4 Step by step analysis of use case

4.1 Overview of scenarios

Scenario conditions						
No.	**Scenario name**	**Scenario description**	**Primary actor**	**Triggering event**	**Pre-condition**	**Post-condition**
Sc.1	Trade Execution	The SO submits a flexibility request, FSPs send offers, MO performs financial feasibility check,SOs coordinate and check network feasibility, trades are cleared, and flexibility services are provided in the system to maintain grid stability.	System Operator (SO)	Detection of an imminent grid imbalance	All actors are authenticated and authorized.	Grid stability is maintained, and FSPs are remunerate d for their services.

4.2 Steps – Scenarios

Scenario								
Scenario name:		FSP Registers and Prequalifies						
Step No.	***Event***	***Name of process/ activity***	***Description of process/ activity***	***Service***	***Information producer (actor)***	***Information receiver (actor)***	***Information Exchanged (IDs)***	***Requirement, R-IDs***
St. 1	Detection of grid imbalance	Submit Flexibility Request	The SO identifies a need for grid flexibility and submits a flexibility request to the MO.	LFM	FSP	MO	Inf. 1	QoS.1, QoS.2, QoS.4 Sec. 1, Sec. 2, Sec.3, D.1, D.2, Conf.1, Conf.2, Conf. 3, Conf. 4, Conf 5
St. 2	Notification to FSPs	Notify Flexibility Service Providers	The MO notifies all registered FSPs about the SO's flexibility request.	Notification Service	MO	FSP	Inf. 2	QoS.1, QoS.2, QoS.3 Sec. 2, Sec.3 Conf.1, Conf.2,
St. 3	Evaluation of request	Evaluate Request and Send Offers	FSPs evaluate the SO's request and send their flexibility offers to the MO.	LFM	FSP	MO	Inf. 3	QoS.1, QoS.2, QoS.3 Sec. 1, Sec. 2, Sec.3, D.1, D.2 Conf.1, Conf.2, Conf. 3, Conf. 4, Conf 5, O.X
St. 4	Financial Feasibility checks	Perform Financial Feasibility Checks	The MO conducts financial feasibility checks on the received offers.	LFM	MO	Internal Process	Inf. 4	QoS.1, QoS.2, QoS.3 Sec. 1, Sec. 2, Sec.3, D.1, D.2, Conf.1, Conf.2, Conf. 3, Conf. 4, Conf 5

St. 5	Network feasibility check	Perform Network Feasibility Check	The SO conducts network feasibility checks on the received offers.	Feasibility Check Service	MO	Internal Process	Inf. 5	QoS.1, QoS.2, QoS.3 Sec. 1, Sec. 2, Sec.3, D.1, D.2 Conf.1, Conf.2, Conf. 3, Conf. 4, Conf 5
St. 6	Market clearing	Approval and Market Clearing	The MO clears feasible trades and communicates the nominated orders to the SO and FSPs.	LFM	MO	SO, & FSP	Inf. 6	QoS.1, QoS.2, QoS.3 Sec. 1, Sec. 2, Sec.3, D.1, D.2, Conf.1, Conf.2, Conf. 3, Conf. 4, Conf 5, O.X
St. 7	Settlement	Settlement & Remuneration	The MO performs the settlement and communicates the results to the SO and FSPs.	LFM	MO	SO, & FSP	Inf. 7	QoS.1, QoS.2, QoS.3 Sec. 1, Sec. 2, Sec.3, D.1, D.2, Conf.1, Conf.2, Conf. 3, Conf. 4, Conf 5, O.X

5 Information exchanged

Information exchanged			
Information exchanged (ID)	***Name of information***	***Description of information exchanged***	***Requirement, R-IDs***
Inf. 1	Flexibility Request	Request submitted by SO for grid flexibility including amount, timeframe, and conditions.	QoS.1, QoS.2, QoS.4 Sec. 1, Sec. 2, Sec.3, D.1, D.2, Conf.1, Conf.2, Conf. 3, Conf. 4, Conf 5
Inf. 2	Flexibility Request Notification	Notification sent by MO to FSPs about the flexibility request from SO.	QoS.1, QoS.2, QoS.3 Sec. 2, Sec.3 Conf.1, Conf.2,
Inf. 3	Flexibility Offers	Offers submitted by FSPs in response to the flexibility request, including amount, price, and conditions.	QoS.1, QoS.2, QoS.3 Sec. 1, Sec. 2, Sec.3, D.1, D.2 Conf.1, Conf.2, Conf. 3, Conf. 4, Conf 5, O.X
Inf. 4	Financial Feasibility Check Results	Results of the financial feasibility checks conducted by MO.	QoS.1, QoS.2, QoS.3 Sec. 1, Sec. 2, Sec.3, D.1, D.2, Conf.1, Conf.2, Conf. 3, Conf. 4, Conf 5
Inf. 5	Network Feasibility Check Results	Results of the network feasibility checks conducted by MO.	QoS.1, QoS.2, QoS.3 Sec. 1, Sec. 2, Sec.3, D.1, D.2 Conf.1, Conf.2, Conf. 3, Conf. 4, Conf 5
Inf. 6	Market Results	Finalized flexibility offers approved by MO and communicated to SO and FSPs.	QoS.1, QoS.2, QoS.3 Sec. 1, Sec. 2, Sec.3, D.1, D.2, Conf.1, Conf.2, Conf. 3, Conf. 4, Conf 5, O.X
Inf. 7	Settlement Details	Details of settlement process and payments made to FSPs.	QoS.1, QoS.2, QoS.3 Sec. 1, Sec. 2, Sec.3, D.1, D.2, Conf.1, Conf.2, Conf. 3, Conf. 4, Conf 5, O.X

6 Requirements

Quality of Service Requirements		
Categories ID	**Category name for requirements**	**Category description**
QoS	Quality of Service	Generic properties that service/SUC should provide – quality attributes.

Requirement R-ID	Requirement name	Requirement description
QoS.1	Availability of information flows	Continuous availability not required but must be available at specific times or under specific conditions
QoS.2	Accuracy of data requirements	Adequate accuracy can be assumed
QoS.3	Frequency of data exchanges	Upon event
QoS.4	Frequency of data exchanges	Random

Security Requirements		
Categories ID	**Category name for requirements**	**Category description**
Sec	Security	Authentication of user, confidentiality, integrity, prevention of denial of service, non-repudiation or accountability, error management.
Requirement R-ID	**Requirement name**	**Requirement description**
Sec.1	Eavesdropping: Ensuring confidentiality, avoiding illegitimate use of data, and preventing unauthorized reading of data, is:	Quite important
Sec.2	Information integrity violation: Ensuring that data is not changed or destroyed is:	Crucial
Sec.3	Authentication and Access Control mechanisms commonly used with this data exchange	API Key / Access Token

Data Management Requirements		
Categories ID	**Category name for requirements**	**Category description**
D	Data Management	Type of data source, accuracy or validity of data, timeliness or timestamping of data, volume of data, synchronisation or consistency of data across different systems, timely access to data, validation of data across organisational boundaries, transaction management, naming, identification and formatting of data across different systems, maintenance of data and databases.
Requirement R-ID	**Requirement name**	**Requirement description**
D.1	Correctness of source data	Source data is always correct (e.g. by definition)
D.2	Up-to-date management	Received data must be up-to-date within seconds of source data changing

Discovery and Configuration Requirements		
Categories ID	**Category name for requirements**	**Category description**
Conf	Configuration	Locations, distances, communication layout, commonly used communication protocol media, network bandwidth, existing protocols, number of devices, systems, data volume, expected growth, etc.
Requirement R-ID	**Requirement name**	**Requirement description**
Conf.1	Number of Information Producers	Two to a few
Conf.2	Number of Information Receivers	Two to a few
Conf.3	Data exchange methods	Client-server
Conf.4	Communication access services requirements	Request-response
Conf.5	Commonly used communication protocol	Include here the communication protocols used for the information exchange.

Other Requirements		
Categories ID	**Category name for requirements**	**Category description**
O	Regulatory obligation related to privacy	2016/679 GDPR (General Data Protection Regulation)
Requirement R-ID	**Requirement name**	**Requirement description**
O.1	A name of the requirement.	Description of the requirement (this might be populated automatically from the repository, if the requirement has already been described in the external document before).
O.2	All constraints also apply.	Personal data may not be processed unless there is at least one legal basis to do so.
O.3	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.
O.4	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.
O.5	Data retention policy	Personal data may not be transferred to a third-party if the data subject did not agree and the third party provide appropriate safeguard.
O.X	All constraints also apply.	All requirements in this category.

7 Common Terms and Definitions

Common Terms and Definitions	
Term	**Definition**
FSP	Flexibility Service Provider
MO	Market Operator
SO	System Operator
LFM	Local Flexibility Marker

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

D2.2
Functional Specifications of the HEDGE-IoT system

|Annex Document 3 - Italian Pilot SUCs|

31/10/2024

PROJECT INFORMATION

Project Number	101136216		
Project Acronym	HEDGE-IoT		
Project Full title	Holistic Approach towards Empowerment of the Digitalization of the Energy Ecosystem through adoption of IoT solutions		
Project Start Date	01 January 2024		
Project Duration	42 months		
Funding Instrument	Horizon Europe Framework Programme	Type of action	HORIZON-IA HORIZON Innovation Actions
Call	HORIZON-CL5-2023-D3-01-15		
Topic	Supporting the green and digital transformation of the energy ecosystem and enhancing its resilience through the development and piloting of AI-IoT Edge-cloud and platform solutions		
Coordinator	European Dynamics Luxembourg SA		

DELIVERABLE INFORMATION

Deliverable No.	D2.2						
Deliverable Title	Functional Specifications of the HEDGE-IoT system – Annex Document 3 – Italian Pilot SUCs						
Work-Package No.	WP2						
Work-Package Title	Stakeholders' Requirements and System Specifications						
Lead Beneficiary	TRIALOG						
Main Author	Mattia Alfieri (APIO) Fabio Di Zazzo (ARETI) Gabriele Fedele (ARETI) And all Italian pilot members						
Other Authors	Léo Cornec (TRIALOG) Lenos Peratitis (ED) Aleksandra Raskovska (JSI)						
Due date	31/10/2024						
Deliverable Type	X	Document, Report (R)		Data management plan (DMP)		Websites, press & media action (DEC)	Other
Dissemination Level	X	Public (PU)		Sensitive (SEN)		Classified	
	PU: Public, fully open SEN: Sensitive, limited under the conditions of the Grant Agreement Classified R-UE/EU-R – EU RESTRICTED under the Commission Decision No2015/444 Classified C-UE/EU-C – EU CONFIDENTIAL under the Commission Decision No2015/444 Classified S-UE/EU-S – EU SECRET under the Commission Decision No2015/444						

Document Revision History

Version	Date	Description of change	List of contributor(s)
0.1	09/10/2024	Compilation of all the pilot SUCs	Léo Cornec (TRIALOG)
0.2	16/10/2024	Review by European Dynamics	Lenos Peratitis (ED)
0.3	23/10/2024	Review by Institut Jozefstefan	Aleksandra Raskovska (JSI)
1.0	29/10/2024	Final document version for integration to Deliverable D2.2	Léo Cornec (TRIALOG)

EXECUTIVE SUMMARY

This document is an annex of HEDGE-IoT deliverable D2.2 titled "Functional Specifications of the HEDGE-IoT system" document. It provides specifications for the System Use Cases (SUCs) of the pilot.

Each SUC was defined by pilot members, based on the corresponding Business Use Case (BUC) and the IEC 62559-2 template, with support from the task leader for the methodology.

This document will be updated later in the project based on additional work and feedback. For the HEDGE-IoT project, the following sections and subsections of the IEC 62559-2 template were defined as mandatory to be completed by the pilot demonstrators for the SUCs:

1. Description of the use case
    1.1. Name of the use case
    1.2. Scope and objectives of the use case
    1.3. Narrative of the use case
2. Diagrams of the use case
3. Technical details
    3.1. Actors
4. Step-by-step analysis of use case
    4.1. Overview of scenarios
    4.2. Steps - scenarios
5. Information exchanged
6. Requirements

The following table links the BUCs and the SUCs of the pilot:

BUC ID & BUC name	SUC ID	SUC name
BUC-IT-01 Energy flow optimisation with dynamic grid limits	SUC-IT-01.1	Energy community power management
	SUC-IT-01.2	Energy community performance forecasting
BUC-IT-02 Flexibility provided by Energy Community to solve a local congestion	SUC-IT-02.1	Grid behaviour forecasting
	SUC-IT-02.2	Grid congestion computing
	SUC-IT-02.3	Localized weather forecast

1 SUC-IT-01.1 – ENERGY COMMUNITY POWER MANAGEMENT

1 Description of the use case

1.1 Name of the use case

ID	Area / Domain(s) / Zones(s)	Name of Use Case
SUC-IT-01.1	Distribution Grid & Flexibility Service Provider Platform	Energy community power management

1.2 Version management

Version Management			
Version No.	**Date**	**Name of Author(s)**	**Changes**
V0.1	22.05.2024	Mattia Alfieri, Apio	First Version
V0.2	28.06.2024	Mattia Alfieri, Apio	Final Version
V0.3	29.07.2024	Mattia Alfieri, Apio	Edits after first review
V1.0	01.10.2024	Mattia Alfieri, Apio	Edits after second review

1.3 Scope and objectives of use case

Scope and Objectives of Use Case	
Scope	Optimizing Energy Community's power management through BTM, EMS, Baseline and market data
Objective(s)	- **OBJ 1**: Provide more accurate power management to energy community administrators - **OBJ 2**: Include social and market parameters in power management
Related business case(s)	BUC-IT-1

1.4 Narrative of use case

Narrative of Use Case
Short description
A classical approach to power management of Behind-The-Meter (BTM) assets relies on a local power manager who has visibility only over local resources. An EC-wide application, leveraging data from multiple sources, such as power managers, EMS, baselines and market, can implement smarter power management policies across the energy community, addressing not only technical parameters but also market-based and social parameters.
Complete description
Within energy communities, the role of power management systems is comprehensive of several goals, from energy flow optimizations to maximizing renewable energy production, demand response, storage management, efficiency and cost reduction. Typically, these systems manage individual household or consumption site, and are aware only of one production plant. A centralized, energy community wide power management solution would allow to manage energy flows not only locally (e.g. optimizing self-consumption for individual members) but also globally. For this example, the system could maximize the self-consumption of the entire energy community, or manage demand-response signals for multiple members of the energy community.

This unified approach could significantly simplify the energy community administration, by providing a single interface for:

- Configuring Energy Community assets
- Configuring the EC optimization algorithms, considering
    - Economic parameters
    - Energy-flow related parameters
    - Social parameters (granting privileges to vulnerable members)
- Generating the activations and forwarding them to the DERs
- Monitor the behaviour of DERs and the aggregated behaviour of ECs.

This scenario will be implemented by developing software tools to enable Flexibility Service Provider's operations in managing the energy community's assets. This component will be capable of receiving data from DERs, configuring Energy Community assets and generating activation setpoints. The software will be implemented as a cloud-native platform, utilizing containerized microservices that can be run either on the cloud or on-premises. Those services will expose functionalities and data as REST JSON APIs.

The main steps to be implement within this use case are:

- **Behind-The-Meter (BTM) resources identification**: Each in-scope device available in the energy community will be registered in the Energy Community Platform
- **BTM resources interfacing**: Device data can be gathered from the field directly, or by using the manufacturer's data channels
- BTM resources data is normalized with the appropriate ontology
- Baseline and other data external from the EC Platform must be collected on the EC Platform
- Optimization algorithms must be developed on the EC Platform to produce optimal activation setpoints
- Setpoint dispatch channels must be in place
- Reports and data analysis interfaces must be available on the User Interface for the Energy Community Admin.

The use case relies on several software platforms as well as hardware devices:

- **Blockchain Access Layer:** An IoT Platform used to receive main meter data coming from the enrolled resources within the energy communities. The platform also timestamps measurements and sends them to the Flexibility Register
- **FSP Platform:** A platform that receives data from behind-the-meter resources and assists the FPS in the management of the energy community and the creation of setpoints (to be developed in the context of this use case)
- **Flexibility Register**: A cloud platform that acts as central registry for measurements, DERs, and activations.
- **DERs hardware:** Resources must be interfaced with hardware capable of acquiring local data and forwarding it to the Blockchain Access Layer.

1.5 Key performance indicators (KPIs)

ID	Name	Description	Reference to mentioned use case objectives
KPI 10	*Number of consumers engaged with flexibility services*	>=1 Energy Communities engaged. At least 6 consumers and at least one vulnerable member.	OBJ 1
KPI 5	*Open source released developments related to data connector implementations*	**Every connector** released as open source as soon as it is developed	We plan to release all implemented connector as open source, and to "build it in public" by leveraging public repositories
KPI 9	*Flexibility unlocked and transacted in markets*	Increase participation in flexibility markets	Our solution will allow energy communities to participate in energy flexibility markets

1.6 Use case conditions

Use case conditions
Assumptions
Prerequisites
• Instrumenting enough members from energy communities • Instrumenting both producers and consumers • Identify at least one vulnerable user within an energy community

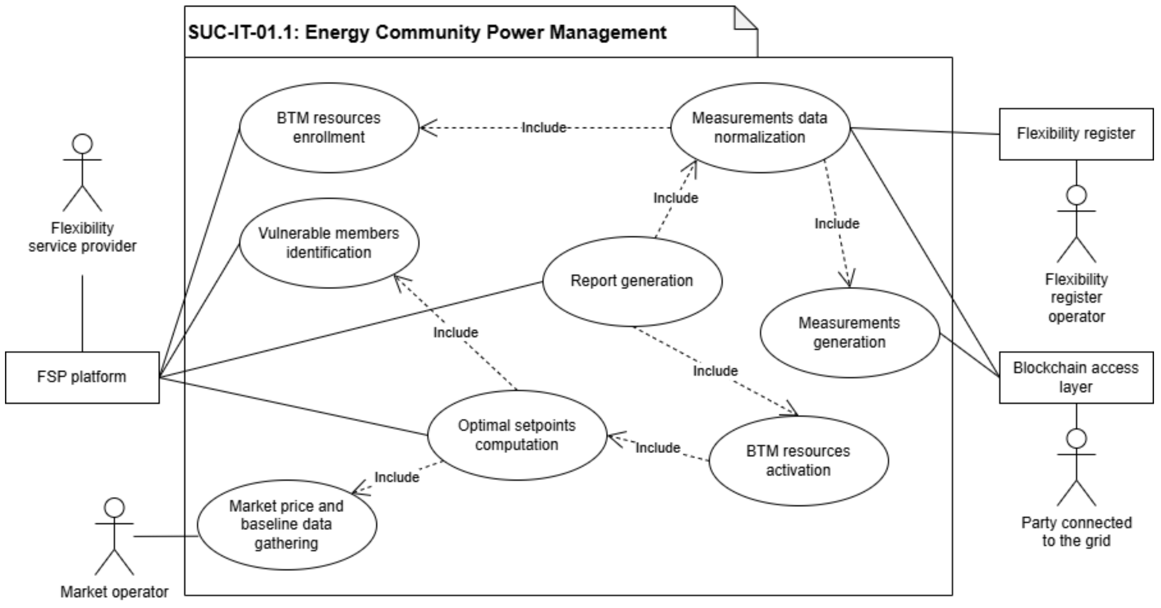
1.7 Further IInformation to the use case for classification / mapping

Classification Information
Relation to other use cases
BUC-IT-01 SUC-IT-02
Level of depth
Prioritisation
Generic, regional or national relation
Nature of the use case
Further keywords for classification

1.8 General Remarks

General Remarks

2 Diagrams of use case

Diagram(s) of use case
 FIGURE 1: UML USE CASE DIAGRAM

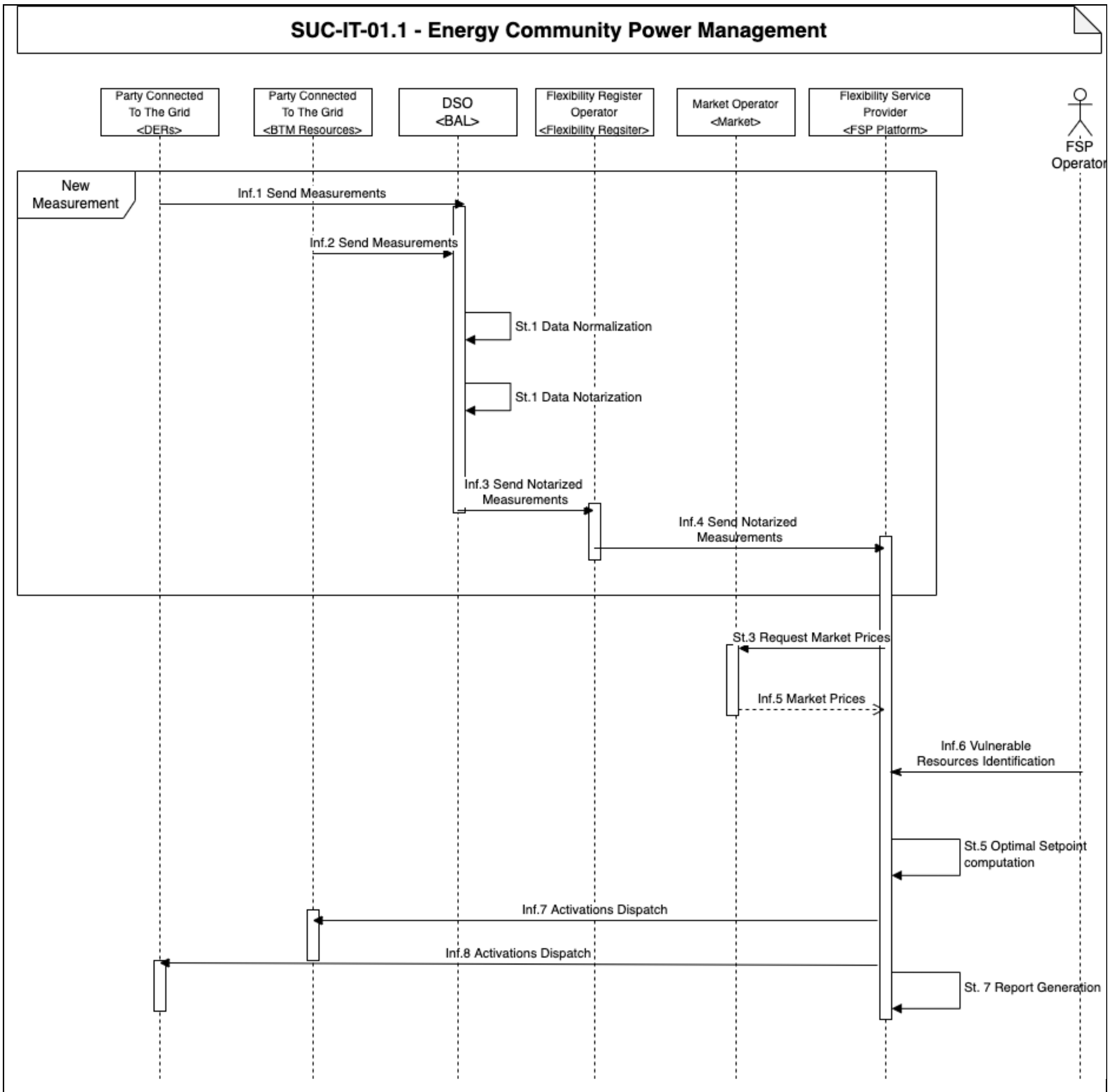


FIGURE 2: UML SEQUENCE DIAGRAM

3 Technical details

3.1 Actors

Actors			Further information specific to this use case
Actor Name	***Actor Type***	***Actor Description***	
DSO	Business Actor	A party responsible for operating, ensuring the maintenance of and, if necessary, developing the system in a given area and, where applicable, its interconnections with other systems, and for ensuring the long-term ability of the system to meet reasonable demands for the distribution of energy.	Areti

Flexibility Register Operator	Operator	Administrator of all the information that is stored in the Flexibility Register. Responsible for allocating access rights to the various actors and controlling the level of access. Stores flexibility assets, results of qualification (both product and grid), stores market results, grid information, aggregates flexibility information and stores the results of the settlement. Forwards activation signals to flexibility assets upon request of the SOs. The Flexibility operator should be a trusted authority due to the sensitivity level of the information being handled.	Areti
Flexibility Service Provider	Business Actor	A party that offers flexibility services based on acquired (aggregated) resources.	Acea Energia
Market Operator	Logical Actor	A party that provides a service whereby the offers to sell energy are matched with bids to buy energy.	-
Party Connected to the Grid	Business Actor	A party that contracts for the right to take out or feed in energy at a Point of Delivery (PoD).	Energy Community Members

3.2 References

References						
No.	***Reference Type***	***Reference***	***Status***	***Impact on use case***	***Originator / organisation***	***Link***

4 Step by step analysis of use case

4.1 Overview of scenarios

Scenario conditions						
No.	**Scenario name**	**Scenario description**	**Primary actor**	**Triggering event**	**Pre-condition**	**Post-condition**
Sc.1	Flexibility Offers	The FSP Operator, who wants to respond to a flexibility request by the DSO, leverages technical, economic and social data to compute and dispatch optimal setpoints to DERs.	Flexibility Service Provider	Flexibility Request is generated by the DSO	-	The minimum amount of resources are enrolled in the platform

4.2 Steps – Scenarios

Scenario								
Scenario name:		Flexibility Offers						
Step No.	Event	Name of process/ activity	Description of process/ activity	Service	Information producer (actor)	Information receiver (actor)	Information Exchanged (IDs)	Requirement, R-IDs
St.1	Measurements are published from the DERs to the BAL	Measurement normalization	The BAL Platform normalizes measurements data generated by DERs	CHANGE	Party Connected to the Grid	DSO	Inf. 3	R1,R2,R3,R4, R5,R6
St.2	Measurements are notarized on blockchain	Measurements notarization	The BAL notarizes normalized measurements on the blockchain	CHANGE	DSO	DSO	Inf. 3	R1,R2,R3,R4, R5,R6
St.3	The FSP operator requests data	Market price and Baseline data Gathering	The FSP Platform fetches data from external sources, such as the Market and the Flexibility Register, in order to obtain the information required for optimizing setpoints.	GET	Market Operator	Flexibility Service Provider	Inf.4 Inf. 5	R1,R2,R3,R4, R6,R7,R8
St.4	FSP Operator has market price and baseline data	Vulnerable resources identification	The FSP Operator uses social parameters to identify vulnerable resources within the energy community	CREATE	Flexibility Service Provider	Flexibility Service Provider	Inf. 2	R1,R2,R3,R4, R6,R7,R8

St.5	Flexibility Request generation	Optimal Setpoint Computation	The FSP operator uses the FSP Platform to compute optimal setpoints	CREATE	Flexibility Service Provider	Flexibility Service Provider	Inf. 6	R1,R5,R6,R7, R8
St.6	Optimal setpoint computation	BTM resources activation	The FSP operator finalizes activations and dispatches them to DERs	REPORT	Flexibility Service Provider	Party Connected to the Grid	Inf. 6	R1,R5,R6,R7, R8
St.7	Scheduled	Report Generation	A periodic report is generated on the FSP platform to highlight KPIs	CREATE	Flexibility Service Provider	Flexibility Service Provider	Inf. 7	R4,R6,R7,R8

5 Information exchanged

Information exchanged			
Information exchanged (ID)	***Name of information***	***Description of information exchanged***	***Requirement, R-IDs***
Inf.1	DERs measurements	The real-time data collected from DERs	R1,R2,R3,R4,R5,R6
Inf.2	DERs measurements	The real-time data collected from DERs	R1,R2,R3,R4,R5,R6
Inf.3	Notarized DERs measurements	The real-time data collected from DERs, notarized by Blockchain Access Layer	R1,R2,R3,R4,R5,R6
Inf.4	Notarized DERs measurements	The real-time data collected from DERs, notarized by Blockchain Access Layer and propagated by Flexibility Register	R1,R2,R3,R4,R5,R6
Inf.5	Market prices	Pricing information provided by the market	R1,R2,R3,R4,R6,R7,R8
Inf.6	Vulnerable resources list	Resources eligible as vulnerable	R1,R2,R3,R4,R5,R7
Inf.7	Activations Dispatch	List of time-indexed target power output or consumption levels assigned to DERs	R1,R5,R6,R7,R8
Inf.8	Activations Dispatch	List of time-indexed target power output or consumption levels assigned to DERs	R1,R5,R6,R7,R8
Inf.9	Report	A summary of a DER's behaviour over a specific period, detailing power setpoint activations and responses to flexibility requests from the DSO	R4,R6,R7,R8
Inf.10	Baseline	The expected power output or consumption profile of a DER	R2,R4,R5,R6,R7,R8

6 Requirements

Requirements		
Categories ID	**Category name for requirements**	**Category description**
Requirement R-ID	**Requirement name**	**Requirement description**
R1	Availability of information flows	Quality of Service (QoS) Issues: • 90% + availability - Allowed outage: 1 month per year
R2	Management of accessing different types of data to be exchanged	Data Management Issues Possible values: • Each data exchange could entail different types of data (e.g. query a database) • Data and models are exchanged every few minutes
R3	Frequency of data exchanges	Quality of Service (QOS) Issues: • Periodicity greater than a few seconds • Upon event

		• Upon request
R4	Management of data across organizational boundaries	Data Management Issues Possible values: • Data is previously stored across organizational boundaries • Data is previously stored across organizational departmental boundaries • Data is previously stored across boundaries between system developed by different vendors
R5	Validation of data exchanges	Data Management Issues - Data and models should be validated.
R6	Management of large volumes of data that are being exchanged	Data Management Issues The solution facilitates the utilization and management of large models along with their dependencies.
R7	Up-to-date management	Data Management Issues Received data must be up-to-date within minutes of source data change.
R8	Correctness of source data	Data Management Issues The solution enables data accuracy verification.

7 Common Terms and Definitions

Common Terms and Definitions	
Term	**Definition**
DER(s)	Distributed Energy Resource(s)
BTM	Behind The Meter
DSO	Distribution system operator
FSP	Flexibility Service Provider
BAL	Blockchain Access Layer
FR	Flexibility Register

2 SUC-IT-01.2 – ENERGY COMMUNITY PERFORMANCE FORECASTING

1 Description of the use case

1.1 Name of the use case

ID	*Area / Domain(s) / Zones(s)*	*Name of Use Case*
SUC-IT-01.2	Distribution Grid & Flexibility Service Provider Platform	Energy community performance forecasting

1.2 Version management

Version Management			
Version No.	*Date*	*Name of Author(s)*	*Changes*
V0.1	22.05.2024	Mattia Alfieri, Apio	First Draft
V0.2	28.06.2024	Mattia Alfieri, Apio	Final Version
V0.3	29.07.2024	Mattia Alfieri, Apio	Edits after first review
V1.0	01.10.2024	Mattia Alfieri, Apio	Edits after second review

1.3 Scope and objectives of use case

Scope and Objectives of Use Case	
Scope	Improving Energy Community performances by continuous performances analysis and forecasting of the BTM resources' output
Objective(s)	- OBJ 1: Improve EC performances
Related business case(s)	BUC-IT-1

1.4 Narrative of use case

Narrative ofUse Case
Short description
The Energy Community Platform can leverage measurements coming from BTM assets, such as inverters, energy meters and sun-meters, to analyze the performances of each production plant and apply learning models to performs production and load forecasts using locally produced data.
Complete description
The Energy Community Platform can leverage measurements generated by BTM resources, such as inverters, sun-meters and storage, to perform comprehensive analysis of each site's performance. The analysis of the Performance Ratio of each plant can provide useful macro-level information about the plant's performance and provide an early indication of possible improvements on the equipment or on the setup. Furthermore, analyzing inverter's currents can lead to finding out which modules are under performing due to wear or require maintenance and cleaning. These parameters can be monitored in real-time and compared to threshold values to trigger corrective actions.

Details about the deployed resources can also be used to generate continuous forecasts, which can be used as benchmarks for the current state of the site and, at the same time, provide information useful for planning. Energy Community Administrators will be able to access this data from a dedicated User Interface, which will provide KPIs, forecasts, anomalies and basic asset management features for each plant. This scenario will be implemented by developing software tools on top of the platform built for SUC-IT-01.1. The platform's capabilities will be expanded with continuous forecasts performances for the EC, along with KPIs and anomalies computations to assist the EC management. The software will be implemented as a cloud native platform, using containerized microservices that can be run on cloud or on premises. Those services will expose functionalities and data as REST JSON APIs. The main steps to implement this use case are: - **BTM resources identification:** Each in-scope device within the energy community will be registered in the Energy Community Platform - **BTM resources interfacing:** Devices data can be gathered from the field directly, or by using the manufacturer's data channels - BTM resource data is normalized with the appropriate ontology - Once time series data collection is in place, Performance analysis algorithm must be implemented to compute the wanted KPIs. The same must be done for inverter's string analysis - BTM Data can be used to generate forecasts and benchmarks - Reports and anomaly detection can be accessed by the Energy Community Administrator directly within the Energy Community Platform. The use case relies on several software platforms as well as hardware devices: - **Blockchain Access Layer:** an IoT Platform used to receive main meter data coming from the enrolled resources within energy communities. The platform timestamps measurements and sends them to the Flexibility Register - **FSP Platform:** A platform that receives data from behind-the-meter resources and assists the FPS in the management of the energy community and the creation of setpoints. (To be extended in the context of this use case) - **Flexibility Register**: A cloud platform that acts as central registry for measurements, DERs, and activations. **DERs hardware:** Resources must be interfaced with hardware capable of acquiring local data and of forwarding it to the Blockchain Access Layer.

1.5 Key performance indicators (KPIs)

ID	***Name***	***Description***	***Reference to mentioned use case objectives***
KPI 8	*IoT/Edge/Fog sites uptime and availability*	> 99% Uptime and Availability	OBJ 1
KPI5	*Open source released developments related to data connector implementations*	**Every connector** released as open source as soon as it is developed	We plan to release any connector implemented as open source, and to "build it in public" by leveraging public repositories

1.6 Use case conditions

Use case conditions
Assumptions
Prerequisites
• Instrumenting enough members from energy communities (Producers/Prosumers)

1.7 Further information to the use case for classification / mapping

Classification Information
Relation to other use cases
BUC-IT-01 SUC-IT-01
Level of depth
Prioritisation
Generic, regional or national relation
Nature of the use case
Further keywords for classification

1.8 General Remarks

General Remarks

2 Diagrams of use case

Diagram(s) of use case

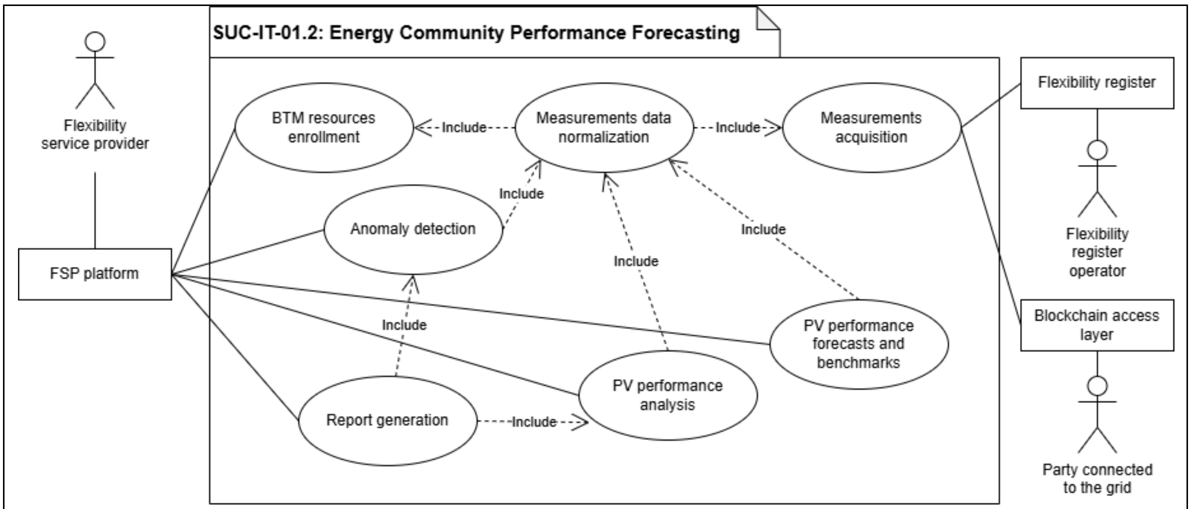


FIGURE 2: UML USE CASE DIAGRAM

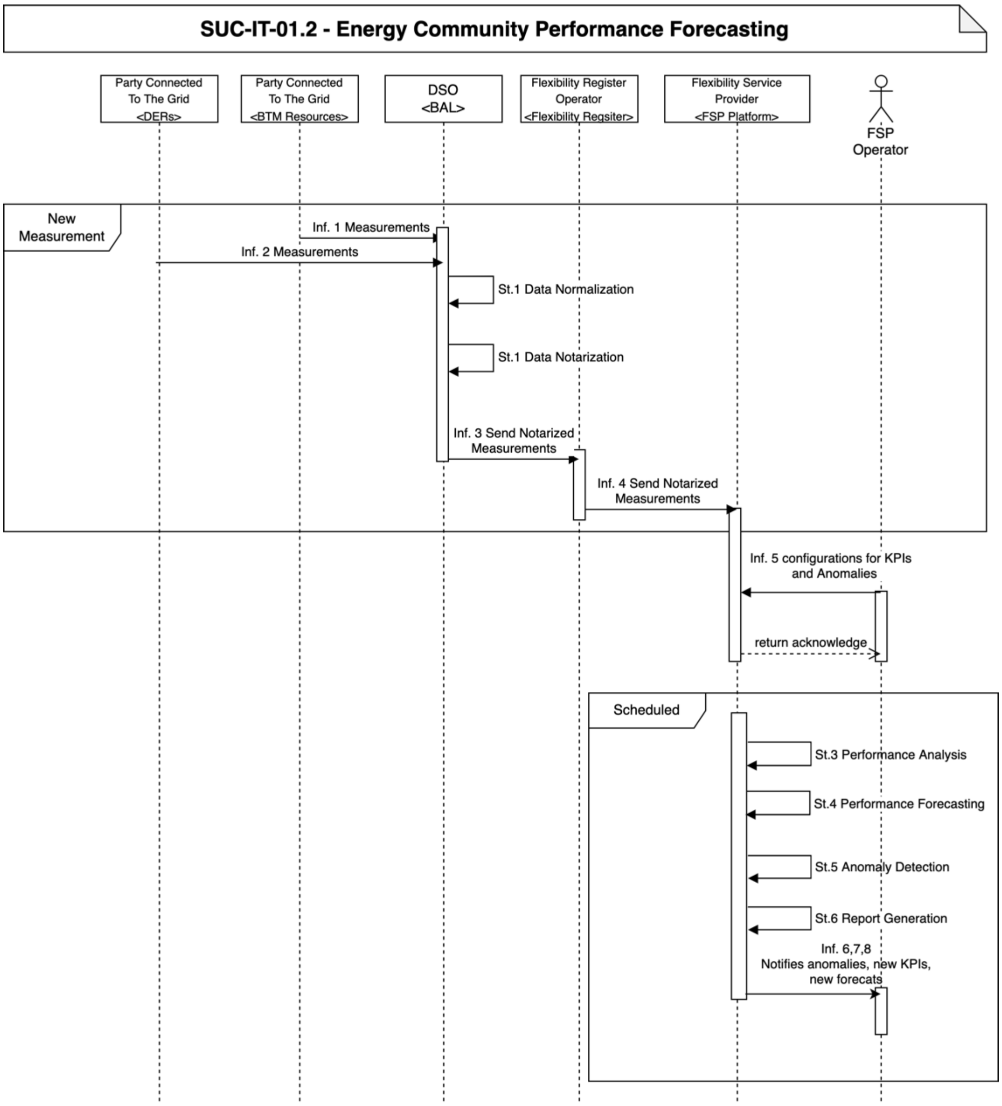


FIGURE 2: UML SEQUENCE DIAGRAM

3 Technical details

3.1 Actors

Actors			
Actor Name	***Actor Type***	***Actor Description***	***Further information specific to this use case***
DSO	Business Role (HEMRM)	A party responsible for operating, ensuring the maintenance of and, if necessary, developing the system in a given area and, where applicable, its interconnections with other systems, and for ensuring the long-term ability of the system to meet reasonable demands for the distribution of energy.	Areti
Flexibility Register Operator	Business Role	Administrator of all the information that is stored in the Flexibility Register. Responsible for allocating access rights to the various actors and controlling the level of access. Stores flexibility assets, results of qualification (both product and grid), stores market results, grid information, aggregates flexibility information and stores the results of the settlement. Forwards activation signals to flexibility assets upon request of the SOs. The Flexibility operator should be a trusted authority due to the sensitivity level of the information being handled.	Areti
Flexibility Service Provider	Business Role (HEMRM)	A party that offers flexibility services based on acquired (aggregated) resources.	Acea Energia
Market Operator	Business Role (HEMRM)	A party that provides a service whereby the offers to sell energy are matched with bids to buy energy.	-
Party Connected to the Grid	Business Role (HEMRM)	A party that contracts for the right to take out or feed in energy at Point of Delivery (PoD).	Energy Community Members

3.2 References

References						
No.	***Reference Type***	***Reference***	***Status***	***Impact on use case***	***Originator / organisation***	***Link***

4 Step by step analysis of use case

4.1 Overview of scenarios

Scenario conditions						
No.	**Scenario name**	**Scenario description**	**Primary actor**	**Triggering event**	**Pre-condition**	**Post-condition**
Sc.1	Flexibility Offers	The FSP Operator, who wants to maximizes the performances of the DERs within an Energy Community, uses analytical tools to forecast and analyze DERs behaviour.	Flexibility Service Provider	–	DERs are enrolled and instrumented to produce measurement for a reasonable amount of time.	Forecasts and Performance analysis are available.

4.2 Steps – Scenarios

Scenario								
Scenario name:	Flexibility Offers							
Step No.	***Event***	***Name of process/ activity***	***Description of process/ activity***	***Service***	***Information producer (actor)***	***Information receiver (actor)***	***Information Exchanged (IDs)***	***Requirement, R-IDs***
St.1	Measurements are published from the DERs to the BAL	Measurement normalization	The BAL Platform normalizes measurement data generated by DERs	CHANGE	Party Connected to the Grid	DSO	Inf.1 Inf.2	R1,R2,R3,R4,R5,R6
St.2	Measurements are notarized on blockchain	Measurements notarization	The BAL notarizes normalized measurements on the blockchain	CHANGE	DSO	DSO	Inf.3	R1,R2,R3,R4,R5,R6
St.3	Measurements are available on the FSP Platform	Performance Analysis	The FSP Platform analyses DER data and the operator receives KPIs	CREATE	Flexibility Service Provider	Flexibility Service Provider	Inf.3	R1,R2,R3,R6,R7
St.4	Enough Measurements are available as well as resources static data	Performance Forecasting	The FSP Platform performs performances forecasting using measurement data. The FSP operator can use these forecasts to act.	CREATE	Flexibility Service Provider	Flexibility Service Provider	Inf.4	R1,R2,R3,R6,R7
St.5	Measurements are available on the FSP Platform, as well as forecasts	Anomaly Detection	The FSP Platform alerts operators of current of foreseen anomalies	REPORT	Flexibility Service Provider	Flexibility Service Provider	Inf.5	R1,R2,R3,R6,R7
St.6	Scheduled	Report Generation	A periodic report is generated on the FSP platform to highlight KPIs	CREATE	Flexibility Service Provider	Flexibility Service Provider	Inf.3 Inf.4 Inf.5	R1,R2,R3,R4,R5,R7,R8, R6

5 Information exchanged

Information exchanged			
Information exchanged (ID)	***Name of information***	***Description of information exchanged***	***Requirement, R-IDs***
Inf. 1	DERs measurements	The real-time data collected from DERs	R1,R2,R3,R4,R5,R6
Inf. 2	DERs measurements	The real-time data collected from DERs	R1,R2,R3,R4,R5,R6
Inf. 3	DERs measurements	The real-time data collected from DERs, notarized and normalized by Blockchain Access Layer	R1,R2,R3,R4,R5,R6
Inf. 4	DERs measurements	The real-time data collected from DERs, notarized and normalized by Blockchain Access Layer and propagated by Flexibility Register	R1,R2,R3,R4,R5,R6
Inf. 5	Configuration	Configuration for KPIs and Anomalies	R1,R2,R3,R6,R7
Inf. 6	KPIs / Performance Analysis	KPIs and benchmarks computed using DERs measurements	R1,R2,R3,R6,R7
Inf. 7	Forecasts	Forecasts for measurements, KPIs and benchmarks	R1,R2,R3,R6,R7
Inf. 8	Anomalies	Anomalies about real time data, historical data and forecasted data	R1,R2,R3,R6,R7

6 Requirements

Requirements		
Categories ID	**Category name for requirements**	**Category description**
Requirement R-ID	**Requirement name**	**Requirement description**
R1	Availability of information flows	Quality of Service (QoS) Issues: • 90% + availability – Allowed outage: 1 month per year
R2	Management of accessing different types of data to be exchanged	Data Management Issues - Data and models are exchanged every few minutes.
R3	Frequency of data exchanges	Quality of Service (QOS) Issues: • Periodicity greater than a few seconds • Upon event • Upon request.
R4	Management of data across organizational boundaries	Data Management Issues • Data is previously stored across organizational departmental boundaries. • Data is previously stored across boundaries between system developed by different vendors.
R5	Validation of data exchanges	Data Management Issues Data and models should be validated.

R6	Management of large volumes of data that are being exchanged	Data Management Issues The solution facilitates the utilization and management of large models along with their dependencies.
R7	Up-to-date management	Data Management Issues • Received data must be up-to-date within seconds of source data change.
R8	Correctness of source data	Data Management Issues The solution enables data accuracy verification.

7 Common Terms and Definitions

Common Terms and Definitions	
Term	**Definition**
DER(s)	Distributed Energy Resource(s)
BTM	Behind The Meter
DSO	Distribution System Operator
FSP	Flexibility Service Provider
BAL	Blockchain Access Layer
FR	Flexibility Register

3 SUC-IT-02.1 – GRID BEHAVIOUR FORECASTING

1 Description of the use case

1.1 Name of the use case

ID	Area / Domain(s) / Zones(s)	Name of Use Case
SUC-IT-02.1	Distribution Grid & Flexibility Service Provider Platform	Grid behaviour forecasting

1.2 Version management

Version Management			
Version No.	**Date**	**Name of Author(s)**	**Changes**
V0.1	24.05.2024	Fabio Di Zazzo (Areti)	First version
V0.2	30.07.2024	Fabio Di Zazzo (Areti)	Edits after first review
V0.3	28.08.2024	Fabio Di Zazzo (Areti)	Edits after second review
V0.4	25.09.2024	Fabio Di Zazzo (Areti)	Edits after third review; new requirements guidelines

1.3 Scope and objectives of use case

Scope and Objectives of Use Case	
Scope	Combine readings from DSO, EC and consumers in order to increase the grid behaviour model's accuracy
Objective(s)	- OBJ1: Enhanced behaviour prediction for both energy production and consumption based on near-real time data
Related business case(s)	BUC-IT-2

1.4 Narrative of use case

Narrative of Use Case
Short description
The goal of this use case is to predict power grid behaviour with a focus on energy production and consumption. Data from substations, BTM (behind the meter) reading, and sensors along power lines can be aggregated in analytics platforms. Substation data reveals macro trends in energy production and distribution, while smart meter data offers granular insights into consumption patterns. Sensors monitor real-time conditions and detect anomalies. Analysing this data with machine learning algorithms allows for accurate demand forecasting and optimized production scheduling. This comprehensive approach helps ensure a stable, efficient energy supply by pre-emptively addressing potential issues and enhancing overall grid reliability.
Complete description
The DSO's ADMS platform provides a forecasting tool designed to predict the expected behaviour of grid elements (line, producers, consumers) based on its historical readings, combined with the

current grid topology and weather forecast. This is achieved by considering current grid topology and weather forecasts at regular intervals. with the data from heterogeneous data sources on the grid ingested whenever available. All data is combined to provide short and mid-term forecasts, usable by both users and as input for other systems. Metering data is collected with 15-minute granularity, exposed by the metering platform and transmitted via PowerLine communication through the Chain1/2 protocol. Substation and line data are collected from both analog sensors and substation IEDs, based on an open-source Eclipse IoT technology stack. Every data point is then used to refine an ML model designed to predict the grid's elements behaviour, with the results made available through REST APIs. Input: DSO sensor data, Meter data, EC data. Output: Forecasted production, consumption and/or load for every data-producing element.

1.5 Key performance indicators (KPIs)

ID	Name	Description	Reference to mentioned use case objectives
KPI 11	*Increased grid operational*	Better prediction leads to an increased capacity to address and avoid overloads and other critical scenarios.	OBJ1
KPI 12	*Faster application response times*	Faster prediction of grid behaviour allows more operational time to address critical scenarios.	OBJ1

1.6 Use case conditions

Use case conditions
Assumptions
Prerequisites
(Near) real time data from PoDs is available; Sensor distribution in both lines and substations is granular enough to provide sufficient data for the forecast model; The clock between the different systems is synchronized with accuracy on seconds.

1.7 Further information to the use case for classification / mapping

Classification Information
Relation to other use cases
Linked to SUC-IT-02.2: • Provides load and production forecast for the grid Linked to SUC-IT-02.3: • Consumes weather forecasts to better predict PV production and consumer's behaviour
Level of depth
Prioritisation
Generic, regional or national relation

Nature of the use case
Further keywords for classification

1.8 General Remarks

General Remarks

2 Diagrams of use case

Diagram(s) of use case

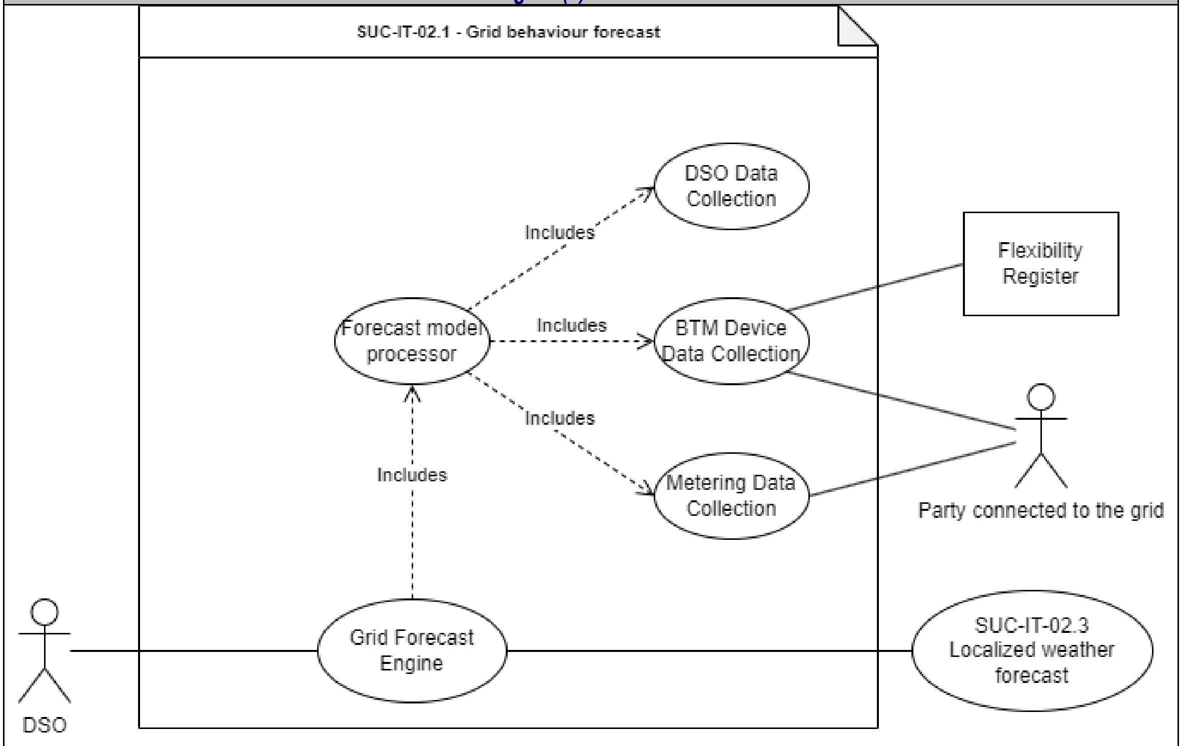


FIGURE 3: UML USE CASE DIAGRAM

3 Technical details

3.1 Actors

Actors			
Actor Name	*Actor Type*	*Actor Description*	*Further information specific to this use case*
DSO	Business Role (HEMRM)	A party responsible for operating, ensuring the maintenance of and, if necessary, developing the system in a given area and, where applicable, its interconnections with other systems, and for ensuring the long-term ability of the system to meet reasonable demands for the distribution of energy	Areti
Flexibility Register	Logical Role	Stores flexibility assets, results of qualification (both product and grid), stores market results, grid information, aggregates flexibility information and stores the results of the settlement. Forwards activation signals to flexibility assets upon request of the SOs.	
Party Connected to the Grid	Business Role	A party that contracts for the right to take out or feed in energy at Point of Delivery (PoD).	Contributes data from both metering and BTM devices.

3.2 References

References						
No.	*Reference Type*	*Reference*	*Status*	*Impact on use case*	*Originator / organisation*	*Link*

4 Step by step analysis of use case

4.1 Overview of scenarios

Scenario conditions						
No.	**Scenario name**	**Scenario description**	**Primary actor**	**Triggering event**	**Pre-condition**	**Post-condition**
Sc.1	BTM Data collection	Data is uploaded from BTM devices to DSO's central systems to refine the grid forecast model	Party Connected to the Grid	Scheduled	BTM Device is installed and connected	Production capacity and consumption are sent to the DSO
Sc.2	DSO Data collection	Data is uploaded from sensors in substations and/or lines to DSO's central system to refine the grid forecast	DSO	Line and/or substation sensors data is available	Sensors and measurement devices are installed in substations and/or lines and connected	Grid status is observed and sent to DSO's central systems
Sc.3	Load and production forecast	Data from BTM, metering, lines, substation is	DSO	Scheduled	BTM Data, DSO sensors data, grid topology	The Load & Forecast tool

		integrated into a ML model able to predict the behaviour of data-producing elements			and weather forecast are available	acquires the measurements from the meter and runs the algorithm to foresee the consumption and the production

4.2 Steps – Scenarios

Scenario								
Scenario name:		Sc.1 BTM Data collection						
Step No.	***Event***	***Name of process/ activity***	***Description of process/ activity***	***Service***	***Information producer (actor)***	***Information receiver (actor)***	***Information Exchanged (IDs)***	***Requirement, R-IDs***
St.1	Schedule and/or reading need(s) to be performed	Send signed measurements	BTM Device signs the collected readings and forwards them to the Blockchain Access Layer	REPORT	Party connected to the grid	DSO	Inf. 1	QoS.2; QoS.3; QoS.5; Sec.1; Sec.2; Sec.3; Sec.5; D.1; D.4; Conf.1; Conf.2; Conf.3; Conf.6; Conf.7; O.2
St.2	Data from step 1 is received	Verifies signatures	The BAL verifies the signatures from the received measurements	EXECUTE	DSO	DSO	x	QoS.2; QoS.3; QoS.5; Sec.1; Sec.2; Sec.3; Sec.5; D.1; D.4; Conf.1; Conf.2; Conf.3; Conf.6; Conf.7; O.2
St.3	Step 2 is completed	Notarized signatures	The BAL notarized the measurements via blockchain publication	EXECUTE	DSO	DSO	x	QoS.2; QoS.3; QoS.5; Sec.1; Sec.2; Sec.3; Sec.5; D.1; D.4; Conf.1; Conf.2; Conf.3; Conf.6; Conf.7; O.2
St.4	Step 3 is completed	Dispatch measurement	The BAL dispatches the measurements to the Flexibility Register	REPORT	DSO	Flexibility Register	Inf. 2	QoS.2; QoS.3; QoS.5; Sec.1; Sec.2; Sec.3; Sec.5; D.1; D.4; D.6; Conf.1; Conf.2; Conf.3; Conf.6; Conf.7; O.2
St.5	Data from step 4 is received	Measurement sanity check	Flexibility Register Performs Data Quality Checks	EXECUTE	Flexibility Register	Flexibility Register	x	QoS.2; QoS.3; QoS.5; Sec.1; Sec.2; Sec.3; Sec.5; D.1; D.4; D.6; Conf.1; Conf.2; Conf.3; Conf.6; Conf.7; O.2
St.6	Step 5 is completed	Dispatched measurements	The Flexibility Register dispatches the validated measurements to the ADMS's Forecast Engine	REPORT	Flexibility Register	DSO	Inf. 3	QoS.2; QoS.3; QoS.5; Sec.1; Sec.2; Sec.3; Sec.5; D.1; D.4; Conf.1; Conf.2; Conf.3; Conf.6; Conf.7; O.2
St.7	Data from	Persistence	Data is persisted	CREATE	DSO	DSO	x	QoS.2; QoS.3; QoS.5;

	step 6 is received							Sec.1; Sec.2; Sec.3; Sec.5; D.1; D.4; Conf.1; Conf.2; Conf.3; Conf.6; Conf.7; O.2
St.8	Step 7 is completed	Measures integrated into forecast model	Newly received measurements are integrated into the forecast model	EXECUTE	DSO	DSO	x	QoS.2; QoS.3; QoS.5; Sec.1; Sec.2; Sec.3; Sec.5; D.1; D.4; Conf.1; Conf.2; Conf.3; Conf.6; Conf.7; O.2
St.9				REPEAT(1-8)				

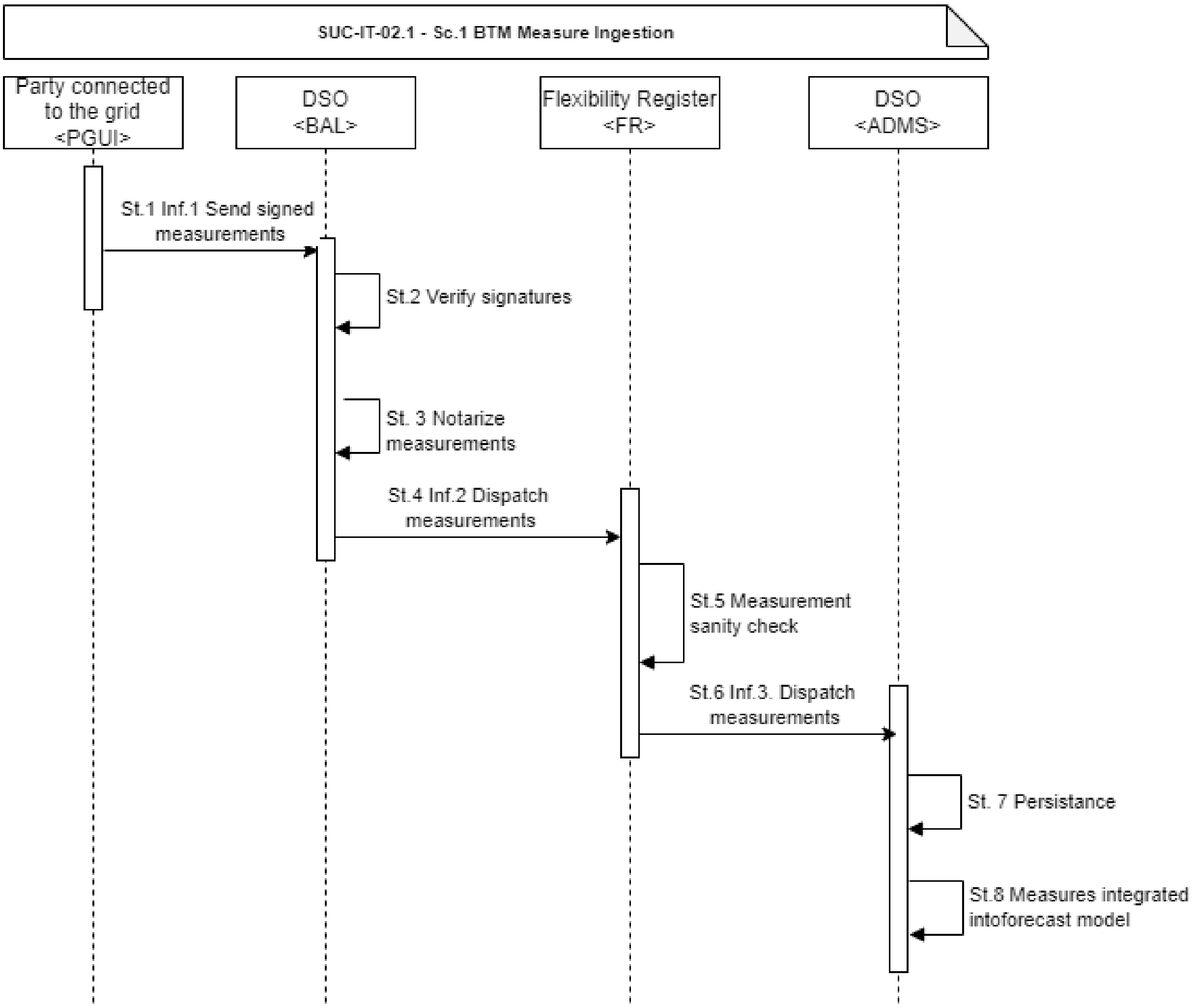


FIGURE 4: SC.1 UML SEQUENCE DIAGRAM

Scenario								
Scenario name:		Sc.2 DSO Data collection						
Step No.	**Event**	**Name of process/ activity**	**Description of process/ activity**	**Service**	**Information producer (actor)**	**Information receiver (actor)**	**Information Exchanged (IDs)**	**Requirement, R-IDs**
St.1	Loop	Data sampling	Data is sampled from sensors in substations	GET	DSO	DSO	x	QoS.1; QoS.2; QoS.3; QoS.4; Sec.4; Sec.5; D.2; D.4; D.6; Conf.1; Conf.4; Conf.6; O.1
St.2	Data from step 1 is sampled	Data health check on edge	Data is checked for both correct sensor readings and for variations since last sample significant enough to require a notification to the central system	EXECUTE	DSO	DSO	x	QoS.1; QoS.2; QoS.3; QoS.4; Sec.4; Sec.5; D.2; D.4; D.6; Conf.1; Conf.4; Conf.6; O.1
St.3	Significant number of data samples are collected in step 2	Dispatch substation sensor readings	Measurements are sent to the DSO's IoT Platform	REPORT	DSO	DSO	Inf.4	QoS.1; QoS.2; QoS.3; QoS.4; Sec.4; Sec.5; D.2; D.4; D.6; Conf.1; Conf.4; Conf.6; O.1
St.4				REPEAT(1-3)				
St.5	Loop	Data sampling	Data is sampled from sensors along lines	GET	DSO	DSO	x	QoS.1; QoS.2; QoS.3; QoS.4; Sec.4; Sec.5; D.2; D.4; D.6; Conf.1; Conf.4; Conf.6; O.1
St.6	Data from step 5 is sampled	Data health check on edge	Data is checked for both correct sensor readings and for variations since last sample significant enough to require a notification to the central system	EXECUTE	DSO	DSO	x	QoS.1; QoS.2; QoS.3; QoS.4; Sec.4; Sec.5; D.2; D.4; D.6; Conf.1; Conf.4; Conf.6; O.1
St.7	Significant	Dispatch line	Measurements are sent to	REPORT	DSO	DSO	Inf.5	QoS.1; QoS.2;

	number of data samples are collected in step 6	sensor readings	the DSO's IoT Platform					QoS.3; QoS.4; Sec.4; Sec.5; D.2; D.4; D.6; Conf.1; Conf.4; Conf.6; O.1
St.8				REPEAT(5-7)				
St.9	Data from steps 3 or 7 is received	Check against device registry	Received data is checked against the IoT Platform device registry, for both authentication and validation of source device location	EXECUTE	DSO	DSO	x	QoS.1; QoS.2; QoS.3; QoS.4; Sec.4; Sec.5; D.2; D.4; D.6; Conf.1; Conf.4; Conf.6; O.1
St.10	Step 9 is successfully completed	Dispatch measurements	Data is forwarded to the ADMS's Forecast Engine	REPORT	DSO	DSO	Inf.6	QoS.1; QoS.2; QoS.3; QoS.4; Sec.4; Sec.5; D.2; D.4; D.6; Conf.1; Conf.4; Conf.6; O.1
St.11	Data from step 10 is received	Persistence	Data is persisted	CREATE	DSO	DSO	x	QoS.1; QoS.2; QoS.3; QoS.4; Sec.4; Sec.5; D.2; D.4; D.6; Conf.1; Conf.4; Conf.6; O.1
St.12	Step 11 is completed	Measurements integrated into the forecast model	Newly received measurements are integrated into the forecast model	EXECUTE	DSO	DSO	x	QoS.1; QoS.2; QoS.3; QoS.4; Sec.4; Sec.5; D.2; D.4; D.6; Conf.1; Conf.4; Conf.6; O.1

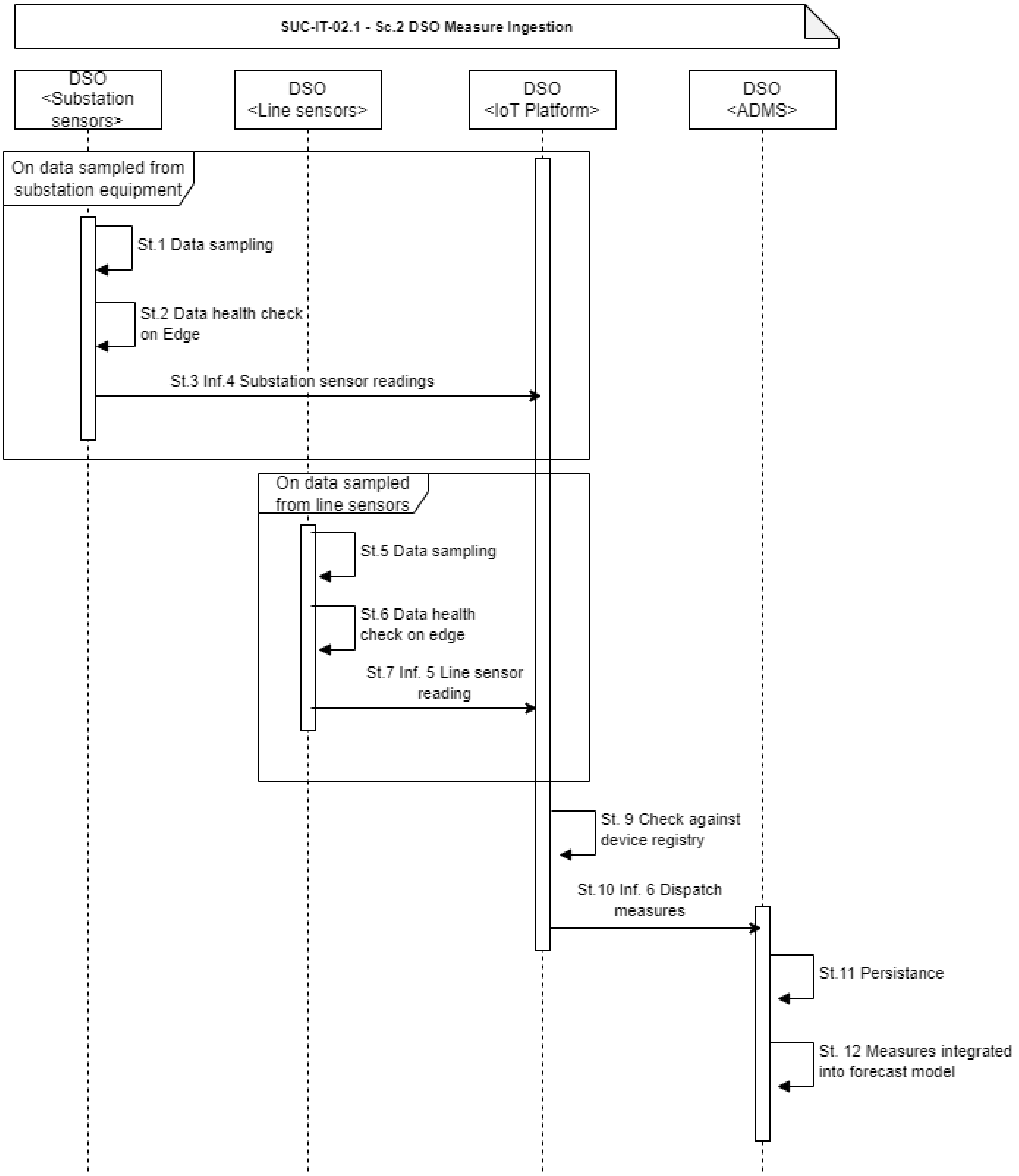


FIGURE 5: SC.2 UML SEQUENCE DIAGRAM

Scenario								
Scenario name:		Sc.3 Load and Production Forecast						
Step No.	**Event**	**Name of process/ activity**	**Description of process/ activity**	**Service**	**Information producer (actor)**	**Information receiver (actor)**	**Information Exchanged (IDs)**	**Requirement, R-IDs**
St.1	Schedule	Request for grid topology	The Topology Processor receives the state of the circuit breakers and defines the real configuration of the grid. Moreover, the DSO operator can change the output, setting the topology foreseen (i.e. to face a maintenance plan).	GET	DSO	DSO	Inf. 7	QoS.1; QoS.4; Sec.1; Sec.4; D.1; D.4; D.5; D.6; Conf.4; Conf.6; Conf.7; O.1
St.2				REPEAT 1				
St.3	Schedule	Request for weather forecast	Updated weather forecasts are retrieved, both wide breadth and granular, for specific points of interest (e.g. solar production areas)	GET	DSO	DSO	Inf. 8	QoS.1; QoS.2; Sec.4; D.2; Conf.4; O.1
St.4				REPEAT 3			x	
St.5	Schedule	Forecast data is computed or refined	Forecasted grid behaviour is updated considering both the updated grid and weather data, and the measurement from the DSO and grid connected parties, received since the last iteration	CHANGE	DSO	DSO	x	R1; R2; R3; R4; R5; R6; R7; R8
St.6				REPEAT 5			x	
St.7	Forecasted behaviour is requested	Request forecast behaviour	A DSO operator or system requests the up-to-date grid behaviour	GET	DSO	DSO	Inf. 9	QoS.1; QoS.2; QoS.3; QoS.4; Sec.4; Sec.5; D.2; D.3; Conf.4; Conf.5; O.1

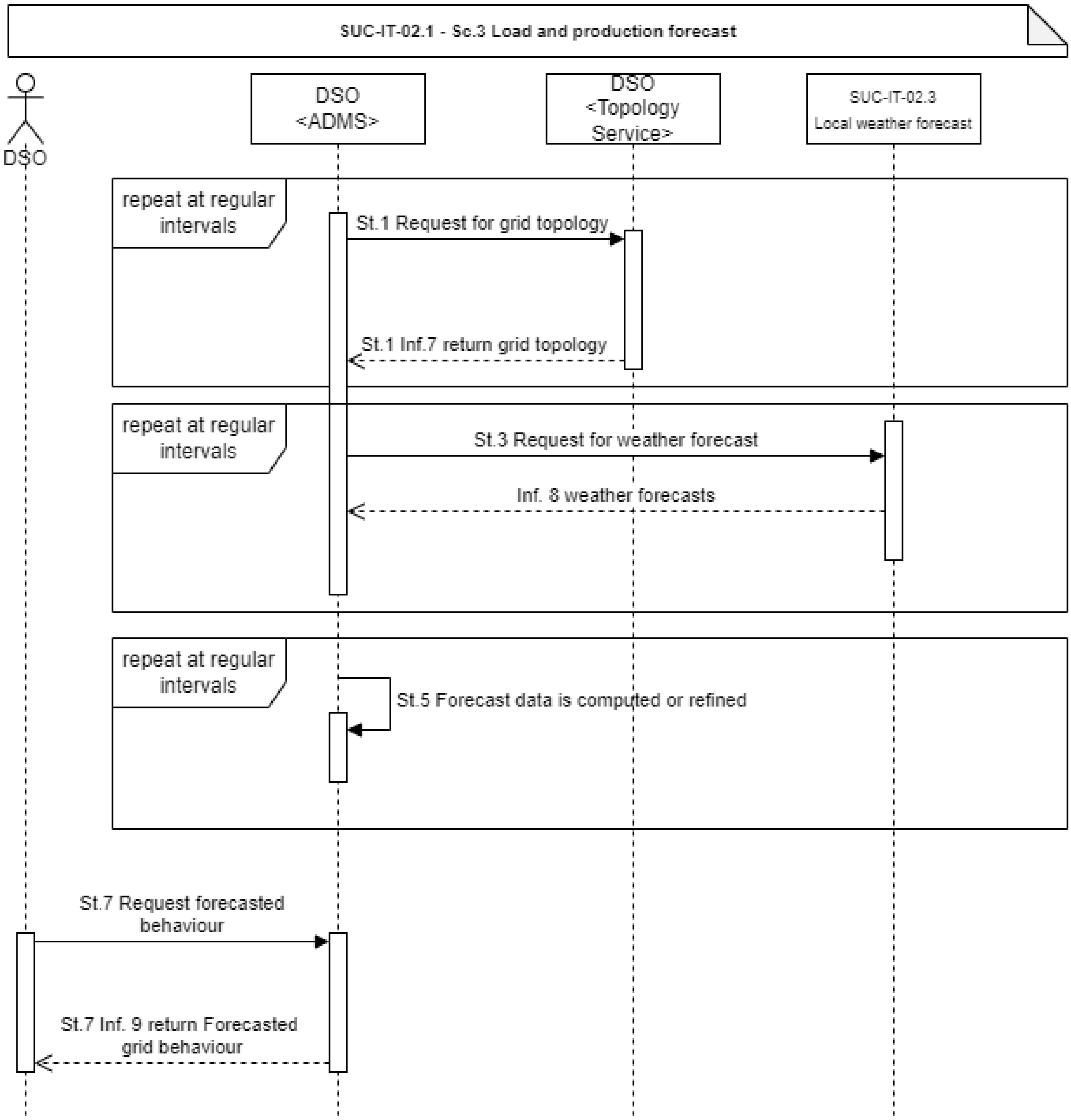


FIGURE 6: SC.3 UML SEQUENCE DIAGRAM

5 Information exchanged

Information exchanged			
Information exchanged (ID)	*Name of information*	*Description of information exchanged*	*Requirement, R-IDs*
Inf.1	BTM device data	Data coming from EC members' Behind the Meter devices	QoS.2; QoS.3; QoS.5; Sec.1; Sec.2; Sec.3; Sec.5; D.1; D.4; Conf.1; Conf.2; Conf.3; Conf.6; Conf.7; O.2
Inf.2	Verified BTM data	Data coming from EC members' Behind the Meter devices, verified by DSO's collector	QoS.2; QoS.3; QoS.5; Sec.1; Sec.2; Sec.3; Sec.5; D.1; D.4; D.6; Conf.1; Conf.2; Conf.3; Conf.6; Conf.7; O.2
Inf.3	Sanitized BTM data	Data coming from EC members' Behind the Meter devices, sanitized by Flexibility Register	QoS.2; QoS.3; QoS.5; Sec.1; Sec.2; Sec.3; Sec.5; D.1; D.4; Conf.1; Conf.2; Conf.3; Conf.6; Conf.7; O.2
Inf.4	Substation sensor readings	Electrical or environmental readings from substations sensors	QoS.1; QoS.2; QoS.3; QoS.4; Sec.4; Sec.5; D.2; D.4; D.6; Conf.1; Conf.4; Conf.6; O.1
Inf.5	Line sensor readings	Electrical or environmental readings from sensors along the grid	QoS.1; QoS.2; QoS.3; QoS.4; Sec.4; Sec.5; D.2; D.4; D.6; Conf.1; Conf.4; Conf.6; O.1
Inf.6	IoT sensor data	Electrical or environmental readings from sensors, routed and formatted by DSO's IoT Platform	QoS.1; QoS.2; QoS.3; QoS.4; Sec.4; Sec.5; D.2; D.4; D.6; Conf.1; Conf.4; Conf.6; O.1
Inf.7	Grid topology	Energized grid topology useful for the forecast analysis	QoS.1; QoS.4; Sec.1; Sec.4; D.1; D.4; D.5; D.6; Conf.4; Conf.6; Conf.7; O.1
Inf.8	Weather forecast	Weather status or forecast	QoS.1; QoS.2; Sec.4; D.2; Conf.4; O.1
Inf.9	Forecasted grid behaviour	Consumptions and productions foreseen for the state estimation time window	QoS.1; QoS.2; QoS.3; QoS.4; Sec.4; Sec.5; D.2; D.3; Conf.4; Conf.5; O.1

6 Requirements

Quality of Service Requirements		
Categories ID	**Category name for requirements**	**Category description**
QoS	Quality of Service	Generic properties that service/SUC should provide – quality attributes
Requirement R-ID	**Requirement name**	**Requirement description**
QoS.1	Availability of information flows	Continuous availability not required as long as downtime is scheduled
QoS.2	Accuracy of data requirements	The age of the data must be identifiable
QoS.3	Accuracy of data requirements	Time skew of data must be known
QoS.4	Frequency of data exchanges	Upon event
QoS.5	Frequency of data exchanges	Every 15 minutes

Security Requirements		
Categories ID	**Category name for requirements**	**Category description**
Sec	Security	Authentication of user, confidentiality, integrity, prevention of denial of service, non-repudiation or accountability, error management
Requirement R-ID	**Requirement name**	**Requirement description**
Sec.1	Eavesdropping	Ensuring confidentiality, avoiding illegitimate use of data, and preventing unauthorized reading of data is crucial
Sec.2	Information integrity violation	Ensuring that data is not changed or destroyed is crucial
Sec.3	Authentication and Access Control mechanisms commonly used with this data exchange	Certificate
Sec.4	Authentication and Access Control mechanisms commonly used with this data exchange	Shared secret
Sec.5	Network security measures commonly used with this data exchange	VLAN segregation

Data Management Requirements		
Categories ID	**Category name for requirements**	**Category description**
D	Data Management	Type of source of data, correctness or validity of data, timeliness or time stamping of data, volume of data, synchronization or consistency of data across systems, timely access to data, validation of data across organizational boundaries, transaction management, data naming, identification, formats across disparate systems, maintenance of data and databases.
Requirement R-ID	**Requirement name**	**Requirement description**
D.1	Correctness of source data	Source data is always correct (e.g. by definition)
D.2	Correctness of source data	Source data is usually correct
D.3	Up-to-date management	Received data must be up to date within minutes of source data change
D.4	Management of data across departmental boundaries	Data exchanges go across departmental boundaries
D.5	Data maintenance effort: human versus automation	Data maintenance is mostly automated but requires occasional intervention. Data maintenance is (or can be if authorized) completely automated (e.g. Live Update of Virus, Microsoft Updates).
D.6	Validation of data exchanges	Data from different sources must be validated against each other

Discovery and Configuration Requirements		
Categories ID	**Category name for requirements**	**Category description**
Conf	Configuration	Locations, distances, communication layout, commonly used communication protocol media, network bandwidth, existing protocols, number of devices, systems, volume of data items, expected growth, etc.
Requirement R-ID	**Requirement name**	**Requirement description**
Conf.1	Number of Information Producers	Few to a hundred
Conf.2	Communication media	Power Line Communication (Chain2)
Conf.3	Data exchange methods	Master-slave
Conf.4	Data exchange methods	Publish-subscribe
Conf.5	Communication access services requirements	Request-response
Conf.6	Relative maturity of current implementation	Very mature and widely implemented
Conf.7	Existence of legacy systems	Few changes will be needed

Other Requirements		
Categories ID	**Category name for requirements**	**Category description**
O	Regulatory obligation related to privacy	2016/679 GDPR (General Data Protection Regulation)
Requirement R-ID	**Requirement name**	**Requirement description**
O.1	No GDPR constraints	No personal data is processed or transferred
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.

7 Common Terms and Definitions

Common Terms and Definitions	
Term	**Definition**
EC	Energy Community
BTM	Behind The Meter device
IED	Intelligent Electronic Device
ML	Machine Learning

4 SUC-IT-02.2 – GRID CONGESTION COMPUTING

1 Description of the use case

1.1 Name of the use case

ID	*Area / Domain(s) / Zones(s)*	*Name of Use Case*
SUC-IT-02.2	Smart Grid / Distribution / Operation	Grid congestion computing

1.2 Version management

Version Management			
Version No.	*Date*	*Name of Author(s)*	*Changes*
V0.1	25.05.2024	Gabriele Fedele (Areti)	First Version
V0.2	01.08.2024	Gabriele Fedele (Areti)	Edits after first review
V0.3	28.08.2024	Gabriele Fedele (Areti)	Edits after second review
V0.4	25.09.2024	Gabriele Fedele (Areti)	Edits after third review; new requirements guidelines

1.3 Scope and objectives of use case

Scope and Objectives of Use Case	
Scope	Demonstrate effectiveness and appropriateness to forecast the grid congestion defining the distribution grid components and resources involved.
Objective(s)	- **OBJ1**: Deferral of grid reinforcement investments (defer or avoid MV feeder or secondary substation replacements). Improve security of supply enabling a demand-response mechanism to prevent congestion in the distribution grid.
Related business case(s)	BUC-IT-2

1.4 Narrative of use case

Narrative of Use Case
Short description
Due to excessive and increasing energy consumptions, MV feeders and MV/LV secondary substations occasionally become thermally overloaded, leading to power line congestion. Flexibility resources can be useful in relieving or even preventing overloads in distribution grid components. In particular, the optimal dispatch of the resources within Energy Communities located in the area can be used to reduce the grid load during peak hours.
Complete description
This System Use Case (SUC) leverages the assets and tools available in the DSO system and exploits the results coming from the previous SUCs implemented in the Italian pilot. The main algorithms will be implemented in the Distribution Management System (DMS) of the DSO, to develop an innovative flexible module consisting of several functions described below.

Beginning with SCADA, the measurements and grid information are received by the topology processor to check the actual state of the circuit breakers and the feeder configuration. At the end of this process the updated grid topology is sent to the state estimation tool. In parallel, the dynamic line rating tool acquires updated weather forecast, coming from the devices installed along the network, and runs to detect the actual limits of the grid elements. The algorithm used in this phase will be adapted starting from the transmission grid experience. All the information about EC resources involved will be registered in the flexibility database, where the baseline will also be evaluated using real-time measurements from the DSO smart meter. Finally, all users located in the demo area will be processed through the load and production forecast tool, to define the profile useful for the state estimation. All the information will be processed by the State Estimation tool to detect congestion (e.g. voltage violations, line power limitations, etc.) in the grid. Input: RT measurements, grid topology, thermal limits, baselines + load & production forecasts Output: U/Imax issues

1.5 Key performance indicators (KPIs)

ID	Name	Description	Reference to mentioned use case objectives
KPI 4	*% Of real-time data sharing among stakeholders*	An increase in real time data availability leads to better forecast models	OBJ1
KPI 11	*Increased grid operational*	Better allocation of flexibility resources to address critical scenarios	OBJ1
KPI 12	*Faster application response times*	Faster prediction of grid behaviour allows more operational time to address critical scenarios	OBJ1
KPI 22	*Increase DERs participation in flexibility provision*	Decreased downtime	OBJ1

1.6 Use case conditions

Use case conditions
Assumptions
Prerequisites
Balanced distribution of flexibility in the grid area; Availability of real time data readings; Grid topology is available and updated in (near) real time.

1.7 Further information to the use case for classification / mapping

Classification Information
Relation to other use cases
Linked to SUC-IT-02.1:

• Consumes load and prediction forecasts to engage State Estimation algorithms in different scenarios Linked to SUC-IT-02.3: • Consumes local weather status and forecast to calculate dynamic grid rating
Level of depth
Prioritisation
Generic, regional or national relation
Nature of the use case
Further keywords for classification

1.8 General Remarks

General Remarks

2 Diagrams of use case

Diagram(s) of use case

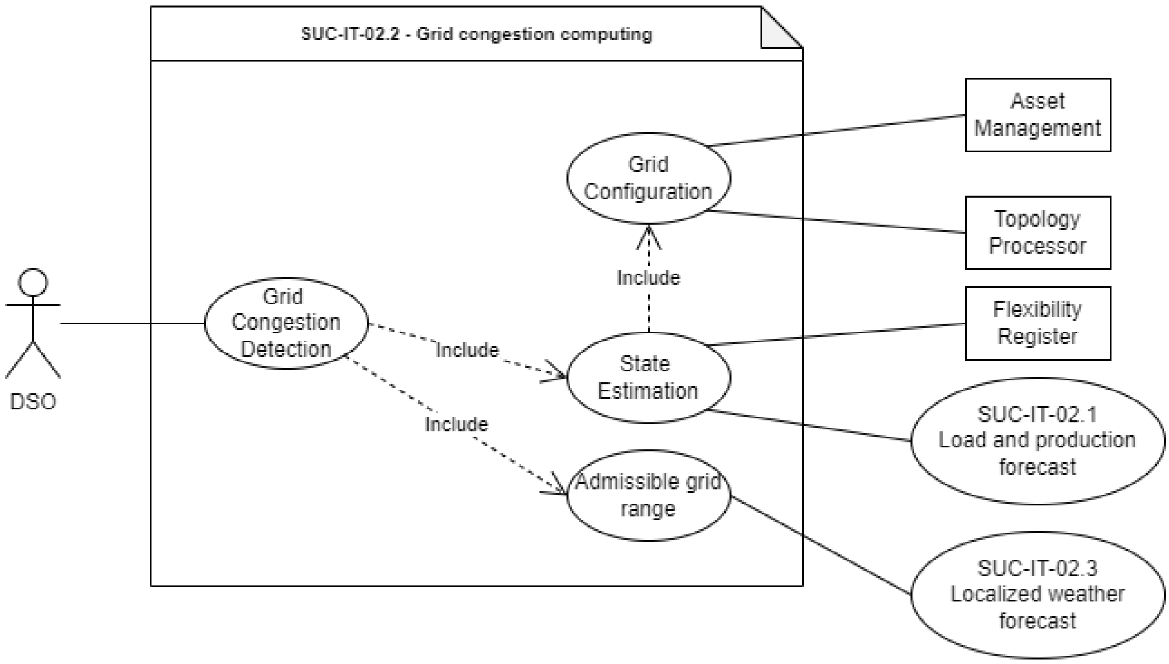


FIGURE 7: UML USE CASE DIAGRAM

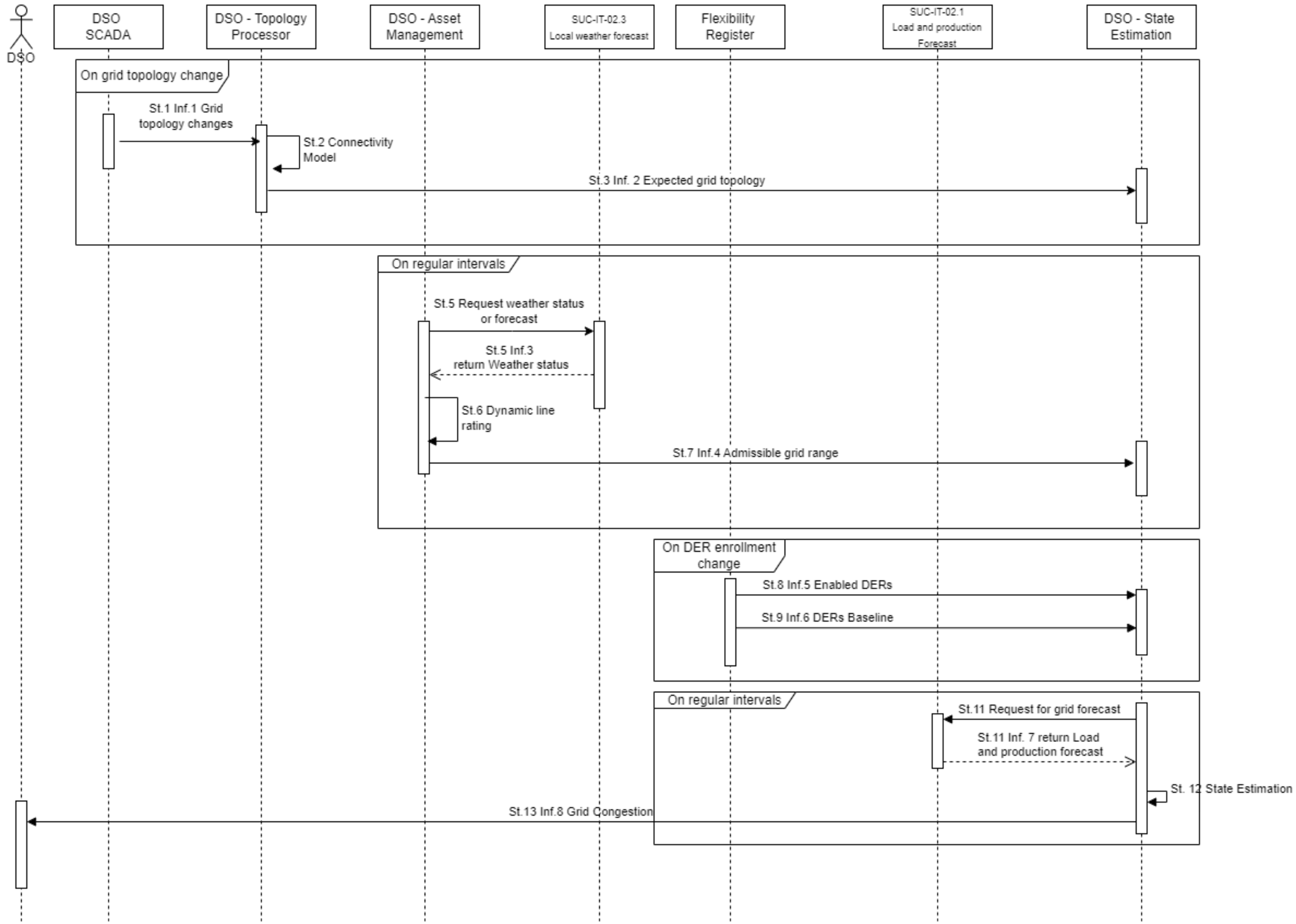


FIGURE 8: UML SEQUENCE DIAGRAM

3 Technical details

3.1 Actors

Actors			
Actor Name	**Actor Type**	**Actor Description**	**Further information specific to this use case**
DSO	Business Role (HEMRM)	A party responsible for operating, ensuring the maintenance of and, if necessary, developing the system in a given area and, where applicable, its interconnections with other systems, and for ensuring the long-term ability of the system to meet reasonable demands for the distribution of energy.	Areti
Flexibility Register	Logical Role	Responsible for allocating access rights to the various actors and controlling the level of access. Stores flexibility assets, results of qualification (both product and grid), stores market results, grid information, aggregates flexibility information and stores the results of the settlement. Forwards activation signals to flexibility assets upon request of the SOs.	Administrator of all the information that is stored in the Flexibility Register. The Flexibility operator should be a trusted authority due to the sensitivity level of the information being handled.
Asset Management	Logical Role	A DSO's system handling the physical and constructive characteristics of grid elements	Areti
Topology Processor	Logical Role	A DSO's system containing the current and expected grid topology (e.g. planned downtime of grid sections).	Areti

3.2 Reference

References						
No.	**Reference Type**	**Reference**	**Status**	**Impact on use case**	**Originator / organisation**	**Link**

4 Step by step analysis of use case

4.1 Overview of scenarios

Scenario conditions						
No.	**Scenario name**	**Scenario description**	**Primary actor**	**Triggering event**	**Pre-condition**	**Post-condition**
Sc.1	Data acquisition and processing	Data is collected from both field devices and central systems; then combined to provide a useful state estimation input	DSO	Real time grid management	Topology is available; Weather data is available; DERs are enrolled and available;	The data is collected by the central system and is ready for elaboration

Sc.2	State Estimation	The DSO runs the state estimation to evaluate the short-term grid needs	DSO	On regular intervals	Data from Sc.1 is available	The state estimation outcomes are available for the real time grid limits

4.2 Steps – Scenarios

Scenario								
Scenario name:		Sc.1 Data acquisition and processing						
Step No.	**Event**	**Name of process/ activity**	**Description of process/ activity**	**Service**	**Information producer (actor)**	**Information receiver (actor)**	**Information Exchanged (IDs)**	**Requirement, R-IDs**
St.1	Status change	Grid topology changes	The devices on field detect the state of the circuit breakers and send the information to the SCADA system	REPORT	DSO	DSO	Inf.1	QoS.1; QoS.4; Sec.1; Sec.4; D.1; D.4; D.5; D.6; Conf.4; Conf.6; Conf.7; O.1
St.2	Data from St.1 is received	Connectivity model	The Topology Processor receives the state of the circuit breakers and defines the real configuration of the grid. Moreover, the DSO operator can change the output, setting the topology foreseen (i.e. to face a maintenance plan)	CHANGE	DSO	DSO	x	QoS.1; QoS.4; Sec.1; Sec.4; D.1; D.4; D.5; D.6; Conf.4; Conf.6; Conf.7; O.1
St.3	Step 2 is completed	Expected grid topology	The state estimation tool is notified about the update in grid topology	REPORT	DSO	DSO	Inf.2	QoS.1; QoS.4; Sec.1; Sec.4; D.1; D.4; D.5; D.6; Conf.4; Conf.6; Conf.7; O.1
St.4				REPEAT(1-3)			x	
St.5	Scheduled	Request for weather status or forecast	Weather data for the relevant time frame is requested for the DSO's Weather Service	GET	DSO	DSO	Inf.3	QoS.1; QoS.2; Sec.4; D.2; Conf.4; O.1
St.6	Data from step 5 is received	Dynamic asset rating	The Asset Management tool receives the weather data and forecast, hence it runs the algorithms to detect the admissible limit range for the network asset (i.e. transformer, line,..)	CREATE	DSO	DSO	x	QoS.1; QoS.4; Sec.1; Sec.4; D.1; D.4; D.5; D.6; Conf.4; Conf.6; Conf.7; O.1
St.7	Step 6 is	Admissible	The admissible grid range	REPORT	DSO	DSO	Inf.4	QoS.1; QoS.4; Sec.1;

	complete	grid range	and limits are sent to the state estimation tool					Sec.4; D.1; D.4; D.5; D.6; Conf.4; Conf.6; Conf.7; O.1
St.8				REPEAT (5-7)			x	
St.9	Change in enrolled DERs	Notify Enabled DERs	Changes in enrolled DERs are sent to the State Estimation tool	REPORT	Flexibility Register	DSO	Inf.5	QoS.2; QoS.3; Sec.3; Sec.4; D.2; D.5; D.6; D.7; Conf.5; Conf.6; O.2
St.10	Change in DER baseline	Notify DER baseline	Changes in DER baseline are sent to the State Estimation tool	REPORT	Flexibility Register	DSO	Inf.6	QoS.2; QoS.3; Sec.3; Sec.4; D.2; D.5; D.6; D.7; Conf.5; Conf.6; O.2
St.11				REPEAT(9-11)			x	

Scenario								
Scenario name:		Sc.2 State Estimation						
Step No.	***Event***	***Name of process/ activity***	***Description of process/ activity***	***Service***	***Information producer (actor)***	***Information receiver (actor)***	***Information Exchanged (IDs)***	***Requirement, R-IDs***
St.12	Scheduled	Request for grid forecast	Grid forecast for the relevant timeframe is requested for the DSO's forecast tool	GET	DSO	DSO	Inf.7	QoS.1; QoS.2; QoS.3; QoS.4; Sec.4; Sec.5; D.2; D.3; Conf.4; Conf.5; O.1
St.13	Data from step 12 is received	State Estimation	The distribution management system runs the state estimation tool to detect limit violations and flexibility needs	CREATE	DSO	DSO	x	QoS.1; QoS.2; QoS.3; QoS.4; Sec.4; Sec.5; D.2; D.3; Conf.4; Conf.5; O.1
St.14	Step 13 is completed	Notify grid congestions	Grid congestions and flexibility needs are notified to DSO's operator and/or systems	REPORT	DSO	DSO	Inf. 8	QoS.1; QoS.2; QoS.3; QoS.4; Sec.4; Sec.5; D.2; D.3; Conf.4; Conf.5; O.1
St.15				REPEAT(12-14)			x	

5 Information exchanged

Information exchanged			
Information exchanged (ID)	*Name of information*	*Description of information exchanged*	*Requirement, R-IDs*
Inf. 1	Topology changes	On\off state of the circuit breakers, affecting the energized topology diagram	QoS.1; QoS.4; Sec.1; Sec.4; D.1; D.4; D.5; D.6; Conf.4; Conf.6; Conf.7; O.1
Inf.2	Grid topology	Energized topology useful for the forecast analysis	QoS.1; QoS.4; Sec.1; Sec.4; D.1; D.4; D.5; D.6; Conf.4; Conf.6; Conf.7; O.1
Inf.3	Weather data	Weather data	QoS.1; QoS.2; Sec.4; D.2; Conf.4; O.1
Inf.4	Admissible local grid range	Dynamic limit range of the equipment involved into the experimentation	QoS.1; QoS.4; Sec.1; Sec.4; D.1; D.4; D.5; D.6; Conf.4; Conf.6; Conf.7; O.1
Inf.5	Enabled DERs	DERs marked as available to contribute production on flexibility request	QoS.2; QoS.3; Sec.3; Sec.4; D.2; D.5; D.6; D.7; Conf.5; Conf.6; O.2
Inf.6	DERs baseline	Expected DER behaviour with no flexibility commands	QoS.2; QoS.3; Sec.3; Sec.4; D.2; D.5; D.6; D.7; Conf.5; Conf.6; O.2
Inf.7	Load and production forecasts	Consumption and production foreseen for the state estimation time window	QoS.1; QoS.2; QoS.3; QoS.4; Sec.4; Sec.5; D.2; D.3; Conf.4; Conf.5; O.1
Inf.8	Grid congestions	Portion of the grid where an overload or a voltage violation may occur; Suggested grid change is provided if possible	QoS.1; QoS.2; QoS.3; QoS.4; Sec.4; Sec.5; D.2; D.3; Conf.4; Conf.5; O.1

6 Requirements

Quality of Service Requirements		
Categories ID	**Category name for requirements**	**Category description**
QoS	Quality of Service	Generic properties that a service/SUC should provide – quality attributes
Requirement R-ID	**Requirement name**	**Requirement description**
QoS.1	Availability of information flows	Continuous availability not required as long as downtime is scheduled
QoS.2	Accuracy of data requirements	The age of the data must be identifiable
QoS.3	Accuracy of data requirements	Time skew of data must be known
QoS.4	Frequency of data exchanges	Upon event
QoS.5	Frequency of data exchanges	Every 15 minutes

Security Requirements		
Categories ID	**Category name for requirements**	**Category description**

Sec	Security	Authentication of user, confidentiality, integrity, prevention of denial of service, non-repudiation or accountability, error management.
Requirement R-ID	**Requirement name**	**Requirement description**
Sec.1	Eavesdropping	Ensuring confidentiality, avoiding illegitimate use of data, and preventing unauthorized reading of data, is crucial
Sec.2	Information integrity violation	Ensuring that data is not changed or destroyed is crucial
Sec.3	Authentication and Access Control mechanisms commonly used with this data exchange	Certificate
Sec.4	Authentication and Access Control mechanisms commonly used with this data exchange	Shared secret
Sec.5	Network security measures commonly used with this data exchange	VLAN segregation

Data Management Requirements		
Categories ID	**Category name for requirements**	**Category description**
D	Data Management	Type of source of data, correctness or validity of data, timeliness or time stamping of data, volume of data, synchronization or consistency of data across systems, timely access to data, validation of data across organizational boundaries, transaction management, data naming, identification, formats across disparate systems, maintenance of data and databases.
Requirement R-ID	**Requirement name**	**Requirement description**
D.1	Correctness of source data	Source data is always correct (e.g. by definition)
D.2	Correctness of source data	Source data is usually correct
D.3	Up-to-date management	Received data must be up-to-date within minutes of source data change
D.4	Management of data across departmental boundaries	Data exchanges go across departmental boundaries
D.5	Data maintenance effort: human versus automation	Data maintenance is mostly automated but requires occasional intervention
D.6	Validation of data exchanges	Data from different sources must be validated against each other
D.7	Management of data across organizational boundaries	Data exchanges go across organizational boundaries

Discovery and Configuration Requirements		
Categories ID	**Category name for requirements**	**Category description**

Conf	Configuration	Locations, distances, communication layout, commonly used communication protocol media, network bandwidth, existing protocols, number of devices, systems, volume of data items, expected growth, etc.
Requirement R-ID	**Requirement name**	**Requirement description**
Conf.1	Number of Information Producers	Few to a hundred
Conf.2	Communication media	Power Line Communication (Chain2)
Conf.3	Data exchange methods	Master-slave
Conf.4	Data exchange methods	Publish-subscribe
Conf.5	Communication access services requirements	Request-response
Conf.6	Relative maturity of current implementation	Very mature and widely implemented
Conf.7	Existence of legacy systems	Few changes will be needed

Other Requirements		
Categories ID	**Category name for requirements**	**Category description**
O	Regulatory obligation related to privacy	2016/679 GDPR (General Data Protection Regulation)
Requirement R-ID	**Requirement name**	**Requirement description**
O.1	No GDPR constraints	No personal data is processed or transferred
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.

7 Common Terms and Definitions

Common Terms and Definitions	
Term	**Definition**
DER	Distributed Energy Resource

5 SUC-IT-02.3 – LOCALIZED WEATHER FORECAST

1 Description of the use case

1.1 Name of the use case

ID	Area / Domain(s) / Zones(s)	Name of Use Case
SUC-IT-02.3	Distribution Grid & Flexibility Service Provider Platform	Localized weather forecast

1.2 Version management

Version Management			
Version No.	Date	Name of Author(s)	Changes
V0.1	24.05.2024	Fabio Di Zazzo (Areti)	First version
V0.2	30.07.2024	Fabio Di Zazzo (Areti)	Edits after first review
V0.3	28.08.2024	Fabio Di Zazzo (Areti)	Edits after second review
V0.4	25.09.2024	Fabio Di Zazzo (Areti)	Edits after third review; new requirements guidelines

1.3 Scope and objectives of use case

Scope and Objectives of Use Case	
Scope	City wide weather forecasts can be combined with local IoT weather stations to achieve finer predictions, accurate to the single renewal production plant and/or city block.
Objective(s)	- **OBJ 1**: Enable a better prediction of renewable sources energy production based on localized weather forecasts.
Related business case(s)	BUC-IT-2

1.4 Narrative of use case

Narrative of Use Case
Short description
Integrating an IoT weather station alongside city-level forecasts can greatly enhance solar panel energy production predictions. The IoT weather station offers real-time, localized data on solar radiation, temperature, and cloud cover, which are essential for precise energy output calculations. Combining this detailed data with broader city-level forecasts allows for the development of a more accurate and dynamic prediction model. This model can adjust to real-time environmental conditions and trends, optimizing performance and energy management for solar installations. By merging local and regional data, more reliable energy production forecasts can be achieved, resulting to better planning and efficiency in solar energy utilization.
Complete description

By combining public-availability weather data and private IoT-enabled weather stations, the ADMS platform can interpolate data to provide current and forecast status for both weather condition and solar radiation. The data can be used to forecast both consumption (e.g. AC usage) and production (e.g. DER solar production). The data is available for use by both users and other DSO services. Each weather station is connected via the Modbus protocol (either RTU or TCP) to an open source-based IoT gateway equipped with an LTE modem. Environment readings are transferred to both an external weather service, integrating the readings into its forecast model, and DSO's systems leveraging near real time weather data. Input: Weather forecast, weather stations data Output: Localized weather and solar irradiance forecast and status

1.5 Key performance indicators (KPIs)

ID	Name	Description	Reference to mentioned use case objectives
KPI 7	*Increased RES and IoT deployment for providing flexibility services*	Deployment of IoT weather stations in strategic locations allows for better forecast of load and production	OBJ1
KPI 8	*IoT/Edge/Fog sites uptime and availability*	Availability of weather stations allow for a quicker response to forecasted changes in grid load and production	OBJ1

1.6 Use case conditions

Use case conditions
Assumptions
Prerequisites
External weather service is available; IoT weather stations are installed in strategic (substations, areas with high DER density) locations, configured, and able to communicate with DSO's systems.

1.7 Further information to the use case for classification / mapping

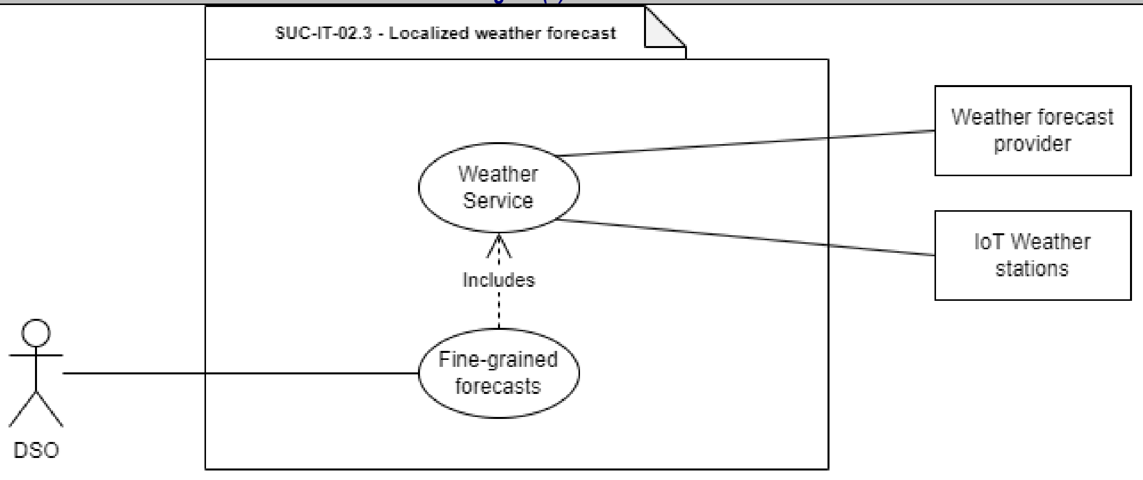
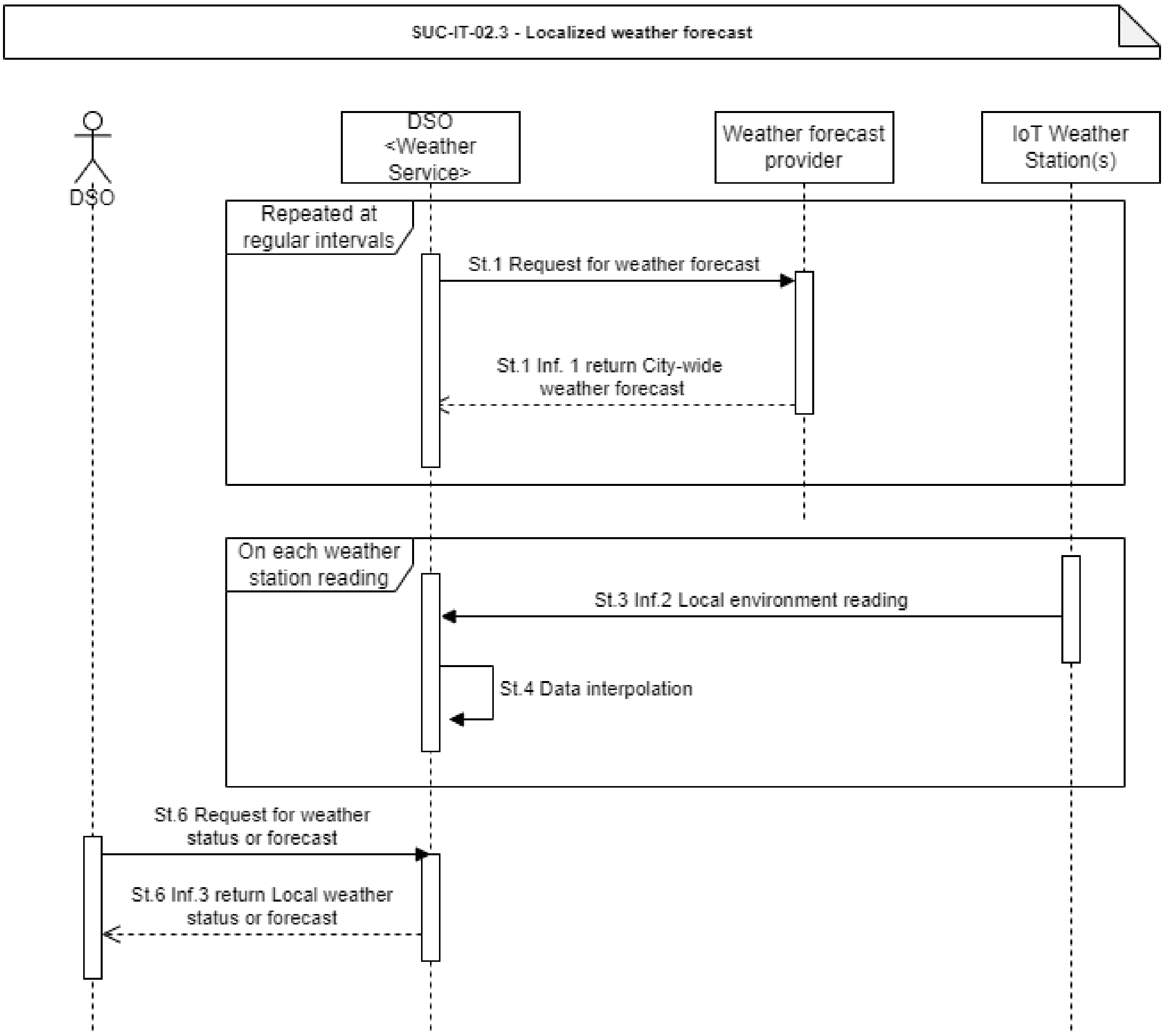
Classification Information
Relation to other use cases
Linked to SUC-IT-02.1: • Provides weather forecasts at locations of interest Linked to SUC-IT-02.2: • Provides weather status at locations of interest
Level of depth
Prioritisation

Generic, regional or national relation
Nature of the use case
Further keywords for classification

1.8 General Remarks

General Remarks

2 Diagrams of use case

Diagram(s) of use case
 FIGURE 9: UML USE CASE DIAGRAM  FIGURE 10: UML SEQUENCE DIAGRAM

3 Technical details

3.1 Actors

Actors			
Actor Name	***Actor Type***	***Actor Description***	***Further information specific to this use case***
DSO	Business Role (HEMRM)	A party responsible for operating, ensuring the maintenance of and, if necessary, developing the system in a given area and, where applicable, its interconnections with other systems, and for ensuring the long-term ability of the system to meet reasonable demands for the distribution of energy	Areti
Weather forecast provider	Logical Role	Publicly available weather forecast provider, to be interrogated by DSO's services	OpenWeatherMap
IoT Weather stations	Logical Role	DSO owned weather station, installed near substations and/or lines	Areti

3.2 References

References						
No.	***Reference Type***	***Reference***	***Status***	***Impact on use case***	***Originator / organisation***	***Link***

4 Step by step analysis of use case

4.1 Overview of scenarios

Scenario conditions						
No.	**Scenario name**	**Scenario description**	**Primary actor**	**Triggering event**	**Pre-condition**	**Post-condition**
Sc.1	Localized weather forecast	Data from public services and DSO's IoT weather stations are interpolated to provide local weather forecasts	DSO	Scheduled	Public city-wide weather service is available; Private IoT weather station(s) are installed and configured	Weather forecast localized on specific points of interest is available

4.2 Steps – Scenarios

Scenario								
Scenario name:		Sc.1 Localized weather forecast						
Step No.	**Event**	**Name of process/ activity**	**Description of process/ activity**	**Service**	**Information producer (actor)**	**Information receiver (actor)**	**Information Exchanged (IDs)**	**Requirement, R-IDs**
St.1	Schedule	Request for weather forecast	Weather status and forecast are retrieved from an external provider	GET	Public weather service	DSO	Inf.1	QoS.1;QoS.2; Qos.4; Sec.1; D.1 ; Conf.3; O.1
St.2				REPEAT(1)			x	
St.3	Data from weather station is available	Dispatch local environment readings	Local weather data is sent to DSO's systems	REPORT	DSO	DSO	Inf. 2	QoS.1; QoS.2; QoS.3; Sec.1; D.1; Conf.1; Conf.2; Conf.4; O.1
St.4	Data from weather station is received	Data Interpolation	Local weather data is integrated into weather and forecast models	CHANGE	DSO	DSO	x	QoS.1; QoS.2; QoS.3; Sec.1; D.1; Conf.1; Conf.2; Conf.4; O.1
St.5				REPEAT(3-4)			x	
St.6	DSO Operator requests data	Request for weather status or forecast	DSO operator or system requests weather status or forecast on a specific point of interest	GET	DSO	DSO	Inf. 3	QoS.1; QoS.2; QoS.4; Sec.1; D.1; Conf.3; O.1

5 Information exchanged

Information exchanged			
Information exchanged (ID)	*Name of information*	*Description of information exchanged*	*Requirement, R-IDs*
Inf.1	City-wide weather forecast	Weather forecast data, up to 7 days, provided by a public service	QoS.1;QoS.2; Qos.4; Sec.1; D.2 ; Conf.3; O.1
Inf.2	Local environment readings	Weather data including temperature, humidity, wind strength and direction, and GPS coordinates, provided by a private IoT Weather station	QoS.1; QoS.2; QoS.3; Sec.1; D.2; Conf.1; Conf.2; Conf.4; O.1
Inf.3	Local weather forecast	Weather forecast for a specific point in time on a point of interest	QoS.1; QoS.2; QoS.4; Sec.1; D.2; Conf.3; O.1

6 Requirements

Quality of Service Requirements		
Categories ID	**Category name for requirements**	**Category description**
QoS	Quality of Service	Generic properties that service/SUC should provide – quality attributes.
Requirement R-ID	**Requirement name**	**Requirement description**
QoS.1	Availability of information flows	Continuous availability not required as long as downtime is scheduled
QoS.2	Accuracy of data requirements	The age of the data must be identifiable
QoS.3	Frequency of data exchanges	Upon event
QoS.4	Frequency of data exchanges	Periodicity greater than a few seconds

Security Requirements		
Categories ID	**Category name for requirements**	**Category description**
Sec	Security	Authentication of user, confidentiality, integrity, prevention of denial of service, non-repudiation or accountability, error management
Requirement R-ID	**Requirement name**	**Requirement description**
Sec.1	Authentication and Access Control mechanisms commonly used with this data exchange	Shared secret

Data Management Requirements		
Categories ID	**Category name for requirements**	**Category description**
D	Data Management	Type of source of data, correctness or validity of data, timeliness or time stamping of data, volume of data, synchronization or consistency of data across systems, timely access to data,

		validation of data across organizational boundaries, transaction management, data naming, identification, formats across disparate systems, maintenance of data and databases.
Requirement R-ID	**Requirement name**	**Requirement description**
D.1	Correctness of source data	Source data is usually correct

Discovery and Configuration Requirements		
Categories ID	**Category name for requirements**	**Category description**
Conf	Configuration	Locations, distances, communication layout, commonly used communication protocol media, network bandwidth, existing protocols, number of devices, systems, volume of data items, expected growth, etc.
Requirement R-ID	**Requirement name**	**Requirement description**
Conf.1	Distance between entities	A few kilometers
Conf.2	Number of Information Producers	Two to a few
Conf.3	Communication access services requirements	Request-response
Conf.4	Communication access services requirements	Periodic reporting

Other Requirements		
Categories ID	**Category name for requirements**	**Category description**
O	Regulatory obligation related to privacy	2016/679 GDPR (General Data Protection Regulation)
Requirement R-ID	**Requirement name**	**Requirement description**
O.1	No GDPR constraints	No personal data is processed or transferred

7 Common Terms and Definitions

Common Terms and Definitions	
Term	**Definition**

HEDGE-IoT

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

D2.2

Functional Specifications of the HEDGE-IoT system

|Annex Document 4 - Dutch Pilot SUCs|

31/10/2024

Co-funded by the European Union

This project has received funding from the European Union's Horizon Europe research and innovation programme under the Grant Agreement number 101136216. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Climate, Infrastructure and Environment Executive Agency. Neither the European Union nor the granting authority can be held responsible for them.

PROJECT INFORMATION

Project Number	101136216		
Project Acronym	HEDGE-IoT		
Project Full title	Holistic Approach towards Empowerment of the Digitalization of the Energy Ecosystem through adoption of IoT solutions		
Project Start Date	01 January 2024		
Project Duration	42 months		
Funding Instrument	Horizon Europe Framework Programme	Type of action	HORIZON-IA HORIZON Innovation Actions
Call	HORIZON-CL5-2023-D3-01-15		
Topic	Supporting the green and digital transformation of the energy ecosystem and enhancing its resilience through the development and piloting of AI-IoT Edge-cloud and platform solutions		
Coordinator	European Dynamics Luxembourg SA		

DELIVERABLE INFORMATION

Deliverable No.	D2.2						
Deliverable Title	Functional Specifications of the HEDGE-IoT system – Annex Document 4 – Dutch Pilot SUCs						
Work-Package No.	WP2						
Work-Package Title	Stakeholders' Requirements and System Specifications						
Lead Beneficiary	TRIALOG						
Main Author	Laura Daniele (TNO) Sophie Lathouwers (TNO) Wouter Beelen (AB) and all Dutch pilot members						
Other Authors	Léo Cornec (TRI) Lenos Peratitis (ED) Nika Mlinarič Hribar (JSI)						
Due date	31/10/2024						
Deliverable Type	X	Document, Report (R)		Data management plan (DMP)		Websites, press & media action (DEC)		Other
Dissemination Level	X	Public (PU)		Sensitive (SEN)		Classified		
	PU: Public, fully open SEN: Sensitive, limited under the conditions of the Grant Agreement Classified R-UE/EU-R – EU RESTRICTED under the Commission Decision No2015/444 Classified C-UE/EU-C – EU CONFIDENTIAL under the Commission Decision No2015/444 Classified S-UE/EU-S – EU SECRET under the Commission Decision No2015/444						

Document Revision History

Version	Date	Description of change	List of contributor(s)
0.1	09/10/2024	Compilation of all the pilot SUCs	Léo Cornec (TRI)
0.2	11/10/2024	Small adjustment of the SUCs based on Dutch pilot review	Laura Daniele (TNO)
0.3	23/10/2024	Review by European Dynamics	Lenos Peratitis (ED)
0.4	26/10/2024	Review by Institut Jozefstefan	Nika Mlinarič Hribar (JSI)
1.0	29/10/2024	Final document version for integration to Deliverable D2.2	Léo Cornec (TRIALOG)

EXECUTIVE SUMMARY

This document is an annex of HEDGE-IoT deliverable D2.2 titled "Functional Specifications of the HEDGE-IoT system" document. It provides specifications for the System Use Cases (SUCs) of the pilot.

Each SUC was defined by pilot members, based on the corresponding Business Use Case (BUC) and the IEC 62559-2 template, with support from the task leader for the methodology.

This document will be updated later in the project based on additional work and feedback. For the HEDGE-IoT project, the following sections and subsections of the IEC 62559-2 template were defined as mandatory to be completed by the pilot demonstrators for the SUCs:

1. Description of the use case
    1.1. Name of the use case
    1.2. Scope and objectives of the use case
    1.3. Narrative of the use case
2. Diagrams of the use case
3. Technical details
    3.1. Actors
4. Step-by-step analysis of use case
    4.1. Overview of scenarios
    4.2. Steps - scenarios
5. Information exchanged
6. Requirements

The following table links the BUCs and the SUCs of the pilot:

BUC ID & BUC name	SUC ID	SUC name
BUC-NL-01 Energy Flexibility at business park	SUC-NL-01.1	Monitor energy nodes and local grid & dashboard for data insights
	SUC-NL-01.2	Integrate energy nodes and EMS/BMS via semantics for control and explainability
	SUC-NL-01.3	Optimize energy production & consumption
	SUC-NL-01.4	Flexibility alignment
BUC-NL-02 Enhance local grid resilience through detection & prevention	SUC-NL-02.1	Anomaly and fault detection in the local grid
	SUC-NL-02.2	Predictive maintenance

1 SUC-NL-01.1 – MONITOR ENERGY NODES AND LOCAL GRID & DASHBOARD FOR DATA INSIGHTS

1 Description of the use case

1.1 Name of the use case

ID	*Area / Domain(s) / Zones(s)*	*Name of Use Case*
SUC-NL-01.1	Energy Flexibility at business park	Monitor energy nodes and local grid & dashboard for data insights [Monitoring & Dashboards]

1.2 Version management

Version Management			
Version No.	*Date*	*Name of Author(s)*	*Changes*
1	03-04-2024	W.Beelen (AB) and S. Lathouwers (TNO)	Draft outline of use case
2	26-6-2024	W.Beelen (AB)	Update of SUC
3	03-07-2024	L.Daniele (TNO)	Added UML diagrams (Use Case and Sequence)
3	3-7-2024	W.Beelen (AB)	
4	5-7-2024	S. Lathouwers (TNO)	Update Scenarios, Information Exchanged and Requirements
5	12-7-2024	S. Lathouwers (TNO)	Update document based on feedback from Léo
6	31-7-2024	S. Lathouwers (TNO)	Updated UML diagrams
7	2-8-2024	S. Lathouwers (TNO)	Aligned Scenarios with UML diagrams
8	4-9-2024	S. Lathouwers (TNO)	Updated diagrams, scenarios, requirements, and other details based on changes in the diagrams
9	1-10-2024	W.Beelen (AB) & L.Daniele (TNO)	Update KPI's and requirements according to new guidelines

1.3 Scope and objectives of use case

Scope and Objectives of Use Case	
Scope	The decentral grid of Arnhems Buiten
Objective(s)	1. **Real-Time Data Collection**: Capture and aggregate data from diverse energy nodes in (near) real-time. 2. **Actionable Insights**: Develop dashboards that provide clear insights and improve explainability of energy consumption and technical functions.
Related business case(s)	BUC-NL-01 – Energy Flexibility at Business park BUC-NL-02 – Enhance local grid resilience through detection & prevention

1.4 Narrative of use case

Narrative of Use Case
Short description

From all (smart) energy nodes real-time data will be monitored and stored. This data will be pre-processed and combined/integrated in one or more dashboard(s). The data will be stored on premises and/or cloud.

Complete description

The Electricity Campus is a business park where the electricity grid is owned and managed by Arnhems Buiten, which functions as a local Distribution System Operator (DSO). This use case describes a system designed to monitor and control various energy nodes, optimize grid flexibility, and provide real-time data insights through advanced dashboards. The system will cater to multiple stakeholders, including prosumers (owners and/or users of energy nodes), Arnhems Buiten, and an aggregator.

Stakeholders and Roles

- **Prosumers**: Owners and/or users of energy nodes (heat pumps, smart meters, batteries, V2G chargers).
- **Arnhems Buiten**: The local DSO responsible for managing and optimizing the grid.
- **Aggregator**: The exact role and impact of the aggregator must be aligned with the DSO Alliander. The aggregator might be the same as the Energy Supplier. If included in the SUC, the aggregator entity will consolidate data from multiple prosumers and energy nodes to optimize energy production and consumption.

System Architecture

Components

- **Energy Nodes**: Each node is equipped with control interfaces for monitoring and operational adjustments.
- **Communication Network**: A robust network infrastructure to ensure real-time data transmission from energy nodes to the central system.
- **Data Management System**: A platform to aggregate, store, and process incoming data.
- **Dashboards**: User-friendly interfaces that visualize data insights for grid operators and stakeholders.

Data Flow

- **Data Collection**: (sensors on) energy nodes collect data on parameters such as energy consumption, generation, temperature, and charge levels.
- **Data Transmission**: This data is transmitted in real-time to the central data management system via the communication network.
- **Data Aggregation and Storage**: The central system aggregates data from all nodes and stores it in a structured format.
- **Visualization and Insight Generation**: Dashboards display the analyzed data in a user-friendly format, providing insights and recommendations.

Dashboard Features

- **Real-Time Monitoring**: Display the current status and performance of all energy nodes.
- **Historical Data Analysis**: Access historical data to identify trends and patterns.

1.5 Key performance indicators (KPI)

ID	Name	Description	Reference to mentioned use case objectives
KPI4	Real-time data sharing among stakeholders	Sharing % of one or more data streams from the Dutch pilot that are real-time available for the actors	Objective 1 & 2
OB1	Different types of IoT/edge devices to be exploited in Demo Areas e.g., Smart Meter, HEMS, Sensors, inverter	The IoT/edge devices to be used within this SUC	Objective 1 & 2
OB4	Users involved in the piloting	Number of users part of the Demo, based on the installations of edge/IoT devices	Objective 1 & 2

1.6 Use case conditions

Use case conditions
Assumptions
• **Reliable Communication Infrastructure**: There should be a reliable communication infrastructure capable of real-time data transmission from energy nodes to the central system. • **Compatibility of Energy Nodes**: All energy nodes (heat pumps, smart meters, batteries, V2G chargers) are compatible with the central data management system and can communicate seamlessly. • **Availability of Prosumers' Data**: Prosumers consent to sharing their energy usage data with Arnhems Buiten and the aggregator for analysis and optimization. • **Regulatory Compliance**: The system operates within the regulatory framework governing energy distribution and data privacy. Special attention is to the non-formal DSO status of Electricity Campus • **Correct actor/role definition**: Since Electricity Campus isn't a formal closed distribution grid, roles might not be aligned with the harmonised Electricity Market Role model • **Cybersecurity Measures**: Robust cybersecurity measures are in place to protect data integrity and privacy. • **Stakeholder Engagement**: All stakeholders (prosumers, Arnhems Buiten, aggregator, DSO) are engaged and willing to cooperate in the deployment and use of the system. • **Scalability and Flexibility**: The system is designed to be scalable to accommodate future expansion of the business park and the addition of new energy nodes.
Prerequisites
• Conducting a detailed assessment of existing infrastructure and requirements. • Defining the technical and operational specifications for the system. • Procurement and installation of compatible energy nodes across the business park. • A reliable communication network for real-time data transmission. • Set up a cloud-based/local data management system to aggregate, store, and process data. • Deploy an analytical engine with advanced analytics tools and algorithms. • Develop user-friendly dashboards tailored to the needs of grid operators and stakeholders. • Dashboards and/or interfaces to provide real-time monitoring, historical data analysis, predictive analytics, and optimization recommendations. • Development and implementation of standardised protocols for seamless integration of data from diverse energy nodes. • Ensure compatibility and interoperability of all system components. • Training for staff and stakeholders on using the system and interpreting dashboard insights. • Setup and/or design of maintenance and support roles and processes

1.7 Further Information to the use case for classification / mapping

Classification Information
Relation to other use cases
Used as t System Use Case for both BUC-NL-01 and BUC-NL-02.
Level of depth
Prioritisation
Generic, regional or national relation
Nature of the use case
System use case
Further keywords for classification
Energy nodes, real-time data, storage, monitoring

1.8 General Remarks

General Remarks
Energy nodes contain: Buildings, charging stations, EV (via V2G), Batteries, PV

2 Diagrams of use case

Diagram(s) of use case

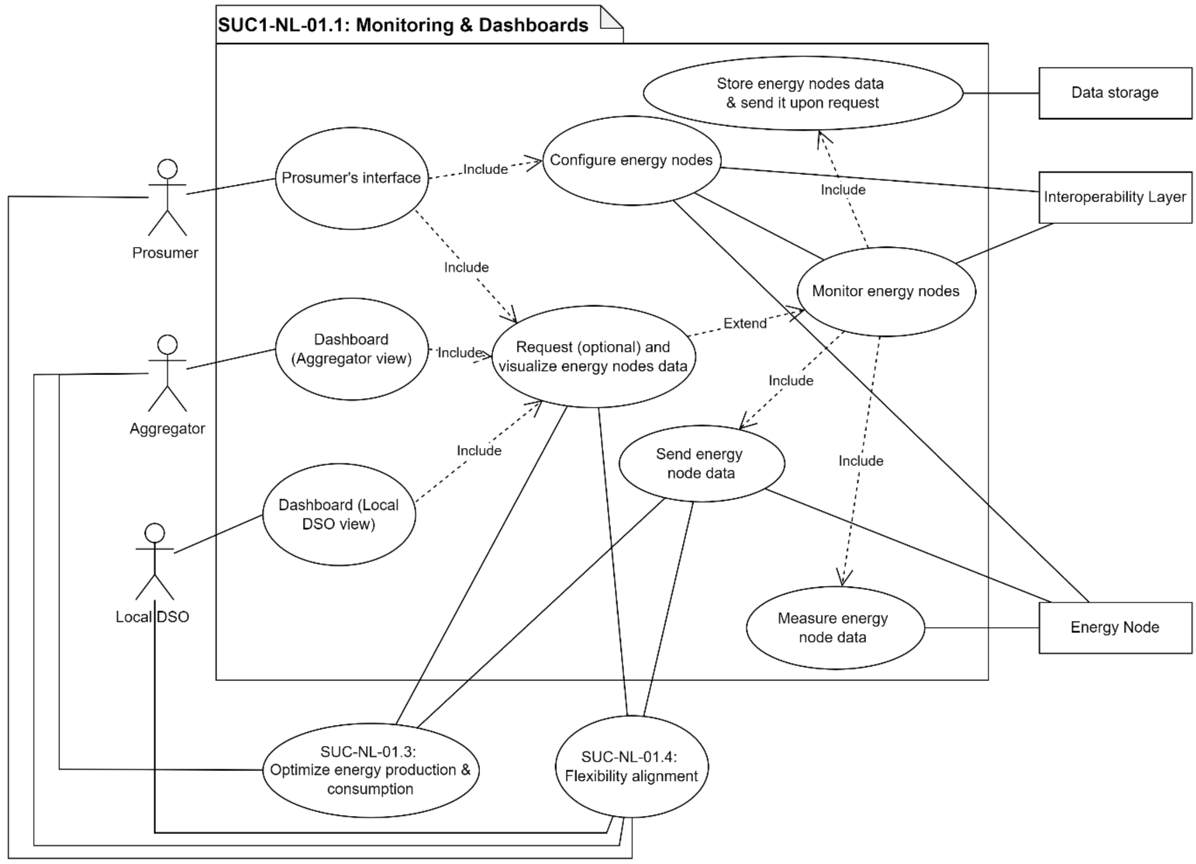


FIGURE 1: UML USE CASE DIAGRAM

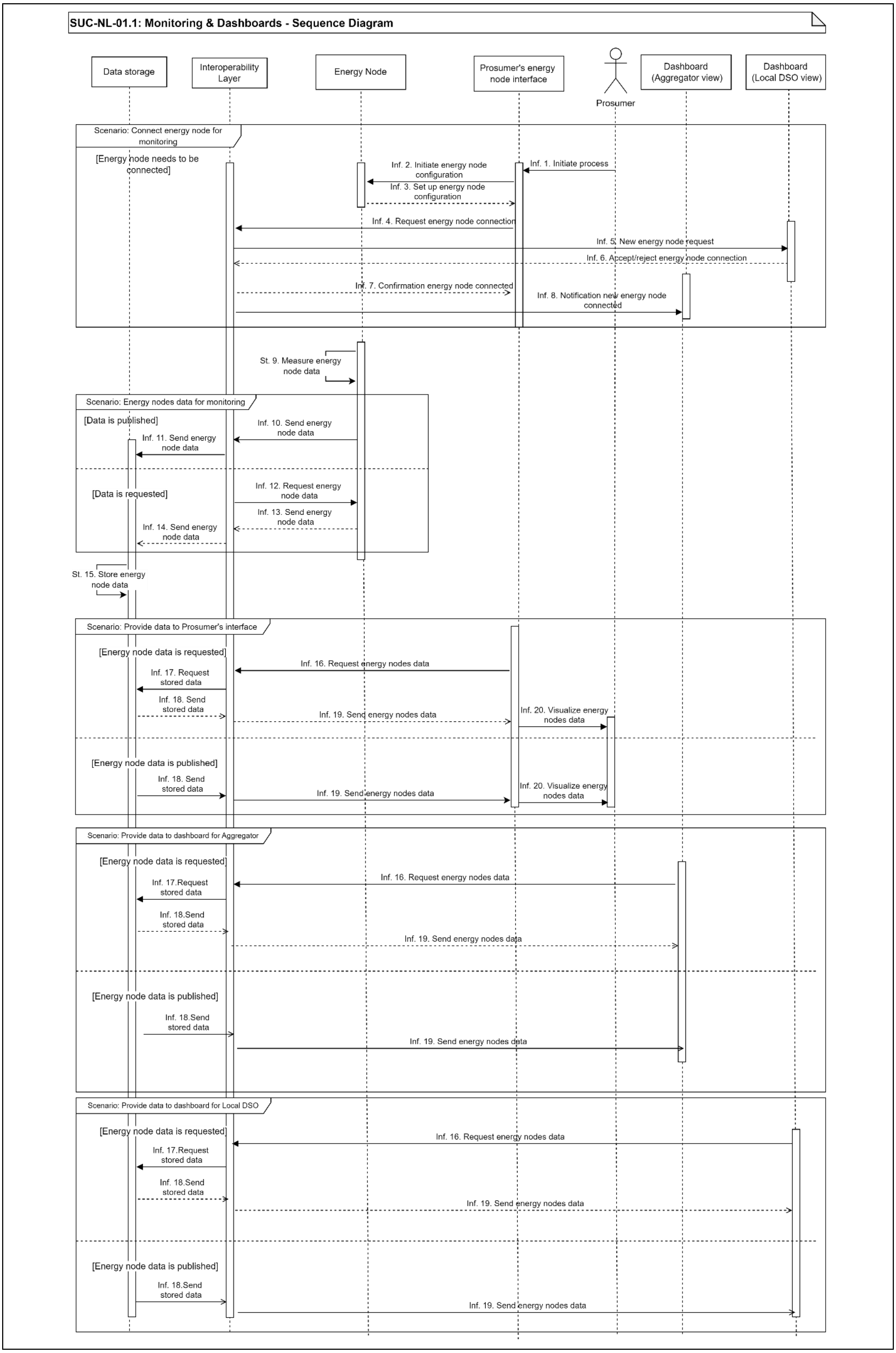

SUC-NL-01.1: Monitoring & Dashboards - Sequence Diagram
Data storage
Interoperability Layer
Energy Node
Prosumer's energy node interface
Prosumer
Dashboard (Aggregator view)
Dashboard (Local DSO view)
Scenario: Connect energy node for monitoring
[Energy node needs to be connected]
Inf. 1. Initiate process
Inf. 2. Initiate energy node configuration
Inf. 3. Set up energy node configuration
Inf. 4. Request energy node connection
Inf. 5. New energy node request
Inf. 6. Accept/reject energy node connection
Inf. 7. Confirmation energy node connected
Inf. 8. Notification new energy node connected
St. 9. Measure energy node data
Scenario: Energy nodes data for monitoring
[Data is published]
Inf. 10. Send energy node data
Inf. 11. Send energy node data
[Data is requested]
Inf. 12. Request energy node data
Inf. 13. Send energy node data
Inf. 14. Send energy node data
St. 15. Store energy node data
Scenario: Provide data to Prosumer's interface
[Energy node data is requested]
Inf. 16. Request energy nodes data
Inf. 17. Request stored data
Inf. 18. Send stored data
Inf. 19. Send energy nodes data
Inf. 20. Visualize energy nodes data
[Energy node data is published]
Inf. 18. Send stored data
Inf. 19. Send energy nodes data
Inf. 20. Visualize energy nodes data
Scenario: Provide data to dashboard for Aggregator
[Energy node data is requested]
Inf. 16. Request energy nodes data
Inf. 17.Request stored data
Inf. 18.Send stored data
Inf. 19. Send energy nodes data
[Energy node data is published]
Inf. 18.Send stored data
Inf. 19. Send energy nodes data
Scenario: Provide data to dashboard for Local DSO
[Energy node data is requested]
Inf. 16. Request energy nodes data
Inf. 17.Request stored data
Inf. 18.Send stored data
Inf. 19. Send energy nodes data
[Energy node data is published]
Inf. 18.Send stored data
Inf. 19. Send energy nodes data

FIGURE 2: UML SEQUENCE DIAGRAM

3 Technical details

3.1 Actors

Actors			
Actor name	***Actor type***	***Actor description***	***Further information specific to this use case***
Prosumer	Business actor	A party that consumes and/or generates electricity.	The combination of: – Visitor or tenant, paying (in)direct, via Grid operator energy bill for using energy for charging EV, or using office (facilities). – Owner of buildings and (e.g. connected) PV, charging stations and batteries Visiting EV User connection car to grid (V2G or normal charging), tenants of office space and/or Arnhems Buiten as Building owner
Aggregator	Business actor	A party that aggregates data for usage by other participants.	Exact content and organization in charge must be defined and selected. Must be aligned with the DSO Alliander.
Local DSO	Operator	A party responsible for providing access to the local grid.	Local/decentral DSO Owner of the Mid and Low voltage grid. Arnhems Buiten
Energy node	Logic actor	A party that consumes and/or generates electricity.	Device that produces and/or consumes energy. It collects energy node data and can share it with other parties. Examples: Battery, Heat Pump, EV, EV charging, PVs, Smart Meters
Data storage	Logic actor	A system responsible for storing energy node data.	Can be a central database as well as local storage for an energy node
Interoperability layer	Logic actor	A system responsible for sharing data between participants in an interoperable manner.	TNO and VU/A as main contributors

3.2 References

References						
No.	***Reference Type***	***Reference***	***Status***	***Impact on use case***	***Originator / organisation***	***Link***

4 Step by step analysis of use case

4.1 Overview of scenarios

Scenario conditions						
No.	**Scenario name**	**Scenario description**	**Primary actor**	**Triggering event**	**Pre-condition**	**Post-condition**
Sc. 1	Connect energy node for monitoring	Before sharing data, the energy nodes need to be connected to the local grid and the interoperability layer with which they'll share their energy node data.	Prosumer	Prosumer wants to connect a new energy node	-	Energy node is connected to the local grid and the network to share data to.
Sc. 2	Measure energy node data for monitoring	Once the energy nodes are up and running, they can start measuring (e.g., their energy production and/or consumption)	Energy Node	Continuously triggered based on a timer	Energy nodes need to be able to measure their energy node data.	Energy node data is available for sharing
Sc. 3	Store energy node data	The Data Storage will receive energy node data via the interoperability layer. This needs to be stored so it can be accessed in the future.	Data Storage	Whenever new energy nodes data becomes available or is requested	Interoperability layer needs to have access to energy node data	Energy node data is stored allowing for future access.
Sc. 4	Provide data to Prosumer's interface	The Prosumer's interface will receive data from the Data Storage to visualize for the Prosumer.	Prosumer's energy node interface	When new measurements become available or when requested	Energy nodes, the interoperability layer and the interface need to be connected through a data-sharing network.	Energy node data is visualized in the Prosumer's energy node interface
Sc. 5	Provide data to dashboards	The dashboard for the Aggregator & Local DSO will receive data from the Data Storage.	Dashboard (Aggregator view & Local DSO view)	When new measurements become available or when requested	Energy nodes, the interoperability layer and the interface need to be connected through a data-sharing network.	Energy node data is shared with the Dashboard (Aggregator view & Local DSO view)

4.2 Steps – Scenarios

Scenario								
Scenario name:		**Sc.1 Connect energy node for monitoring**						
Step No.	**Event**	**Name of process/ activity**	**Description of process/ activity**	**Service**	**Information producer (actor)**	**Information receiver (actor)**	**Information Exchanged (IDs)**	**Requirement, R-IDs**
1	Prosumer wants to connect a new energy node	Initiate process	The Prosumer uses the Prosumer's energy node interface to add a new energy node to the (local) network.	CREATE	Prosumer	Prosumer's energy node interface	Inf 1	QoS.5 Conf.6, Conf.8
2	Initiate process	Initiate energy node configurati on	The Prosumer's energy node interface will set up a new Energy Node	CREATE	Prosumer's energy node interface	Energy node	Inf 2	QoS.5 Conf.6, Conf.8
3	Initiate energy node configuration	Set up energy node configurati on	The Energy Node reports its configuration to the Prosumer's energy node interface	REPORT	Energy Node	Prosumer's energy node interface	Inf 3	QoS.5 Conf.6, Conf.8
4	Set up energy node configuration	Request energy node connection	Prosumer's energy node interface informs the Interoperability layer that a new node wants to join the network and requests the Interoperability layer to connect to the new energy node.	GET	Interoperab ility layer	Prosumer's energy node interface	Inf 4	QoS.5 Conf.6, Conf.8
5	Request energy node connection	New energy node request	Interoperability layer asks whether the new energy node should be connected to the network.	REPORT	Interoperab ility layer	Dashboard (Local DSO view)	Inf 5	QoS.5 Conf.6, Conf.8
6	New energy node request	Accept/rej ect energy node connection	Dashboard (Local DSO view) tells the Interoperability layer whether the new energy node should be	REPORT	Dashboard (Local DSO view)	Interoperabilit y layer	Inf 6	QoS.5 Conf.6, Conf.8

			connected to the network or not.					
7	Accept/reject energy node connection	Notification new energy node connected	Interoperability layer informs the Dashboard (Aggregator view) when a new energy node joins the network.	REPORT	Interoperability layer	Dashboard (Aggregator view)	Inf 7	QoS.5 Conf.6, Conf.8
8	Notification new energy node connected	Confirmation energy node connected	Interoperability layer informs the Prosumer's energy node interface when the new energy node has been connected to the network.	REPORT	Interoperability layer	Prosumer's energy node interface	Inf 8	QoS.5 Conf.6, Conf.8

Scenario								
Scenario name:		***Sc.2 Measure energy node data for monitoring***						
Step No.	***Event***	***Name of process/ activity***	***Description of process/ activity***	***Service***	***Information producer (actor)***	***Information receiver (actor)***	***Information Exchanged (IDs)***	***Requirement, R-IDs***
9	Sc. 1 (New energy node is connected) or timer	Measure energy node data	The Energy Node measures its energy node data.	CREATE	Energy node	–	–	–

Scenario								
Scenario name:		***Sc. 3 Store energy node data***						
Step No.	***Event***	***Name of process/ activity***	***Description of process/ activity***	***Service***	***Information producer (actor)***	***Information receiver (actor)***	***Information Exchanged (IDs)***	***Requirement, R-IDs***
10	New measurements available from Scenario "Measure energy node data for	Send energy node data	The Energy Node sends the newest measurements of energy node data to the Interoperability layer	REPORT	Energy node	Interoperability layer	Inf 10	QoS.2, QoS.3, QoS.4, QoS.5 Sec.2, Sec.4 D.2, D.5, D.6 Conf.3, Conf.4, Conf.6, Conf.8

	monitoring"							O.X
11	New measurements available in Interoperability layer	Send energy node data	The Interoperability layer sends energy node data to Data Storage so that it can be stored for future usage.	REPORT	Interoperability layer	Data Storage	Inf 11	QoS.2, QoS.3, QoS.4, QoS.5 Sec.2, Sec.4 D.2, D.5, D.6 Conf.3, Conf.4, Conf.6, Conf.8 O.X
12	Interoperability layer wants (specific) measurements from Energy Node	Request energy node data	The Interoperability layer requests energy node data from the Energy Node.	GET	Interoperability layer	Energy node	Inf 12	QoS.2, QoS.3, QoS.4, QoS.5 Sec.2, Sec.4 D.2, D.5, D.6 Conf.3, Conf.4, Conf.6, Conf.8 O.X
13	Energy node receives request for energy node data	Send energy node data	Energy node sends requested energy node data to Interoperability layer		Energy node	Interoperability layer	Inf 13	QoS.2, QoS.3, QoS.4, QoS.5 Sec.2, Sec.4 D.2, D.5, D.6 Conf.3, Conf.4, Conf.6, Conf.8 O.X
14	Interoperability layer received requested	Send energy node data	Interoperability layer shares requested energy node data with the Data storage for storage.	REPORT	Interoperability layer	Data storage	Inf 14	QoS.2, QoS.3, QoS.4, QoS.5 Sec.2, Sec.4 D.2, D.5, D.6

	data from energy node							Conf.3, Conf.4, Conf.6, Conf.8 O.X
15	Data storage receives energy node data	Store energy node data	Data Storage receives energy node data and stores it so that it can be used in the future	CREATE	Data storage	-	-	-

Scenario								
Scenario name:		***Sc. 4 Provide data to Prosumer's interface***						
Step No.	***Event***	***Name of process/ activity***	***Description of process/ activity***	***Service***	***Information producer (actor)***	***Information receiver (actor)***	***Information Exchanged (IDs)***	***Requirement, R-IDs***
16	Dashboard wants new information	Send energy nodes data	Dashboard sends a request for energy nodes data to the interoperability layer	REPORT	Dashboard (Aggregator or Local DSO view)	Interoperability layer	Inf 16	QoS.2, QoS.3, QoS.4, QoS.5 Sec.2, Sec.4 D.2, D.5, D.6 Conf.3, Conf.4, Conf.6, Conf.8 O.X
17	Interoperability layer has received a request for stored data	Request stored data	The Interoperability layer will forward the request to the Data Storage when data needs to be	REPORT	Interoperability layer	Data Storage	Inf 17	QoS.2, QoS.3, QoS.4, QoS.5 Sec.2, Sec.4 D.2, D.5, D.6 Conf.3, Conf.4, Conf.6, Conf.8 O.X

18	Based on a timer or after Data Storage has received a request for data	Send stored data	The Data Storage will send energy node data to the Interoperability layer when this is requested or based on a timer.	REPORT	Data Storage	Interoperability layer	Inf 18	QoS.2, QoS.3, QoS.4, QoS.5 Sec.2, Sec.4 D.2, D.5, D.6 Conf.3, Conf.4, Conf.6, Conf.8 O.X
19	Interoperability layer has energy node data available	Send energy nodes data	The Interoperability layer will send energy node data to the appropriate dashboards when it receives it	REPORT	Interoperability layer	Dashboard (Aggregator or Local DSO view)	Inf 19	QoS.2, QoS.3, QoS.4, QoS.5 Sec.2, Sec.4 D.2, D.5, D.6 Conf.3, Conf.4, Conf.6, Conf.8 O.X
20	Prosumer's interface receives energy node data	Visualize energy nodes data	The Prosumer's interface receives new energy nodes data and will use this to update the visualizations for the Prosumer.	REPORT	Prosumer's energy node interface	Prosumer	Inf 20	QoS.2, QoS.3, QoS.4, QoS.5 Sec.2, Sec.4 D.2, D.5, D.6 Conf.3, Conf.4, Conf.6, Conf.8 O.X

Scenario								
Scenario name:	***Sc. 5 Provide data to dashboards***							
Step No.	***Event***	***Name of process/ activity***	***Description of process/ activity***	***Service***	***Information producer (actor)***	***Information receiver (actor)***	***Information Exchanged (IDs)***	***Requirement, R-IDs***
16	Dashboard wants new	Send energy	Dashboard sends a request for energy nodes data to the	REPORT	Dashboard (Aggregator	Interoperabilit y layer	Inf 16	QoS.2, QoS.3, QoS.4, QoS.5 Sec.2, Sec.4

	information	nodes data	interoperability layer		or Local DSO view)			D.2, D.5, D.6 Conf.3, Conf.4, Conf.6, Conf.8 O.X
17	Interoperability layer has received a request for stored data	Request stored data	The Interoperability layer will forward the request to the Data Storage when data needs to be	REPORT	Interoperability layer	Data Storage	Inf 17	QoS.2, QoS.3, QoS.4, QoS.5 Sec.2, Sec.4 D.2, D.5, D.6 Conf.3, Conf.4, Conf.6, Conf.8 O.X
18	Based on a timer or after Data Storage has received a request for data	Send stored data	The Data Storage will send energy node data to the Interoperability layer when this is requested or based on a timer.	REPORT	Data Storage	Interoperability layer	Inf 18	QoS.2, QoS.3, QoS.4, QoS.5 Sec.2, Sec.4 D.2, D.5, D.6 Conf.3, Conf.4, Conf.6, Conf.8 O.X
19	Interoperability layer has energy node data available	Send energy nodes data	The Interoperability layer will send energy node data to the appropriate dashboards when it receives it	REPORT	Interoperability layer	Dashboard (Aggregator or Local DSO view)	Inf 19	QoS.2, QoS.3, QoS.4, QoS.5 Sec.2, Sec.4 D.2, D.5, D.6 Conf.3, Conf.4, Conf.6, Conf.8 O.X

5 Information exchanged

Information exchanged			
Information exchanged (ID)	**Name of information**	**Description of information exchanged**	**Requirement, R-IDs**
Inf 1	Initiate process	Device information of device that is to be connected, e.g. device manufacturer, identifier and device's IP address.	QoS.5 Conf.6, Conf.8
Inf 2	Initiate energy node configuration	Interface searches for contact with device via its endpoint.	QoS.5 Conf.6, Conf.8
Inf 3	Set up energy node configuration	Reply to confirm communication between energy node and Prosumer's interface	QoS.5 Conf.6, Conf.8
Inf 4	Request energy node connection	A request with information about which energy node (device identifier & endpoint) wants to join the network.	QoS.5 Conf.6, Conf.8
Inf 5	Request to add new energy node to the network	Device identifier, device endpoint, registration data	QoS.5 Conf.6, Conf.8
Inf 6	Acceptance/rejection notification for new energy node	Yes/no whether the energy node is allowed to join the network. It will also share the device identifier to indicate which device can(not) join.	QoS.5 Conf.6, Conf.8
Inf 7	Confirmation energy node connected	Confirmation that the energy node has been connected to the network. It will share the device identifier and endpoint.	QoS.5 Conf.6, Conf.8
Inf 8	Notification new energy node connected	Confirmation that a new energy node has been connected to the network. It will share the device identifier and endpoint.	QoS.5 Conf.6, Conf.8
Inf 10	Publish energy node data from energy node to interoperability layer	Energy node publishes its newest energy node data measurement to the interoperability layer	QoS.2, QoS.3, QoS.4, QoS.5 Sec.2, Sec.4 D.2, D.5, D.6 Conf.3, Conf.4, Conf.6, Conf.8 O.X
Inf 11	Publish energy node data from interoperability layer to data storage	The Interoperability layer sends the received data from the energy node to the data storage and indicates to which energy node the data belongs.	QoS.2, QoS.3, QoS.4, QoS.5 Sec.2, Sec.4 D.2, D.5, D.6 Conf.3, Conf.4, Conf.6, Conf.8

			O.X
Inf 12	Request energy node data	The Interoperability layer sends a request for energy node data of a specific time to the energy node	QoS.2, QoS.3, QoS.4, QoS.5 Sec.2, Sec.4 D.2, D.5, D.6 Conf.3, Conf.4, Conf.6, Conf.8 O.X
Inf 13	Reply with energy node data from energy node to interoperability layer	Energy node sends the energy node data for the requested time.	QoS.2, QoS.3, QoS.4, QoS.5 Sec.2, Sec.4 D.2, D.5, D.6 Conf.3, Conf.4, Conf.6, Conf.8 O.X
Inf 14	Forward energy node data from interoperability layer to data storage	Interoperability layer forwards the received data from the energy node to the data storage. It forwards the energy node data as well as the time and the energy node that it belongs to.	QoS.2, QoS.3, QoS.4, QoS.5 Sec.2, Sec.4 D.2, D.5, D.6 Conf.3, Conf.4, Conf.6, Conf.8 O.X
Inf 16	Request energy nodes data	An interface requests new energy nodes data from the interoperability layer. It may indicate - A specific device - A specific period - Type of data (e.g. energy production or consumption)	QoS.2, QoS.3, QoS.4, QoS.5 Sec.2, Sec.4 D.2, D.5, D.6 Conf.3, Conf.4, Conf.6, Conf.8 O.X
Inf 17	Request stored data	Interoperability layer retrieves the requested data from the parties that have stored it.	QoS.2, QoS.3, QoS.4, QoS.5 Sec.2, Sec.4 D.2, D.5, D.6 Conf.3, Conf.4, Conf.6, Conf.8 O.X

Inf 18	Send stored data	Data storage will return the requested data from Inf 16 that it has available.	QoS.2, QoS.3, QoS.4, QoS.5 Sec.2, Sec.4 D.2, D.5, D.6 Conf.3, Conf.4, Conf.6, Conf.8 O.X
Inf 19	Send energy nodes data	Data storage sends energy nodes data if it knows that the interface is interested in it.	QoS.2, QoS.3, QoS.4, QoS.5 Sec.2, Sec.4 D.2, D.5, D.6 Conf.3, Conf.4, Conf.6, Conf.8 O.X
Inf 20	Visualize energy nodes data	Interface visualizes the energy nodes data which can then be inspected by the Prosumer. These will be e.g. bar graphs or line charts indicating energy production and consumption. The data may be visualized per energy node or aggregated.	QoS.2, QoS.3, QoS.4, QoS.5 Sec.2, Sec.4 D.2, D.5, D.6 Conf.3, Conf.4, Conf.6, Conf.8 O.X

6 Requirements

	Quality of Service Requirements	
Categories ID	**Category name for requirements**	**Category description**
QoS	Quality of Service	Generic properties that service/SUC should provide – quality attributes.
Requirement R-ID	**Requirement name**	**Requirement description**
QoS.2	Elapsed time response requirements for exchanging data	More than 10 seconds
QoS.3	Availability of information flows	Continuous availability not required but must be available at specific times or under specific conditions
QoS.4	Accuracy of data requirements	Adequate accuracy can be assumed
QoS.5	Frequency of data exchanges	Upon event

	Security Requirements	
Categories ID	**Category name for requirements**	**Category description**
Sec	Security	Authentication of user, confidentiality, integrity, prevention of denial of service, non-repudiation or accountability, error management.
Requirement R-ID	**Requirement name**	**Requirement description**
Sec.2	Eavesdropping	Ensuring confidentiality, avoiding illegitimate use of data, and preventing unauthorized reading of data, is: Quite important

Sec.4	Authentication and Access Control mechanisms commonly used with this data exchange	Public key encryption (e.g. SSL/TLS)

Data Management Requirements		
Categories ID	**Category name for requirements**	**Category description**
D	Data Management	Type of source of data, correctness or validity of data, timeliness or time stamping of data, volume of data, synchronization, or consistency of data across systems, timely access to data, validation of data across organizational boundaries, transaction management, data naming, identification, formats across disparate systems, maintenance of data and databases.
Requirement R-ID	**Requirement name**	**Requirement description**
D.2	Correctness of source data	Source data is always correct (e.g. by definition)
D.5	Management of data across organizational boundaries	Data exchanges go across organizational boundaries
D.6	Data maintenance effort: human versus automation	Data maintenance is mostly automated buy requires occasional intervention

Discovery and Configuration Requirements		
Categories ID	**Category name for requirements**	**Category description**
Conf	Configuration	Locations, distances, communication layout, commonly used communication protocol media, network bandwidth, existing protocols, number of devices, systems, volume of data items, expected growth, etc.
Requirement R-ID	**Requirement name**	**Requirement description**
Conf.2	Distance between entities	Varies and/or is not relevant
Conf.3	Number of Information Producers	Few to a hundred
Conf.4	Number of Information Receivers	Two to a few
Conf.6	Data exchange methods	Other: REST API (client-server)
Conf.7	Communication access services requirements	Request-response
Conf.8	Commonly used communication protocol	Natively REST, other protocols (e.g., MODBUS, MQTT) supported via semantic adapters.

Other Requirements		
Categories ID	**Category name for requirements**	**Category description**

O	Regulatory obligation related to privacy	2016/679 GDPR (General Data Protection Regulation)
Requirement R-ID	**Requirement name**	**Requirement description**
O.2	Personal data use	Personal data may not be processed unless there is at least one legal basis to do so.
O.3	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.
O.4	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.
O.5	Data retention policy	Personal data may not be transferred to a third-party if the data subject did not agree and the third party provide appropriate safeguard.
O.X	All constraints also apply.	All requirements in this category.

7 Common Terms and Definitions

Common Terms and Definitions	
Term	**Definition**
Energy nodes	Hardware such as batteries, heat pumps, PVs, EV-chargers, smart meters and other energy (flexibility) assets with interoperable interface/connection and owned by the Prosumer
EMS	Energy Management System. The solution and therefore provider has to be selected.
BMS	Building Management System
EV	Electric Vehicle
PV	Photo Voltaic
HP	Heat Pump
DSO	Distribution System Operator
V2G	Vehicle-to-Grid. A technology that allows energy from a vehicle's battery to flow to the grid.

2 SUC-NL-01.2 – INTEGRATE ENERGY NODES AND EMS/BMS VIA SEMANTICS FOR CONTROL AND EXPLAINABILITY

1 Description of the use case

1.1 Name of the use case

ID	Area / Domain(s) / Zones(s)	Name of Use Case
SUC-NL-01.2	Energy Flexibility at business park	Integrate energy nodes and EMS/BMS via semantics for control and explainability [Semantic integration energy nodes]

1.2 Version management

Version Management			
Version No.	**Date**	**Name of Author(s)**	**Changes**
1	08-09-2024	W.Beelen (AB)	Draft outline of use case
2	09-09-2024	L.Daniele (TNO)	Added use case and sequence diagrams, actors, scenarios, information exchanged
3	18-09-2024	L.Daniele (TNO)	Updated use case diagram to incorporate Leo's (Trialog) feedback
4	23-09-2024	L.Daniele (TNO)	Updated SUC name according to naming convention. Added steps of the scenarios.
5	1-10-2024	W.Beelen (AB) & L. Daniele (TNO)	Updates 1.4, 1.5 and 1.6, and added requirements

1.3 Scope and objectives of use case

Scope and Objectives of Use Case	
Scope	The decentral grid of Arnhems Buiten
Objective(s)	3. Detection of (new) energy nodes 4. Creating semantic adapters 5. Explainability via semantics
Related business case(s)	BUC-NL-01 – Energy Flexibility at business park BUC-NL-02 – Enhance local grid resilience based on detection & prevention

1.4 Narrative of use case

Narrative of Use Case
Short description
This use case describes the process of integrating energy nodes and an Energy Management System (EMS) or Building Management System (BMS) using semantic technologies for enhanced control, explainability, and human-in-the-loop interaction. The goal is to enable seamless communication and interoperability between heterogeneous energy nodes and the central management system, while providing a transparent and understandable interface for human operators.
Complete description

This use case aims to optimize energy flexibility and fault detection in commercial buildings by seamlessly integrating a variety of energy nodes (solar panels, batteries, electric vehicles, heat pumps, HVAC systems) into a unified Energy Management System (EMS) or Building Management System (BMS). By leveraging semantic technologies, the system can effectively manage and optimize energy consumption, production, and storage.

Key Features:

- **Semantic Data Modeling:** Represent energy concepts and system components using ontologies and knowledge graphs to enable intelligent decision-making.
- **Knowledge Graph Creation:** Establish relationships between energy nodes, system components, and their properties to understand the overall system behavior.
- **Energy Optimization:** Use the knowledge graph to optimize energy consumption, production, and storage based on factors like energy prices, grid conditions, and building demands.
- **Fault Detection and Diagnosis:** Analyze data from energy nodes and the knowledge graph to identify potential faults and their root causes.
- **Human-in-the-Loop Interaction:** Provide a user-friendly interface for human operators to monitor system performance, configure settings, and receive alerts.

Benefits:

- **Improved Energy Efficiency:** Optimize energy consumption and reduce energy costs.
- **Increased Reliability:** Proactively detect and address faults to minimize downtime.
- **Enhanced Flexibility:** Adapt to changing energy conditions and grid requirements.
- **Data-Driven Decision Making:** Utilize semantic technologies to make informed decisions based on real-time data and historical trends.

Technical Considerations:

- **Semantic Technologies:** Employ ontologies, knowledge graphs, and semantic web services to represent and reason about energy data.
- **Communication Protocols:** Use appropriate communication protocols (e.g., MQTT, OPC UA, Modbus) to exchange data between energy nodes and the EMS/BMS.
- **Data Privacy:** Ensure compliance with data privacy regulations and protect sensitive information.
- **Scalability:** Design the system to accommodate future growth and changes in energy needs.

By effectively integrating energy nodes and leveraging semantic technologies, this use case can significantly enhance the efficiency, reliability, and sustainability of commercial building energy systems.

1.5 Key performance indicators (KPI)

ID	*Name*	*Description*	*Reference to mentioned use case objectives*
OB1	Different types of IoT/edge devices to be exploited in Demo Areas e.g., Smart Meter, HEMS, Sensors, inverter	Number of energy nodes that are integrated via semantics	Objectives 1
KPI3	% Of planned usage of HEDGE-IoT tools/data services (e.g., transactions, periodicity) in field demos	% of total services that are being used for this SUC in the Dutch pilot	Objectives 2&3

1.6 Use case conditions

Use case conditions
Assumptions
• **Reliable Communication Infrastructure**: There should be a reliable communication infrastructure capable of real-time data transmission from energy nodes to the central system. • **Compatibility of Energy Nodes**: All energy nodes (heat pumps, smart meters, batteries, V2G chargers) are compatible with the central data management system and can communicate seamlessly. • **Energy nodes are physically connected to the network.** • **EMS/BMS is operational.** • **Semantic adapter software is available and configured.** • **System integrator has the necessary expertise and permissions.**
Prerequisites

• **Hardware Infrastructure:**
    o Suitable communication network (e.g., Ethernet, Wi-Fi) to connect energy nodes and the central system.
    o Sufficient computing power and storage capacity for the EMS/BMS to handle data processing, analysis, and decision-making.
    o Appropriate sensors and communication interfaces on energy nodes to collect and transmit data.
• **Software Components:**
    o EMS/BMS software with the capability to integrate and manage heterogeneous energy nodes.
    o Semantic web tools and libraries for ontology development, knowledge graph creation, and reasoning.
    o Data management and storage systems for storing and accessing energy data.
• **Communication Protocols:**
    o Standardized communication protocols to ensure interoperability between energy nodes and the central system.
• **Data-Related Prerequisites:**
    o **Data Quality:** Ensure the accuracy, completeness, and consistency of data collected from energy nodes.
    o **Data Security:** Implement robust security measures to protect sensitive data and prevent unauthorized access.
    o **Data Privacy:** Comply with relevant data privacy regulations and protect personal information.
• **Organizational Prerequisites:**
    o **Clear Objectives:** Define clear goals and objectives for the integration project, including desired outcomes and benefits.
    o **Stakeholder Alignment:** Involve relevant stakeholders (e.g., facility managers, IT personnel, energy experts) and ensure their support and commitment.
• **Domain Knowledge Prerequisites:**
    o **Energy Systems Understanding:** Have a deep understanding of energy systems, including energy production, consumption, storage, and grid interactions.
    o **Semantic Technologies Expertise:** Possess knowledge of semantic web technologies, ontologies, and knowledge graphs.
    o **Building Automation Systems Familiarity:** Be familiar with building automation systems and their functionalities.

1.7 Further Information to the use case for classification / mapping

Classification Information
Relation to other use cases
Used as System Use Case for both BUC-NL-01 and BUC-NL-02
Level of depth
Prioritisation
Generic, regional or national relation
Nature of the use case
System use case
Further keywords for classification
Energy nodes, real-time data, storage, monitoring

1.8 General Remarks

General Remarks
Energy nodes contain: Buildings, charging stations, EV (via V2G), Batteries, PV

2 Diagrams of use case

Diagram(s) of use case

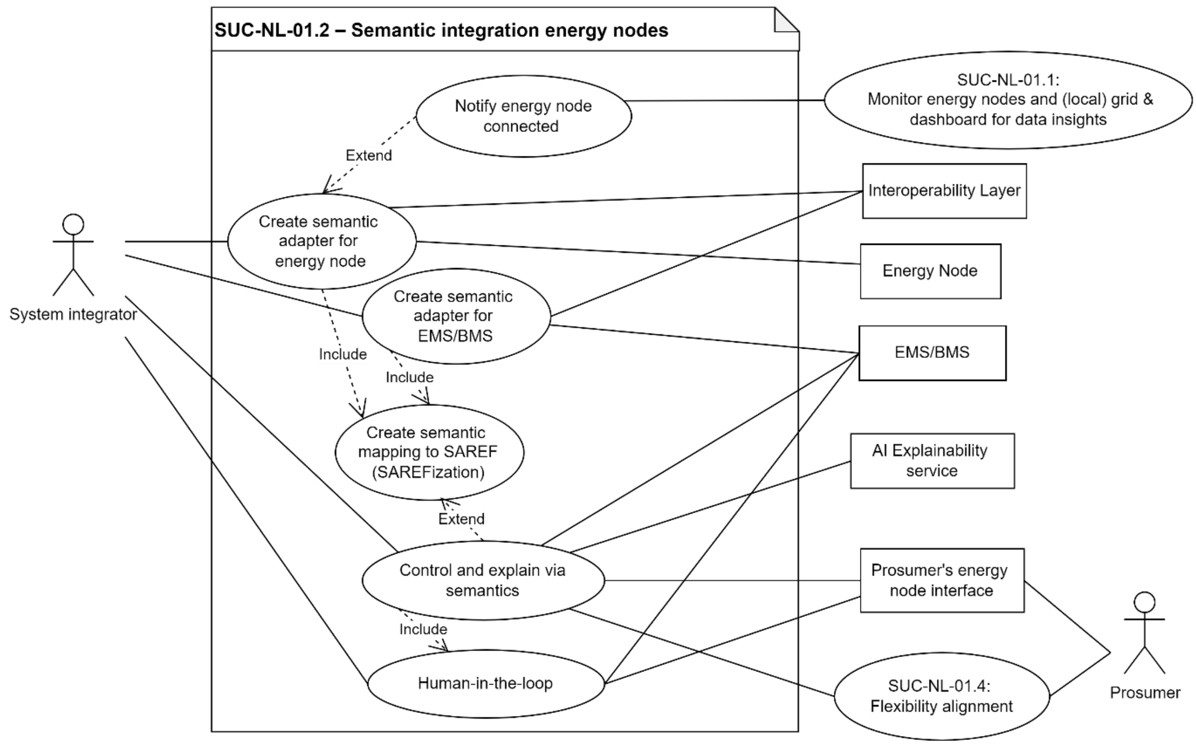


FIGURE 3: UML USE CASE DIAGRAM

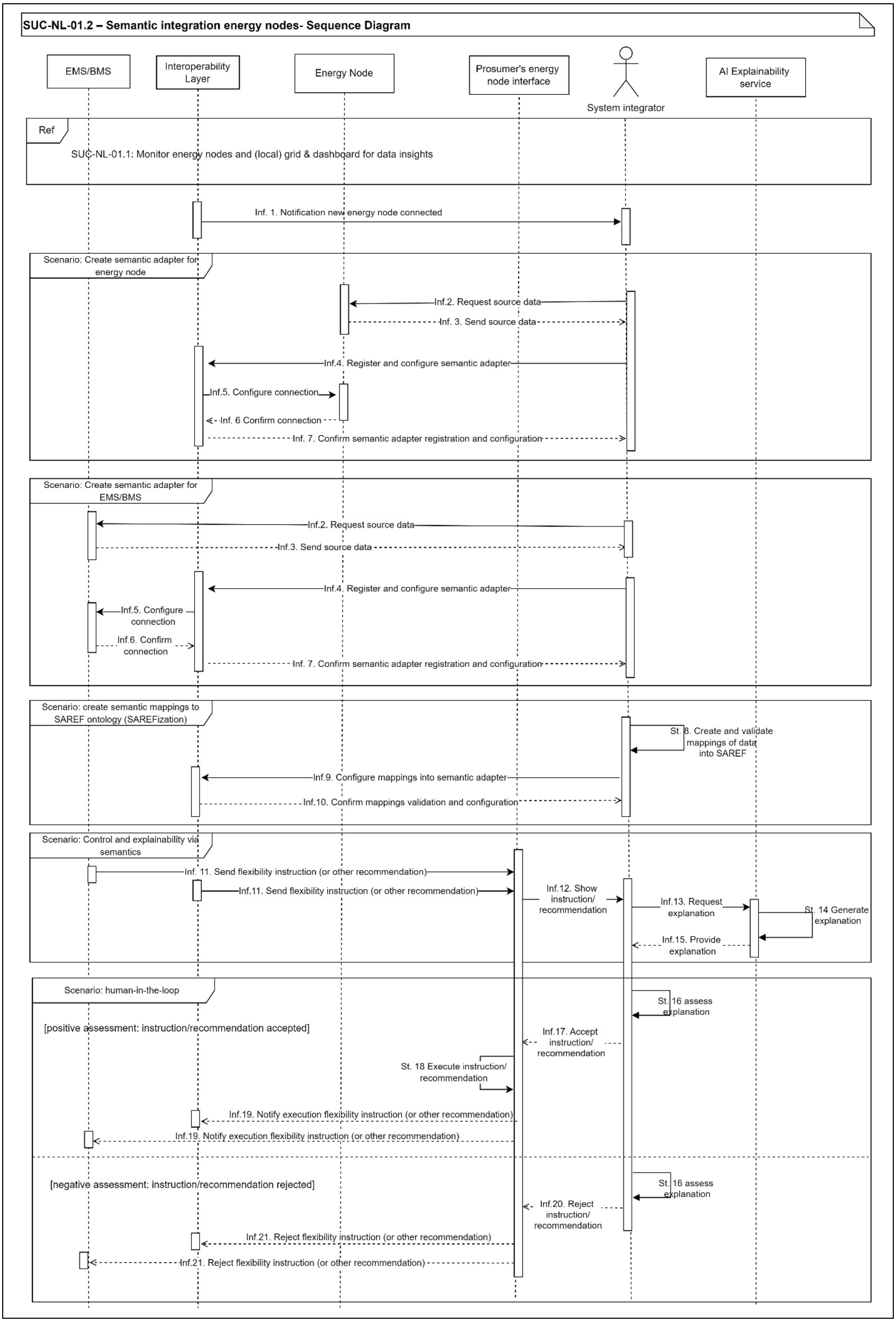

SUC-NL-01.2 – Semantic integration energy nodes- Sequence Diagram
EMS/BMS
Interoperability Layer
Energy Node
Prosumer's energy node interface
System integrator
AI Explainability service
Ref
SUC-NL-01.1: Monitor energy nodes and (local) grid & dashboard for data insights
Inf. 1. Notification new energy node connected
Scenario: Create semantic adapter for energy node
Inf.2. Request source data
Inf. 3. Send source data
Inf.4. Register and configure semantic adapter
Inf.5. Configure connection
Inf. 6 Confirm connection
Inf. 7. Confirm semantic adapter registration and configuration
Scenario: Create semantic adapter for EMS/BMS
Inf.2. Request source data
Inf.3. Send source data
Inf.4. Register and configure semantic adapter
Inf.5. Configure connection
Inf.6. Confirm connection
Inf. 7. Confirm semantic adapter registration and configuration
Scenario: create semantic mappings to SAREF ontology (SAREFization)
St. 8. Create and validate mappings of data into SAREF
Inf.9. Configure mappings into semantic adapter
Inf.10. Confirm mappings validation and configuration
Scenario: Control and explainability via semantics
Inf. 11. Send flexibility instruction (or other recommendation)
Inf.11. Send flexibility instruction (or other recommendation)
Inf.12. Show instruction/ recommendation
Inf.13. Request explanation
St. 14 Generate explanation
Inf.15. Provide explanation
Scenario: human-in-the-loop
[positive assessment: instruction/recommendation accepted]
St. 16 assess explanation
Inf.17. Accept instruction/ recommendation
St. 18 Execute instruction/ recommendation
Inf.19. Notify execution flexibility instruction (or other recommendation)
Inf.19. Notify execution flexibility instruction (or other recommendation)
[negative assessment: instruction/recommendation rejected]
St. 16 assess explanation
Inf.20. Reject instruction/ recommendation
Inf.21. Reject flexibility instruction (or other recommendation)
Inf.21. Reject flexibility instruction (or other recommendation)

FIGURE 4: UML SEQUENCE DIAGRAM

3 Technical details

3.1 Actors

Actors			
Actor name	***Actor type***	***Actor description***	***Further information specific to this use case***
EMS/BMS	Logic actor	The EMS can be integrated into the Interoperability Layer (which is the system responsible for sharing data between participants in an interoperable manner)	The EMS can be integrated into the Interoperability Layer (which is the system responsible for sharing data between participants in an interoperable manner)
Interoperability layer	Logic actor	A system responsible for sharing data between participants in an interoperable manner.	TNO and VU/A as main contributors
Energy node	Logic actor	A party that consumes and/or generates electricity.	Device that produces and/or consumes energy. It collects energy node data and can share it with other parties. Examples: Battery, Heat Pump, EV, EV charging, PVs, Smart Meters
Prosumer	Business actor	A party that consumes and/or generates electricity.	The combination of: – Visitor or tenant, paying (in)direct, via Grid operator) energy bill for using energy for charging EV, or using office (facilities). - Owner of buildings and (e.g. connected) PV, charging stations and batteries) - Visiting EV User connection car to grid (V2G or normal charging), tenants of office space and/or Arnhems Buiten as Building owner
Prosumer's Energy node interface	Logic actor	The user interface through which the prosumers can configure and control their energy nodes	
System Integrator	Operator	A party that is responsible for semantic integration and explainability	Initially data scientists from TNO/VU-A. During the project this can become a commercial party and then will become a logic or business actor
AI explainability service	Logic actor	A system that is dedicated to providing an explanation about certain instructions or recommendations	It can be offered as a separate external service, or it can be integrated in the interoperability layer

3.2 References

References (which are standards, reports, mandates and regulatory constraints) associated with the use case.

References						
No.	***Reference Type***	***Reference***	***Status***	***Impact on use case***	***Originator / organisation***	***Link***

4 Step by step analysis of use case

4.1 Overview of scenarios

Scenario conditions						
No.	**Scenario name**	**Scenario description**	**Primary actor**	**Triggering event**	**Pre-condition**	**Post-condition**
Sc.1	Notify energy node connected	Before sharing data, the energy nodes need to be connected to the local grid and the interoperability layer (Reference to SUC1). In this scenario, the interoperability layer notifies the system integrator about the successful connection of a new energy node.	Interoperability Layer	A new node is connected by the prosumer to the interoperability layer	Energy node is connected to the local grid and the interoperability layer to share data	The System Integrator is notified about the new energy node connected, which is now ready to be also semantically integrated
Sc. 2	Create semantic adapter for energy node	The first step for semantic integration is to create and configure a semantic adapter into the interoperability layer. This scenario creates a semantic adapter for an energy node.	System Integrator	Whenever a new energy node becomes available to the System Integrator	System integrator available to do some development to configure the semantic adaptor.	Semantic adapter connected to the Interoperability Layer for sharing semantically enriched data
Sc. 3	Create semantic adapter for EMS/BMS	The first step for semantic integration is to create and configure a semantic adapter into the interoperability layer. This scenario creates	System Integrator	Whenever a new energy node becomes available to the System Integrator	System integrator available to do some development to configure the semantic adaptor.	Semantic adapter connected to the Interoperability Layer for sharing semantically enriched data

		a semantic adapter for an EMS and/or BMS.				
Sc. 4	Create semantic mapping to SAREF (SAREFization)	The data exchanged by an energy node and EMS/BMS (or any other service offered via the interoperability layer) is translated (mapped) into the SAREF ontology. The mappings are also validated (manually or automatically) to be sure that they are SAREF-compliant.	System Integrator	Whenever a new energy node becomes available to the System Integrator (i.e., together with Sc.2 and Sc.3); OR after creating a semantic adapter (i.e., following Sc.2 and Sc.3)	Data exchanged among energy node(s) and EMS/BMS needs to be available to the System Integrator.	Sematic mappings verified. Semantically enriched data ready to be shared using the semantic adapter.
Sc. 5	Control and explain via semantics	Explanations can be requested by a human why certain instructions (or more general recommendations) coming from the EMS/BMS and/or via the interoperability layer have been generated.	AI explainability service	When a human (e.g., the System Integrator) requests an explanation before the system (e.g., EMS) actuates the control	Instruction/recommendation available to the human (e.g., System Integrator)	An explanation is available about the reasons a certain instruction or recommendation has been generated
Sc. 6	Human-in-the-loop	A human is brought into the loop to investigate and verify instructions and recommendations generated by AI (machines and algorithms) The human assessment can override the execution commands previously given by the EMS/BMS.	System Integrator	When an explanation has been provided for human assessment/feedback	Explanation of Instruction/recommendation available to the human (e.g., System Integrator)	Control of energy nodes is executed according to plan, otherwise instruction/recommendation is overridden by the human

4.2 Steps – Scenarios

Scenario								
Scenario name:		Sc. 1 – Notify energy node connected						
Step No.	Event	Name of process/ activity	Description of process/ activity	Service	Information producer (actor)	Information receiver (actor)	Information Exchanged (IDs)	Requirement, R-IDs
1	Connected energy node for monitoring (SUC1)	Notification new energy node connected	The Interoperability Layer notifies the System Integrator about the successful connection of a new energy node.	REPORT	Interoperability Layer	System Integrator	Inf. 1	QoS.3, QoS.4, QoS.5 Sec.2, Sec.3, Sec.4 D.2, D.6 Conf.2, Conf.3, Conf.4, Conf.8 O.X

Scenario								
Scenario name:		Sc. 2 - Create semantic adapter for energy node						
Step No.	Event	Name of process/ activity	Description of process/ activity	Service	Information producer (actor)	Information receiver (actor)	Information Exchanged (IDs)	Requirement, R-IDs
2	Notification new energy node connected	Request source data	The System Integrator requests a newly connected Energy Node to send the data to be made semantically interoperable.	REPORT	System Integrator	Energy Node	Inf. 2	QoS.3, QoS.4, QoS.5 Sec.2, Sec.3, Sec.4 D.2, D.5, D.6 Conf.2, Conf.3, Conf.4, Conf.6, Conf.7, Conf.8 O.X
3	Request source data	Send source data	The Energy Node replies to the System Integrator with the requested data.	GET	Energy Node	System Integrator	Inf. 3	QoS.3, QoS.4, QoS.5 Sec.2, Sec.3, Sec.4

								D.2, D.5, D.6 Conf.2, Conf.3, Conf.4, Conf.6, Conf.7, Conf.8 O.X
4	Send source data	Register and configure semantic adapter	The System Integrator develops a semantic adapter for the Energy Node and configures it into the Interoperability Layer.	CREATE	System Integrator	Interoperability Layer	Inf. 4	QoS.3, QoS.4, QoS.5 Sec.2, Sec.3, Sec.4 D.2, D.5, D.6 Conf.6, Conf.7, Conf.8
5	Register and configure semantic adapter	Configure connection	The Interoperability Layer contacts the Energy Node and configures the connection of the semantic adapter.	CREATE	Interoperability Layer	Energy Node	Inf. 5	QoS.3, QoS.4, QoS.5 Sec.2, Sec.3, Sec.4 D.2, D.5, D.6 Conf.6, Conf.7, Conf.8
6	Configure connection	Confirm connection	The Energy Node configures the connection of the semantic adapter with the Interoperability Layer and confirms that it has been successfully established.	REPORT	Energy Node	Interoperability Layer	Inf. 6	QoS.3, QoS.4, QoS.5 Sec.2, Sec.3, Sec.4 D.2, D.5, D.6 Conf.6, Conf.7, Conf.8
7	Confirm connection	Confirm semantic adapter registration and configuration	The Interoperability Layer confirms to the System Integrator that the semantic adapter for that specific energy node has been successfully registered and configured	REPORT	Interoperability Layer	System Integrator	Inf. 7	QoS.3, QoS.4, QoS.5 Sec.2, Sec.3, Sec.4 D.2, D.5, D.6 Conf.6, Conf.7, Conf.8

Scenario								
Scenario name:		Sc. 3 – Create semantic adapter for EMS/BMS						
Step No.	**Event**	**Name of process/ activity**	**Description of process/ activity**	**Service**	**Information producer (actor)**	**Information receiver (actor)**	**Information Exchanged (IDs)**	**Requirement, R-IDs**
8	Notification new EMS/BMS connected	Request source data	The System Integrator requests the EMS/BMS to send the data to be made semantically interoperable for exchange with energy nodes.	REPORT	System Integrator	Energy Node	Inf. 2	QoS.3, QoS.4, QoS.5 Sec.2, Sec.3, Sec.4 D.2, D.5, D.6 Conf.2, Conf.3, Conf.4, Conf.6, Conf.7, Conf.8 O.X
9	Request source data	Send source data	The EMS/BMS replies to the System Integrator with the requested data.	GET	Energy Node	System Integrator	Inf. 3	QoS.3, QoS.4, QoS.5 Sec.2, Sec.3, Sec.4 D.2, D.5, D.6 Conf.2, Conf.3, Conf.4, Conf.6, Conf.7, Conf.8 O.X
10	Send source data	Register and configure semantic adapter	The System Integrator develops a semantic adapter for the EMS/BMS and configures it into the Interoperability Layer.	CREATE	System Integrator	Interoperability Layer	Inf. 4	QoS.3, QoS.4, QoS.5 Sec.2, Sec.3, Sec.4 D.2, D.5, D.6 Conf.6, Conf.7, Conf.8
11	Register and configure semantic	Configure connection	The Interoperability Layer contacts the EMS/BMS and	CREATE	Interoperability Layer	Energy Node	Inf. 5	QoS.3, QoS.4, QoS.5 Sec.2, Sec.3, Sec.4

	adapter		configures the connection of the semantic adapter.					D.2, D.5, D.6 Conf.6, Conf.7, Conf.8
12	Configure connection	Confirm connection	The EMS/BMS configures the connection of the semantic adapter with the Interoperability Layer and confirms that it has been successfully established.	REPORT	Energy Node	Interoperability Layer	Inf. 6	QoS.3, QoS.4, QoS.5 Sec.2, Sec.3, Sec.4 D.2, D.5, D.6 Conf.6, Conf.7, Conf.8
13	Confirm connection	Confirm semantic adapter registration and configuration	The Interoperability Layer confirms to the System Integrator that the semantic adapter for the EMS/BMS has been successfully registered and configured	REPORT	Interoperability Layer	System Integrator	Inf. 7	QoS.3, QoS.4, QoS.5 Sec.2, Sec.3, Sec.4 D.2, D.5, D.6 Conf.6, Conf.7, Conf.8

Scenario								
Scenario name:		Sc. 4 – Create semantic mapping to SAREF (SAREFization)						
Step No.	***Event***	***Name of process/ activity***	***Description of process/ activity***	***Service***	***Information producer (actor)***	***Information receiver (actor)***	***Information Exchanged (IDs)***	***Requirement, R-IDs***
14	Confirm semantic adapter registration and configuration	Create and validate mappings of data into SAREF	The System Integrator creates mappings of the data exchanged by energy nodes and EMS/BMS (or any other service offered via the interoperability layer) into the SAREF ontology. The mappings are also validated (manually or automatically)	CREATE	System Integrator	System Integrator	-	–

			to be sure that they are actually SAREF-compliant.					
15	Create and validate mappings of data into SAREF	Configure mappings into semantic adapter	The semantic adapters previously created (in Sc.2 and Sc.3) are properly configured with the validated mappings into SAREF.	CREATE	System Integrator	Interoperability Layer	Inf. 9	QoS.3, QoS.4, QoS.5 Sec.2, Sec.3, Sec.4 D.2, D.5, D.6
16	Configure mappings into semantic adapter	Confirm mappings validation and configuration	The Interoperability Layer confirms to the System Integrator that the semantic mappings into SAREF are correct and have been successfully configured in the semantic adapter.	REPORT	Interoperability Layer	System Integrator	Inf. 10	QoS.3, QoS.4, QoS.5 Sec.2, Sec.3, Sec.4 D.2, D.5, D.6

Scenario								
Scenario name:		Sc. 5 - Control and explain via semantics						
Step No.	***Event***	***Name of process/ activity***	***Description of process/ activity***	***Service***	***Information producer (actor)***	***Information receiver (actor)***	***Information Exchanged (IDs)***	***Requirement, R-IDs***
17	Confirm semantic adapter registration and configuration	Send flexibility instruction (or other recommendation)	A specific instruction (e.g., a flexibility instruction from SUC-NL-01.4) or a recommendation is sent by the EMS/BMS and/or the Interoperability Layer to the Prosumer's energy node interface to be executed (i.e., for control over an energy node)	GET	EMS/BMS and/or Interoperability Layer	Prosumer's Energy Node Interface	Inf. 11	QoS.3, QoS.4, QoS.5 Sec.2, Sec.3, Sec.4 D.2, D.5, D.6 O.X
18	Send flexibility instruction	Show instruction /	The flexibility instruction (or other recommendation) is forwarded by the Prosumer	GET	Prosumer's Energy	System Integrator	Inf. 12	QoS.3, QoS.4, QoS.5 Sec.2, Sec.3, Sec.4

	(or other recommendation)	recommendation	to the System Integrator for human inspection		Node Interface			D.2, D.5, D.6 O.X
19	Show instruction/ recommendation	Request explanation	The System Integrator (acting as the human inspector) requests further explanation of the flexibility instruction (or other recommendation) to a dedicated AI explainability service	GET	System Integrator	AI Explainability Service	Inf. 13	QoS.3, QoS.4, QoS.5 Sec.2, Sec.3, Sec.4 D.2, D.5, D.6 O.X
20	Request explanation	Generate explanation	The AI Explainability Service runs the algorithm and reasoning to provide the requested explanation	CREATE	AI Explainability Service	AI Explainability Service	-	–
21	Generate explanation	Provide explanation	The resulting explanation is returned to the System Integrator	REPORT	AI Explainability Service	System Integrator	Inf. 15	QoS.3, QoS.4, QoS.5 Sec.2, Sec.3, Sec.4 D.2, D.5, D.6 O.X

Scenario								
Scenario name:	Sc. 6 - Human-in-the-loop							
Step No.	***Event***	***Name of process/ activity***	***Description of process/ activity***	***Service***	***Information producer (actor)***	***Information receiver (actor)***	***Information Exchanged (IDs)***	***Requirement, R-IDs***
22	Provide Explanation (Sc. 5)	Assess explanation	The System Integrator (acting as human-in-the-loop inspector) assesses the explanation of the flexibility instruction (or other recommendation) provided	EXECUTE	System Integrator	System Integrator	-	-

			by the AI explainability service					
23	Assess explanation	Accept instruction / recommendation	In this alternative, the System Integrator acknowledges the explanation of the instruction/ recommendation to the Prosumer's Energy Node Interface	REPORT	System Integrator	Prosumer's Energy Node Interface	Inf. 17	QoS.3, QoS.4, QoS.5 Sec.2, Sec.3, Sec.4 D.2, D.5, D.6
24	Accept instruction/ recommendation	Execute instruction / recommendation	The Prosumer's Energy Node Interface executes the instruction/ Recommendation	EXECUTE	Prosumer's Energy Node Interface	Prosumer's Energy Node Interface	-	–
25	Execute instruction/ recommendation	Notify execution flexibility instruction (or other recommendation)	The EMS/BMS and/or the Interoperability Layer are notified by the Prosumer's Energy Node Interface of the successful execution of the flexibility instruction or other recommendation (i.e., for control over an energy node)	REPORT	Prosumer's Energy Node Interface	EMS/BMS and/or Interoperability Layer	Inf. 19	QoS.3, QoS.4, QoS.5 Sec.2, Sec.3, Sec.4 D.2, D.5, D.6
26	Assess explanation	Reject instruction / recommendation	In this alternative, the System Integrator (acting as human-in-the-loop inspector) does not acknowledge the explanation of the instruction/ recommendation obtained from the AI Explainability Service and notifies the Prosumer's Energy Node Interface about the rejection.	REPORT	System Integrator	Prosumer's Energy Node Interface	Inf. 20	QoS.3, QoS.4, QoS.5 Sec.2, Sec.3, Sec.4 D.2, D.5, D.6
27	Reject instruction/	Reject flexibility	The Prosumer's Energy Node Interface rejects the	REPORT	Prosumer's Energy	EMS/BMS and/or	Inf. 21	QoS.3, QoS.4, QoS.5

	recommendation	instruction (or other recommendation)	flexibility instruction (or other recommendation) previously sent by the EMS/BMS and/or Interoperability Layer.		Node Interface	Interoperability Layer		Sec.2, Sec.3, Sec.4 D.2, D.5, D.6

5 Information exchanged

Information exchanged			
Information exchanged (ID)	**Name of information**	**Description of information exchanged**	**Requirement, R-IDs**
Inf 1	Notification new energy node connected	Confirmation that a new energy node has been connected to the network. It will share the device identifier and endpoint.	QoS.3, QoS.4, QoS.5 Sec.2, Sec.3, Sec.4 D.2, D.6 Conf.2, Conf.3, Conf.4, Conf.8 O.X
Inf 2	Request data source	A request to send the data to be made semantically interoperable and exchanged via the interoperability layer. It will depend on what an energy node wants to make available for the EMS/BMS. Some typical examples (real-time or historical) are: - amount of energy used (kWh) actual and historical - amount of energy produced (kWh) actual and historical - state of the energy node (on/off) - voltage actual and historical - other power quality measurements	QoS.3, QoS.4, QoS.5 Sec.2, Sec.3, Sec.4 D.2, D.5, D.6 Conf.2, Conf.3, Conf.4, Conf.6, Conf.7, Conf.8 O.X
Inf 3	Send source data	A response to the request source data in Inf.2	QoS.3, QoS.4, QoS.5 Sec.2, Sec.3, Sec.4 D.2, D.5, D.6 Conf.2, Conf.3, Conf.4, Conf.6, Conf.7, Conf.8 O.X
Inf 4	Register and configure semantic adapter	Code to register and configure semantic adapter into the interoperability layer	QoS.3, QoS.4, QoS.5 Sec.2, Sec.3, Sec.4 D.2, D.5, D.6 Conf.6, Conf.7, Conf.8
Inf 5	Configure connection	Request for connection with energy node (or EMS/BMS) and configuration	QoS.3, QoS.4, QoS.5 Sec.2, Sec.3, Sec.4 D.2, D.5, D.6 Conf.6, Conf.7, Conf.8

Inf 6	Confirm connection	A confirmation that the connection requested in Inf.5 has been established	QoS.3, QoS.4, QoS.5 Sec.2, Sec.3, Sec.4 D.2, D.5, D.6 Conf.6, Conf.7, Conf.8
Inf 7	Confirm semantic adapter registration and configuration	A confirmation that the semantic adapter registered and configured in Inf.4 has been successfully established	QoS.3, QoS.4, QoS.5 Sec.2, Sec.3, Sec.4 D.2, D.5, D.6 Conf.6, Conf.7, Conf.8
Inf 9	Configure mappings into semantic adapter	The SAREFized data in RDF/OWL translated from the original exchange format (e.g., JSON or XML) of the device	QoS.3, QoS.4, QoS.5 Sec.2, Sec.3, Sec.4 D.2, D.5, D.6
Inf 10	Confirm mappings validation and configuration	A confirmation that the SAREFized data is validated (e.g., correctly complies to SAREF) and is configured successfully in the semantic adapter	QoS.3, QoS.4, QoS.5 Sec.2, Sec.3, Sec.4 D.2, D.5, D.6
Inf 11	Send flexibility instruction (or other recommendation)	Flexibility instruction sent by the EMS as a result of flexibility alignment; or, more in general, any recommendation provided by EMS/BMS or the interoperability layer to the prosumer	QoS.3, QoS.4, QoS.5 Sec.2, Sec.3, Sec.4 D.2, D.5, D.6 O.X
Inf 12	Show instruction/ recommendation	Flexibility instruction (or other recommendation) in Inf. 11 is forwarded to the system Integrator for inspection	QoS.3, QoS.4, QoS.5 Sec.2, Sec.3, Sec.4 D.2, D.5, D.6 O.X
Inf 13	Request explanation	A request for further explanation of the Flexibility instruction (or other recommendation) in Inf. 11 and Inf. 12	QoS.3, QoS.4, QoS.5 Sec.2, Sec.3, Sec.4 D.2, D.5, D.6 O.X
Inf 15	Provide explanation	The explanation of the Flexibility instruction (or other recommendation) requested in Inf. 13	QoS.3, QoS.4, QoS.5 Sec.2, Sec.3, Sec.4 D.2, D.5, D.6

			O.X
Inf 17	Accept instruction/ recommendation	Acknowledgment by the human-in-the-loop of the instruction/ recommendation generated by the EMS/BMS or the interoperability layer, as a response to Inf. 12	QoS.3, QoS.4, QoS.5 Sec.2, Sec.3, Sec.4 D.2, D.5, D.6
Inf 19	Notify execution flexibility instruction (or other recommendation)	Notification by the human-in-the-loop that the instruction/ recommendation generated by the EMS/BMS or the interoperability layer has been executed (after human validation), as a response to Inf. 11	QoS.3, QoS.4, QoS.5 Sec.2, Sec.3, Sec.4 D.2, D.5, D.6
Inf 20	Reject instruction/ recommendation	Rejection by the human-in-the-loop of the instruction/ recommendation generated by the EMS/BMS or the interoperability layer, as a response to Inf. 12	QoS.3, QoS.4, QoS.5 Sec.2, Sec.3, Sec.4 D.2, D.5, D.6
Inf 21	Reject flexibility instruction (or other recommendation)	Notification by the human-in-the-loop that the instruction/ recommendation generated by the EMS/BMS or the interoperability layer should not be executed (after human validation), as a response to Inf. 11	QoS.3, QoS.4, QoS.5 Sec.2, Sec.3, Sec.4 D.2, D.5, D.6

6 Requirements

Quality of Service Requirements		
Categories ID	**Category name for requirements**	**Category description**
QoS	Quality of Service	Generic properties that service/SUC should provide – quality attributes.
Requirement R-ID	**Requirement name**	**Requirement description**
QoS.3	Availability of information flows	Continuous availability not required but must be available at specific times or under specific conditions
QoS.4	Accuracy of data requirements	Adequate accuracy can be assumed
QoS.5	Frequency of data exchanges	Upon event

Security Requirements		
Categories ID	**Category name for requirements**	**Category description**
Sec	Security	Authentication of user, confidentiality, integrity, prevention of denial of service, non-repudiation or accountability, error management.
Requirement R-ID	**Requirement name**	**Requirement description**

Sec.2	Eavesdropping:	Ensuring confidentiality, avoiding illegitimate use of data, and preventing unauthorized reading of data, is: Quite important
Sec.3	Information integrity violation:	Ensuring that data is not changed or destroyed is: Quite important
Sec.4	Authentication and Access Control mechanisms commonly used with this data exchange	Public key encryption (e.g. SSL/TLS)

	Data Management Requirements	
Categories ID	**Category name for requirements**	**Category description**
D	Data Management	Type of source of data, correctness or validity of data, timeliness or time stamping of data, volume of data, synchronization, or consistency of data across systems, timely access to data, validation of data across organizational boundaries, transaction management, data naming, identification, formats across disparate systems, maintenance of data and databases.
Requirement R-ID	**Requirement name**	**Requirement description**
D.2	Correctness of source data	Other: Data mappings into SAREF are not always correct. Correctness of data mappings needs to be validated.
D.5	Management of data across organizational boundaries	Data exchanges go across organizational boundaries
D.6	Data maintenance effort: human versus automation	Other: The maintenance of semantic data for creating semantic adapters and mappings into SAREF is partially automated but involves some human time and manual data entries.

	Discovery and Configuration Requirements	
Categories ID	**Category name for requirements**	**Category description**
Conf	Configuration	Locations, distances, communication layout, commonly used communication protocol media, network bandwidth, existing protocols, number of devices, systems, volume of data items, expected growth, etc.
Requirement R-ID	**Requirement name**	**Requirement description**
Conf.2	Distance between entities	Varies and/or is not relevant

Conf.3	Number of Information Producers	Few to a hundred
Conf.4	Number of Information Receivers	Two to a few
Conf.6	Data exchange methods	Other: REST API (client-server)
Conf.7	Communication access services requirements	Request-response
Conf.8	Commonly used communication protocol	Natively REST, other protocols (e.g., MODBUS, MQTT) supported via semantic adapters.

Other Requirements		
Categories ID	**Category name for requirements**	**Category description**
O	Regulatory obligation related to privacy	2016/679 GDPR (General Data Protection Regulation)
Requirement R-ID	**Requirement name**	**Requirement description**
O.2	Personal data use	Personal data may not be processed unless there is at least one legal basis to do so.
O.3	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.
O.4	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.
O.5	Data retention policy	Personal data may not be transferred to a third-party if the data subject did not agree and the third party provide appropriate safeguard.
O.X	All constraints also apply.	All requirements in this category.

7 Common Terms and Definitions

Common Terms and Definitions	
Term	**Definition**
Energy nodes	Hardware such as batteries, heat pumps, PVs, EV-chargers, smart meters and other energy (flexibility) assets with interoperable interface/connection and owned by the Prosumer
EMS	Energy Management System
BMS	Building Management System
EV	Electric Vehicle
PV	Photo Voltaic
HP	Heat Pump

DSO	Distribution System Operator
V2G	Vehicle-to-Grid. A technology that allows energy from a vehicle's battery to flow to the grid.

3 SUC-NL-01.3 – OPTIMIZE ENERGY PRODUCTION & CONSUMPTION

1 Description of the use case

1.1 Name of the use case

ID	Area / Domain(s) / Zones(s)	Name of Use Case
SUC-NL-01.3	Energy Flexibility at business park	Optimize energy production & consumption

1.2 Version management

Version Management			
Version No.	Date	Name of Author(s)	Changes
1	08-09-2024	W.Beelen (AB)	Draft outline of use case
2	09-09-2024	L.Daniele (TNO)	Added use case and sequence diagrams, actors, scenarios, information exchanged
3	18-09-2024	L.Daniele (TNO)	Updated use case diagram to incorporate feedback from Trialog
4	19-09-2024	L.Daniele (TNO)	Updated SUC ID according to naming convention. Added steps of the scenarios.
5	24-09-2024	L.Daniele (TNO)	Updated use case diagram to incorporate additional feedback from Trialog
6	1-10-2024	W.Beelen (AB), L. Daniele	Update 1.4, 1.5 and 1.6 and added requirements

1.3 Scope and objectives of use case

Scope and Objectives of Use Case	
Scope	The decentral grid of Arnhems Buiten in alignment with the DSO grid connection of Alliander.
Objective(s)	1. **Enhance grid stability:** Optimize energy production and consumption to maintain a balanced grid and prevent power outages or voltage fluctuations. 2. **Reduce energy costs:** Minimize energy losses and optimize resource allocation to reduce overall energy costs for both consumers and grid operators. 3. **Promote sustainable energy practices:** Encourage the adoption of renewable energy sources and optimize their integration into the grid to reduce carbon emissions and promote environmental sustainability.
Related business case(s)	BUC-NL-01 Energy Flexibility at business park

1.4 Narrative of use case

Narrative of Use Case

Short description
This use case describes the optimization of energy production and consumption within a decentralized grid, to enhance grid stability, reduce costs, and promote sustainable energy practices. The goal is to facilitate efficient coordination and management of distributed energy resources (DERs) to meet the grid's demand while minimizing energy losses and maximizing economic benefits.
Complete description
This use case focuses on optimizing energy production and consumption within a decentralized grid comprising solar panels, building management systems (BMS), electric vehicles (EVs), batteries, and heat pumps. By leveraging real-time monitoring and a grid management system, the goal is to achieve peak shaving and load shifting to enhance grid stability, reduce costs, and promote sustainable energy practices. The decentralized grid is connected to the main grid via two separate connections: one for a specific building and another for a grid with multiple buildings and energy nodes. Due to grid congestion and restrictions on energy feed-in, the grid connection for the multiple-building grid faces capacity limitations. To address these challenges, this use case aims to: 1. **Align Grid Connections:** Coordinate the two grid connections with the Distribution System Operator (DSO) to optimize energy flow and maximize the utilization of available capacity. 2. **Implement Peak Shaving and Load Shifting:** Utilize real-time monitoring and grid management to identify peak demand periods and shift loads to off-peak times, thereby reducing the burden on the grid. 3. **Leverage Distributed Energy Resources (DERs):** Effectively manage DERs (solar panels, BMS, EVs, batteries, heat pumps) to optimize energy production and consumption, contributing to peak shaving and load shifting. 4. **Explore Non-Firm ATO Agreements:** Consider entering non-firm ATO agreements with the DSO to gain flexibility in energy production and consumption. By implementing these strategies, the use case aims to: • **Enhance grid stability:** Reduce the strain on the grid during peak demand periods. • **Reduce costs:** Minimize energy costs by optimizing energy consumption and potentially selling excess energy back to the grid. • **Promote sustainable energy practices:** Increase the penetration of renewable energy sources and reduce reliance on fossil fuels. • **Facilitate grid growth:** Optimize grid utilization to accommodate future growth in energy demand.

1.5 Key performance indicators (KPI)

ID	*Name*	*Description*	*Reference to mentioned use case objectives*
OB1	Different types of IoT/edge devices to be exploited in Demo Areas e.g., Smart Meter, HEMS, Sensors, inverter	The number of nodes involved in/ using flexibility services	Objective 1
KPI10	Number of consumers engaged with flexibility services	The number of users involved in/ using flexibility services	Objective 1 and 2
KPI22	Increase DERs participation in flexibility provision	The (additional) number of added DER to the grid	Objective 3

1.6 Use case conditions

Use case conditions
Assumptions

• Decentralized grid infrastructure is established. • Energy nodes (e.g., solar panels, wind turbines, batteries) are connected to the grid. • DSO and aggregator have necessary communication channels and data exchange protocols in place.
Prerequisites

• **Technical Prerequisites:**
  ○ **Central Control System:** A robust and scalable central control system capable of real-time monitoring, data analysis, and optimization.
  ○ **Communication Infrastructure:** Reliable communication networks to connect DERs and the central control system.
  ○ **Sensors and Meters:** Accurate and reliable sensors and meters to measure energy production, consumption, and grid parameters.
  ○ **Integration Capabilities:** Integration capabilities for various DERs (e.g., solar panels, BMS, EVs, batteries, heat pumps).
• **Data-Related Prerequisites:**
  ○ **Data Collection and Analysis:** A system for collecting, storing, and analyzing real-time energy data from DERs and the grid.
  ○ **Data Quality:** Ensure the accuracy, reliability, and consistency of the collected data.
  ○ **Data Security:** Implement robust security measures to protect sensitive data and prevent unauthorized access.
• **Organizational Prerequisites:**
  ○ **Stakeholder Involvement:** Collaboration and buy-in from stakeholders, including grid operators, DER owners, and regulatory authorities.
  ○ **Clear Objectives:** Clearly defined objectives for the use case, aligned with the overall goals of the decentralized grid.
  ○ **Resource Allocation:** Sufficient resources (e.g., budget, personnel, time) to implement and maintain the system.
  ○ **Regulatory Compliance:** Adherence to relevant grid codes, regulations, and standards.
• **Grid-Specific Prerequisites:**
  ○ **Grid Topology:** Understanding of the grid's topology, including the distribution of DERs and the capacity of grid connections.
  ○ **Grid Constraints:** Awareness of grid limitations and constraints
  ○ **Grid Services:** Availability of grid services (e.g., demand response, energy storage) and the associated requirements.
• **DER-Specific Prerequisites:**
  ○ **DER Integration:** Compatibility of DERs with the central control system and communication protocols.
  ○ **DER Flexibility:** The ability of DERs to adjust their operation in response to grid signals or optimization commands.
  ○ **DER Data Availability:** Access to data from DERs, including production, consumption, and status information.

1.7 Further Information to the use case for classification / mapping

Classification Information
Relation to other use cases
Used as the third System Use Case for BUC-NL.01. This SUC and SUC-NL-01.4 are complementing each other.
Level of depth
Prioritisation
Generic, regional or national relation

Nature of the use case
System use case
Further keywords for classification
Energy nodes, real-time data, storage, monitoring

1.8 General Remarks

General Remarks
Energy nodes contain: Buildings, charging stations, EV (via V2G), Batteries, PV

2 Diagrams of use case

Diagram(s) of use case

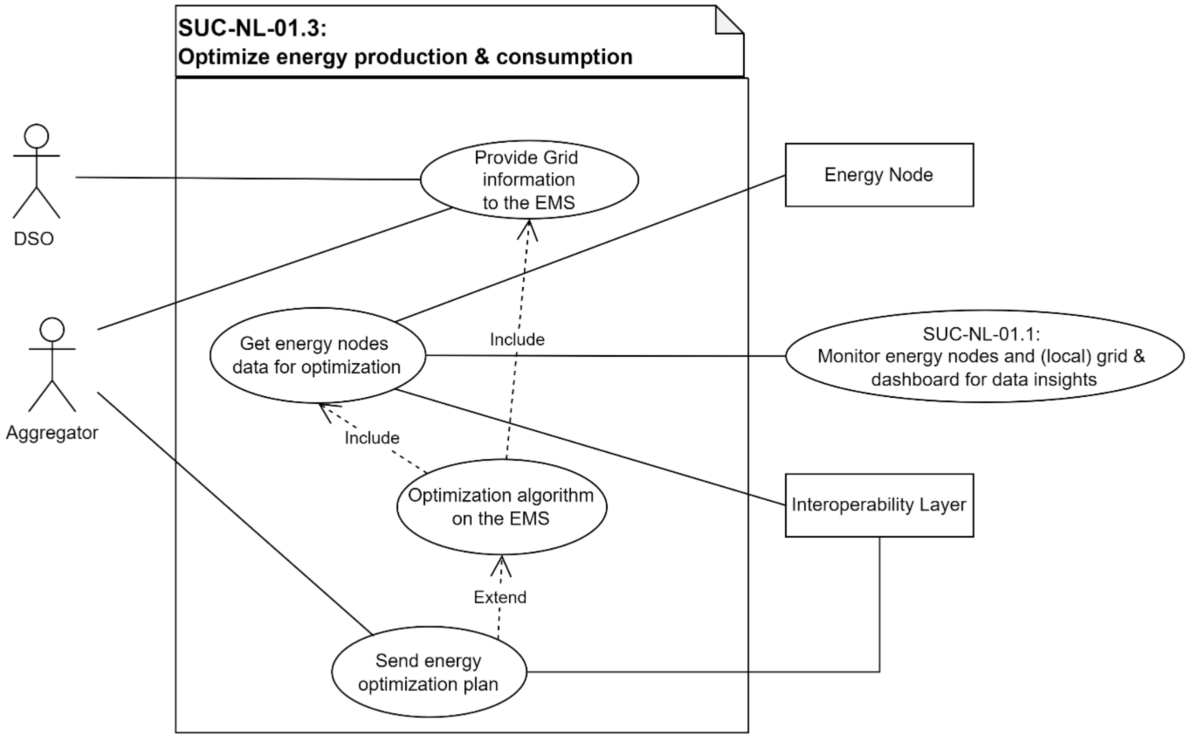


FIGURE 5: UML USE CASE DIAGRAM

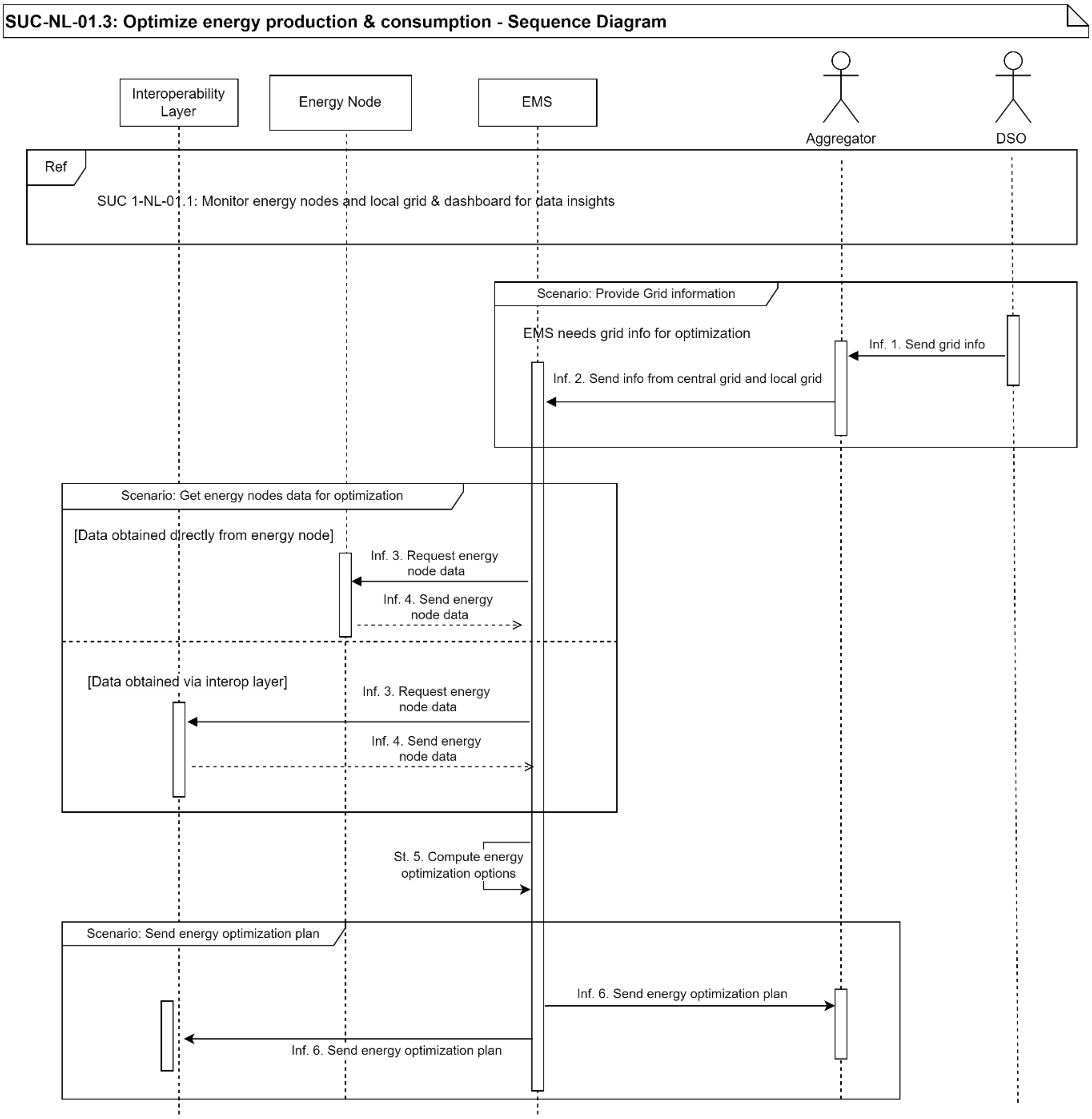


FIGURE 6: UML SEQUENCE DIAGRAM

3 Technical details

3.1 Actors

Actors			
Actor name	***Actor type***	***Actor description***	***Further information specific to this use case***
Interoperability layer	Logic actor	A system responsible for sharing data between participants in an interoperable manner.	TNO and VU/A as main contributors
Energy node	Logic actor	A party that consumes and/or generates electricity.	Device that produces and/or consumes energy. It collects energy node data

			and can share it with other parties. Examples: Battery, Heat Pump, EV, EV charging, PVs, Smart Meters
EMS	Logic actor	The Energy Management System that aggregates and optimizes data for usage by other participants.	The EMS can be integrated into the Interoperability Layer (which is the system responsible for sharing data between participants in an interoperable manner)
Aggregator	Business actor	A party that aggregates data for usage by other participants.	Exact content and organization in charge must be defined and selected. Must be aligned with the DSO Alliander.
DSO	Business actor	The Distributed System Operator responsible for the central grid (with two connections to the local DSO) who sends to the aggregator information and signals about the central grid	Alliander is the DSO responsible for the central grid. Arnhems Buiten is the local DSO.

3.2 References

References						
No.	***Reference Type***	***Reference***	***Status***	***Impact on use case***	***Originator / organisation***	***Link***

4 Step by step analysis of use case

4.1 Overview of scenarios

Scenario conditions						
No.	**Scenario name**	**Scenario description**	**Primary actor**	**Triggering event**	**Pre-condition**	**Post-condition**
Sc.1	Provide Grid information to the EMS	The Aggregator pushes grid info collected from both the central and the local DSOs to the EMS	Aggregator	When new grid info is available to the Aggregator	Aggregator as access to central grid and local grid	EMS can consider grid info when optimizing energy production and consumptio n of nodes
Sc. 2	Get energy nodes data for optimizatio n	The EMS needs data from the energy nodes whose consumption and production needs to be optimized. These data can be obtained by	EMS	When the EMS requests data from energy nodes	Energy node data is available for monitoring	Energy node data is available for optimization

		the EMS via the interoperability layer (as in SUC-NL.01.1) or directly from the energy nodes (as in SUC4)				
Sc. 3	Optimization algorithm on the EMS	The EMS optimizes the energy consumption and production of the various energy nodes based also on the grid info.	EMS	Triggered based on info available to the EMS (e.g., prosumer's preferences and grid info)	Energy node data and grid info are available to the EMS for optimization	Energy optimization options are computed by the EMS and a plan is chosen
Sc. 4	Send energy optimization plan	Aggregator and Interoperability layer can be informed about the EMS optimization plans (note that not here, but in SUC-NL-01.4, the energy optimization plan is executed by the energy nodes)	EMS	When an energy optimization plan is available to the EMS	Optimization plan chosen by the EMS	Optimization plan available for execution

4.2 Steps – Scenarios

Scenario								
Scenario name:		Sc.1 – Provide Grid information to the EMS						
Step No.	**Event**	**Name of process/ activity**	**Description of process/ activity**	**Service**	**Information producer (actor)**	**Information receiver (actor)**	**Information Exchanged (IDs)**	**Requirement, R-IDs**
1	Relevant info from the central grid becomes available to the DSO	Send grid info	When relevant info about the central grid becomes available, the DSO pushes it to the Aggregator	REPORT	DSO	Aggregator	Inf. 1	QoS.2, QoS.3, QoS.4, QoS.5 Sec.2, Sec.4 D.2, D.5 Conf.6, Conf.8 O.X
2	Send grid info	Send info from central grid and local grid	Via its dashboard, the Aggregator pushes grid info collected from the central Grid (DSO) and/or from the local grid (local DSO) to the EMS	REPORT	Aggregator	EMS	Inf. 2	QoS.2, QoS.3, QoS.4, QoS.5 Sec.4 D.2, D.5 Conf.6, Conf.8 O.X

Scenario								
Scenario name:		Sc.2 - Get energy nodes data for optimization						
Step No.	**Event**	**Name of process/ activity**	**Description of process/ activity**	**Service**	**Information producer (actor)**	**Information receiver (actor)**	**Information Exchanged (IDs)**	**Requirement, R-IDs**
3	Sc.1	Request energy node data	The EMS needs data from the energy nodes whose consumption and production needs to be optimized. In this alternative,	REPORT	EMS	Energy Node	Inf. 3	QoS.2, QoS.3, QoS.4, QoS.5 Sec.4 D.2, D.5

			the EMS obtains the data directly from the energy nodes					Conf.3, Conf.4, Conf.6, Conf.8 O.X
4	Request energy node data	Send energy node data	The energy node sends the requested data to the EMS	GET	Energy Node	EMS	Inf. 4	QoS.2, QoS.3, QoS.4, QoS.5 Sec.2, Sec.4 D.2, D.5 Conf.3, Conf.4, Conf.6, Conf.8 O.X
5	Sc.1	Request energy node data	The EMS needs data from the energy nodes whose consumption and production needs to be optimized. In this alternative, the EMS obtains the data via the Interoperability Layer (where the energy nodes are registered)	REPORT	EMS	Interoperability Layer	Inf. 3	QoS.2, QoS.3, QoS.4, QoS.5 Sec.4 D.2, D.5 Conf.3, Conf.4, Conf.6, Conf.8 O.X
6	Request energy node data	Send energy node data	The Interoperability Layer sends the requested data to the EMS	GET	Interoperability Layer	EMS	Inf. 4	QoS.2, QoS.3, QoS.4, QoS.5 Sec.2, Sec.4 D.2, D.5 Conf.3, Conf.4, Conf.6, Conf.8 O.X

Scenario								
Scenario name:		Sc.3 – Optimization algorithm on the EMS						
Step No.	**Event**	**Name of process/ activity**	**Description of process/ activity**	**Service**	**Information producer (actor)**	**Information receiver (actor)**	**Information Exchanged (IDs)**	**Requirement, R-IDs**
7	Timer	Send grid info	The energy consumption/production on the network is continuously monitored. At regular intervals, an algorithm is run on the EMS to optimize the energy consumption and production of the various energy nodes based also on info/signals from the central and local grid.	CREATE	EMS	EMS	–	

Scenario name:		Sc.4 – Send energy optimization plan						
Step No.	**Event**	**Name of process/ activity**	**Description of process/ activity**	**Service**	**Information producer (actor)**	**Information receiver (actor)**	**Information Exchanged (IDs)**	**Requirement, R-IDs**
8	Sc. 3	Send energy optimization plan	The Aggregator is informed about the optimization plan computed by the EMS (note that not here, but in SUC-NL-01.4, the energy optimization plan is executed by the energy nodes)	REPORT	EMS	Aggregator	Inf. 6	QoS.2, QoS.3, QoS.4, QoS.5 Sec.2, Sec.4 D.5 Conf.6, Conf.8 O.X
9	Sc. 3	Send energy optimization plan	The Interoperability Layer is informed about the optimization plan computed by the EMS (note that not here, but in SUC4, the energy optimization plan is executed by the energy nodes)	REPORT	EMS	Interoperability Layer	Inf. 6	QoS.2, QoS.3, QoS.4, QoS.5 Sec.2, Sec.4 D.5 Conf.6, Conf.8 O.X

5 Information exchanged

Information exchanged			
Information exchanged (ID)	***Name of information***	***Description of information exchanged***	***Requirement, R-IDs***
Inf 1	Send grid info	Central grid information provided by the DSO (capacity, signals, unavailability, etc.)	QoS.2, QoS.3, QoS.4, QoS.5 Sec.2, Sec.4 D.2, D.5 Conf.6, Conf.8 O.X
Inf 2	Send info from central grid and local grid	Central grid and local grid information (capacity, signals, unavailability, etc.)	QoS.2, QoS.3, QoS.4, QoS.5 Sec.4 D.2, D.5 Conf.6, Conf.8 O.X
Inf 3	Request energy node data	A request to send the data that an energynode wants to make available for optimization by the EMS. Some typical examples (real-time or historical) are: - amount of energy used (kWh) actual and historical - amount of energy produced (kWh) actual and historical - state of the energy node (on/off) - voltage actual and historical - other power quality measurements	QoS.2, QoS.3, QoS.4, QoS.5 Sec.4 D.2, D.5 Conf.3, Conf.4, Conf.6, Conf.8 O.X
Inf 4	Send energy node data	A response to the request in Inf. 3	QoS.2, QoS.3, QoS.4, QoS.5 Sec.2, Sec.4 D.2, D.5 Conf.3, Conf.4, Conf.6, Conf.8 O.X
Inf 6	Send energy optimization plan	Energy optimization plan of energy nodes sent for information to the interoperability layer and directly to the Aggregator	QoS.2, QoS.3, QoS.4, QoS.5 Sec.2, Sec.4 D.5 Conf.6, Conf.8 O.X

6 Requirements

Quality of Service Requirements		
Categories ID	**Category name for requirements**	**Category description**
QoS	Quality of Service	Generic properties that service/SUC should provide – quality attributes.
Requirement R-ID	**Requirement name**	**Requirement description**
QoS.2	Elapsed time response requirements for exchanging data	More than 10 seconds
QoS.3	Availability of information flows	Continuous availability not required but must be available at specific times or under specific conditions
QoS.4	Accuracy of data requirements	Age of data needs to be knowable Adequate accuracy can be assumed
QoS.5	Frequency of data exchanges	Upon event

Security Requirements		
Categories ID	**Category name for requirements**	**Category description**
Sec	Security	Authentication of user, confidentiality, integrity, prevention of denial of service, non-repudiation or accountability, error management.
Requirement R-ID	**Requirement name**	**Requirement description**
Sec.2	Eavesdropping: Ensuring confidentiality, avoiding illegitimate use of data, and preventing unauthorized reading of data, is:	Quite important
Sec.4	Authentication and Access Control mechanisms commonly used with this data exchange	Public key encryption (e.g. SSL/TLS)

Data Management Requirements		
Categories ID	**Category name for requirements**	**Category description**
D	Data Management	Type of source of data, correctness or validity of data, timeliness or time stamping of data, volume of data, synchronization, or consistency of data across systems, timely access to data, validation of data across organizational boundaries, transaction management, data naming, identification, formats across disparate systems, maintenance of data and databases.
Requirement R-ID	**Requirement name**	**Requirement description**
D.2	Correctness of source data	Source data is always correct (e.g. by definition)
D.5	Management of data across organizational	Data exchanges go across organizational

	boundaries	boundaries

Discovery and Configuration Requirements		
Categories ID	**Category name for requirements**	**Category description**
Conf	Configuration	Locations, distances, communication layout, commonly used communication protocol media, network bandwidth, existing protocols, number of devices, systems, volume of data items, expected growth, etc.
Requirement R-ID	**Requirement name**	**Requirement description**
Conf.3	Number of Information Producers	Few to a hundred
Conf.4	Number of Information Receivers	Two to a few
Conf.6	Data exchange methods	Other: REST API (client-server)
Conf.8	Commonly used communication protocol	Natively REST, other protocols (e.g., MODBUS, MQTT) supported via semantic adapters.

Other Requirements		
Categories ID	**Category name for requirements**	**Category description**
O	Regulatory obligation related to privacy	2016/679 GDPR (General Data Protection Regulation)
Requirement R-ID	**Requirement name**	**Requirement description**
O.2	All constraints also apply.	Personal data may not be processed unless there is at least one legal basis to do so.
O.3	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.
O.4	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.
O.5	Data retention policy	Personal data may not be transferred to a third-party if the data subject did not agree and the third party provide appropriate safeguard.
O.X	All constraints also apply.	All requirements in this category.

7 Common Terms and Definitions

Common Terms and Definitions	
Term	**Definition**

Energy nodes	Hardware such as batteries, heat pumps, PVs, EV-chargers, smart meters and other energy (flexibility) assets with interoperable interface/connection and owned by the Prosumer
EMS	Energy Management System
BMS	Building Management System
EV	Electric Vehicle
PV	Photo Voltaic
HP	Heat Pump
DSO	Distribution System Operator
V2G	Vehicle-to-Grid. A technology that allows energy from a vehicle's battery to flow to the grid.

4 SUC-NL-01.4 – FLEXIBILITY ALIGNMENT

1 Description of the use case

1.1 Name of the use case

ID	Area / Domain(s) / Zones(s)	Name of Use Case
SUC-NL-01.4	Energy Flexibility at business park	Flexibility alignment

1.2 Version management

Version Management			
Version No.	Date	Name of Author(s)	Changes
1	2-9-2024	W.Beelen (AB)	First draft version
2	09-09-2024	L.Daniele (TNO)	Added use case and sequence diagrams
3	10-09-2024	L.Daniele (TNO)	Added Actors, Scenarios and Information Exchange
4	18-09-2024	L.Daniele (TNO)	Updated use case diagram to incorporate Trialog's feedback
5	19-09-2024	L.Daniele (TNO)	Updated SUC ID according to naming convention. Added steps of the scenarios.
6	1-10-2024	W.Beelen (AB), L.Daniele (TNO)	Update 1.4, 1.5 and 1.6. Added requirements

1.3 Scope and objectives of use case

Scope and Objectives of Use Case	
Scope	Implement a flexibility alignment system at Electricity Campus Arnhems Buiten, enabling prosumers and aggregators to exchange and execute energy optimization plans, utilizing smart grid technologies to optimize energy use and demonstrate flexibility benefits.
Objective(s)	1. Implement a functional flexibility exchange system 2. Optimize energy use and reduce costs 3. Mitigate grid congestion
Related business case(s)	BUC-NL-01 Energy Flexibility at business park

1.4 Narrative of use case

Narrative of Use Case
Short description
The process of offering flexibility and contract close/agreement between prosumers and the aggregator in a smart decentralized grid at the Electricity Campus Arnhems Buiten, focusing on energy production, consumption, and storage optimization.
Complete description
Arnhems Buiten, the owner of multiple interconnected buildings, is developing a smart decentralized grid that leverages energy flexibility through the integration of advanced technologies. The grid connects various energy nodes, including batteries, PV systems, and V2G,

all managed through Building Management Systems (BMS) that control heat pumps, lighting, and heating systems. Smart devices and IoT technologies are used to monitor and control the grid in real-time, with data standardized using the SAREF ontology for interoperability. A dedicated Grid Energy Management System (GEMS) will be developed or incorporated to manage communication and coordination between prosumers and the aggregator. Initially, the system will optimize energy distribution based on cost efficiency, with the potential to incorporate additional parameters, such as signals from the Distribution System Operator (DSO), to enhance grid stability and efficiency. The process involves the following steps: 1. Sending energy optimization plans: The Digital System and Infrastructure sends energy optimization plans to the Aggregator's dashboard. 2. Exchanging flexibility options: Prosumers and Aggregators exchange flexibility options through their respective interfaces (Prosumer's interface and Aggregator's dashboard). 3. Choosing energy optimization plans: Aggregators select energy optimization plans based on the available flexibility options. 4. Executing energy optimization plans: The chosen plans are executed through the Digital System and Infrastructure. Electricity Campus Arnhems Buiten is not yet recognized as a formal Closed Distribution System (CDS). This allows for experimentation with new technologies and approaches. Therefore also the roles from the Harmonised Electricity Market Role model not perfectly align to this (and other) SUC. Also, Market access isn't formalised within the role of Arnhems Buiten as a DSO. The way to access the market must be arranged and formalised.

1.5 Key performance indicators (KPI)

ID	Name	Description	Reference to mentioned use case objectives
OB4	Users involved in the piloting activities	# Users in a period that are involved by using devices (OB1) and or services of the pilot (i.e., EV users, tenants, building owners etc.)	Objective 1 and 2
KPI6	End-users' bill reduction by offering flexibility services	The financial reduction (based on kWh)	Objective 2
KPI11	Increased grid operational performance	Not to be measured in CAIDI	Objective 3

1.6 Use case conditions

Use case conditions
Assumptions
- The smart decentralized grid at Electricity Campus Arnhems Buiten can support bidirectional energy flow. - Prosumers have or will have the necessary equipment to offer flexibility (e.g., smart meters, controllable loads, energy storage systems). - The Digital System and Infrastructure will have the capability to generate and execute energy optimization plans. - There will be a reliable communication infrastructure in place to support real-time data exchange between all actors.

- The regulatory environment allows for experimentation with flexibility trading and grid management.
Prerequisites
- Installation of smart meters and necessary equipment at prosumer. - Development and deployment of the Prosumer's interface and Aggregator's. - Implementation of the Digital System and Infrastructure capable of handling energy optimization plans. - Establishment of clear protocols for flexibility trading and contract agreements. - Training for prosumers and aggregators on how to use the system effectively. - Selection of service providers for the creation of a grid management system. - Procurement of necessary hardware. - Development of the grid energy management platform.

1.7 Further Information to the use case for classification / mapping

Classification Information
Relation to other use cases
This SUC needs input from: SUC-NL-01.1 Monitoring & Dashboards SUC-NL-01.3 Optimize energy production & consumption
Level of depth
Prioritisation
Generic, regional or national relation
Nature of the use case
System Use case
Further keywords for classification

1.8 General Remarks

General Remarks

2 Diagrams of use case

Diagram(s) of use case

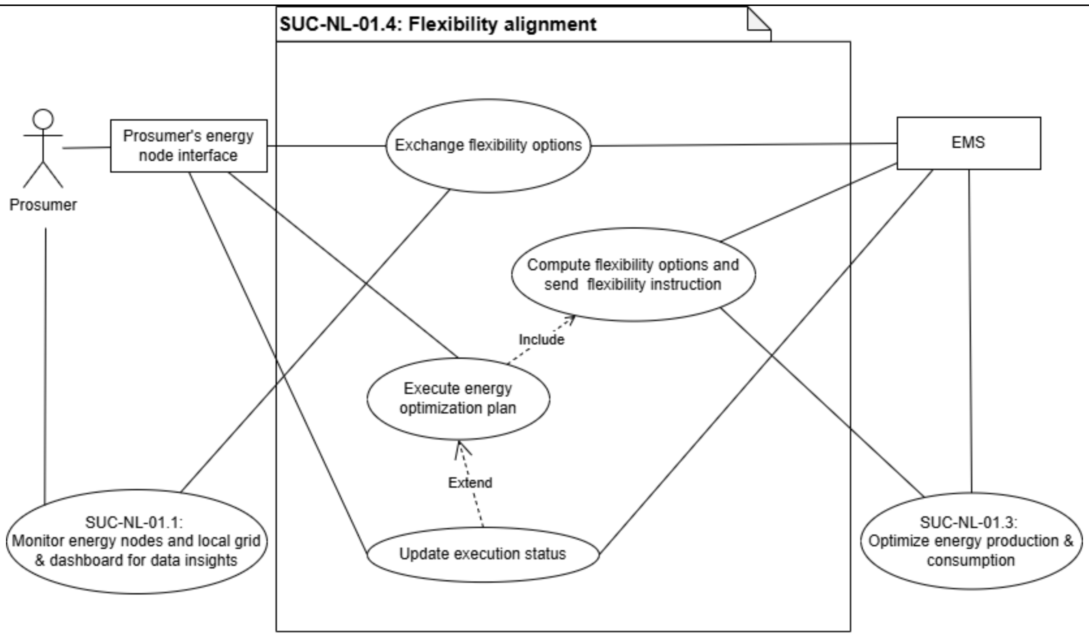


FIGURE 7: UML USE CASE DIAGRAM

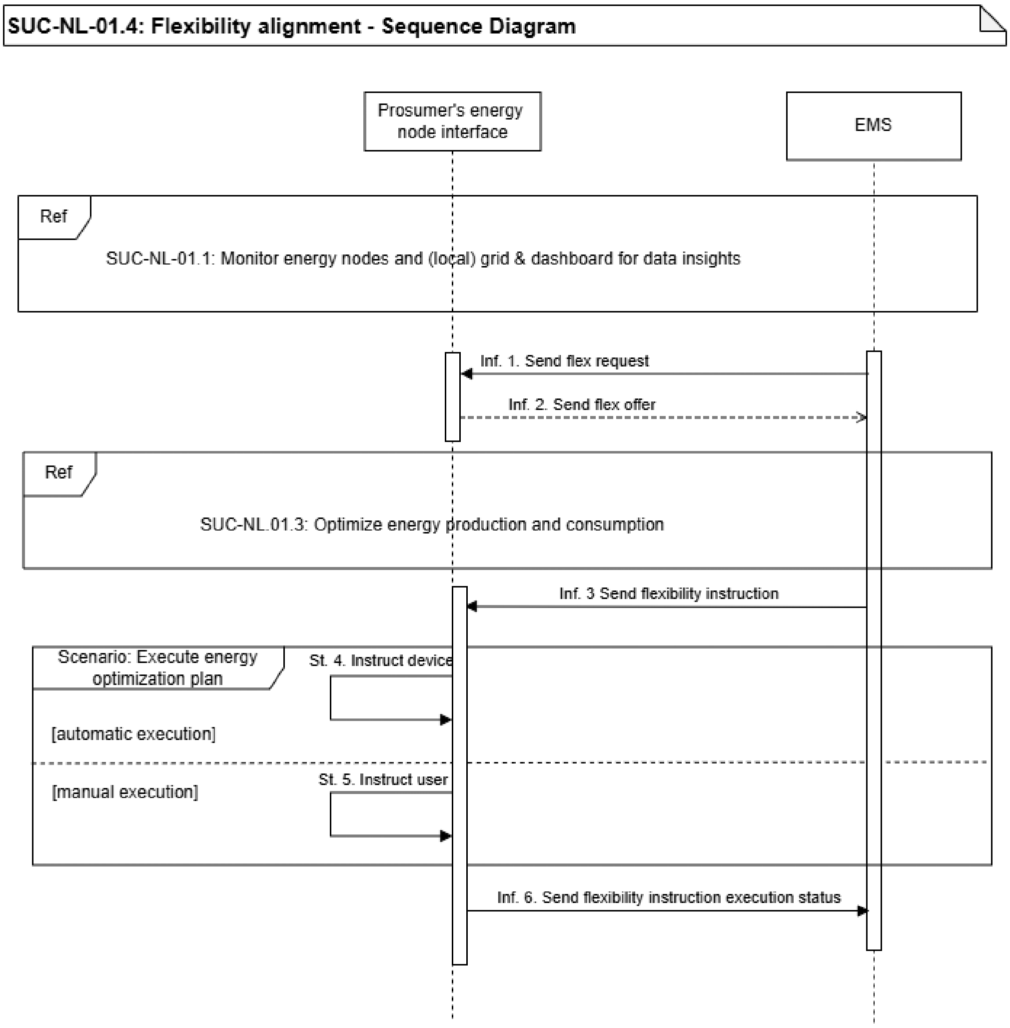


FIGURE 8: UML SEQUENCE DIAGRAM

3 Technical details

3.1 Actors

Actors			
Actor Name	***Actor Type***	***Actor Description***	***Further information specific to this use case***
EMS	Logic actor	The Energy Management System that aggregates and optimizes data for usage by other participants.	The EMS can be integrated into the Interoperability Layer (which is the system responsible for sharing data between participants in an interoperable manner)
Prosumer's Energy node interface	Logic actor	The user interface through which the prosumers can configure and control their energy nodes	
Prosumer	Business actor	A party that consumes and/or generates electricity.	The combination of: - Visitor or tenant, paying (in)direct, via Grid operator) energy bill for using energy for charging EV, or using office (facilities). - Owner of buildings and (e.g. connected) PV, charging stations and batteries) - Visiting EV User connection car to grid (V2G or normal charging), tenants of office space and/or Arnhems Buiten as Building owner

3.2 References

References						
No.	***Reference Type***	***Reference***	***Status***	***Impact on use case***	***Originator / organisation***	***Link***

4 Step by step analysis of use case

4.1 Overview of scenarios

Scenario conditions						
No.	**Scenario name**	**Scenario description**	**Primary actor**	**Triggering event**	**Pre-condition**	**Post-condition**
Sc. 1	Exchange flexibility options	A flexibility request message is sent by the EMS to the prosumer's energy node interface to inquire for the	EMS	When the EMS requests the flexibility options of the energy nodes	Energy nodes are connected, and their data is available for monitoring (SUC-NL-01.1)	Energy node flexibility options (offers) are available to the EMS for optimization

		flexibility that energy nodes can offer. The energy node interface of the prosumer sends back a response to the EMS with an offer that indicates the flexibility possibilities of that node.				
Sc. 2	Compute flexibility options and send flexibility instruction	The EMS, also considering the info collected from the local and central grids, computes an optimized energy plan (in SUC-NL-01.3) and sends to the energy node prosumer's interface a flexibility instruction, which is the option (chosen by the EMS among those indicated in the flex offer by the energy node) to be executed	EMS	When all flex offers are available to the EMS, together with central and local grid info (from SUC-NL-01.3)	Energy node flex offers and grid info are available to the EMS for optimization	A plan is computed by the EMS and flex instructions to execute this plan are sent to the nodes
Sc. 3	Execute energy optimizatio n plan	The instruction is executed either automatically on the device (e.g., start heat pump) or via the prosumer who first needs to take some action (e.g., plug the EV to charge it).	Prosumer's Energy node interface	When the flexibility instruction is received by the energy node prosumer's interface	Optimization plan available for execution	Optimization plan executed
Sc. 4	Update execution status	The energy node updates the EMS about the execution status of the flexibility instruction resulting from the flexibility alignment.	Prosumer's Energy node interface	When the flexibility instruction has reached the energy node for execution	EMS not aware of flexibility plan execution status	EMS informed about flexibility plan status execution

4.2 Steps – Scenarios

Scenario								
Scenario name:	Sc.1 - Exchange flexibility options							
Step No.	**Event**	**Name of process/ activity**	**Description of process/ activity**	**Service**	**Information producer (actor)**	**Information receiver (actor)**	**Information Exchanged (IDs)**	**Requirement, R-IDs**
1	Timer	Send flex request	At certain intervals (e.g., daily or hourly), a flexibility request message is sent by the EMS (of the aggregator) to the prosumer's energy node interface to inquire for the flexibility that energy nodes can offer.	CREATE	EMS	Prosumer's Energy Node Interface	Inf. 1	QoS.2, QoS.3, QoS.4, QoS.5 Sec.4 D.2, D.5 Conf.3, Conf.4, Conf.6, Conf.8 O.X
2	Send flex request	Send flex offer	The energy node interface of the prosumer sends back a response to the EMS with an offer that indicates the flexibility possibilities of that node.	GET	Prosumer's Energy Node Interface	EMS	Inf. 2	QoS.2, QoS.3, QoS.4, QoS.5 Sec.2, Sec.4 D.2, D.5 Conf.3, Conf.4, Conf.6, Conf.8 O.X

Scenario								
Scenario name:	Sc.2 - Compute flexibility options and send flexibility instruction							
Step No.	**Event**	**Name of process/ activity**	**Description of process/ activity**	**Service**	**Information producer (actor)**	**Information receiver (actor)**	**Information Exchanged (IDs)**	**Requirement, R-IDs**
3	Send flex offer	Optimize energy production and consumption (SUC-NL-01.3)	Algorithms are run on the EMS to optimize the energy consumption and production of the various energy nodes based also on info/signals from the central and local grid (see SUC-NL-01.3).	CREATE	EMS	EMS	-	-

4	Optimize energy production and consumption (SUC-NL-01.3)	Send flexibility instruction	The EMS sends to the energy node prosumer's interface a flexibility instruction, which is the most optimized option to be executed (chosen by the EMS among those indicated by the energy node in the flex offer)	REPORT	EMS	Prosumer's Energy Node Interface	Inf. 3	QoS.2, QoS.3, QoS.4, QoS.5 Sec.2, Sec.4 D.5 Conf.6, Conf.8 O.X

Scenario								
Scenario name:		Sc.3 - Execute energy optimization plan						
Step No.	***Event***	***Name of process/ activity***	***Description of process/ activity***	***Service***	***Information producer (actor)***	***Information receiver (actor)***	***Information Exchanged (IDs)***	***Requirement, R-IDs***
5	Send flexibility instruction	Instruct device	In this alternative step, the flexibility instruction is executed automatically on the energy node with no need of human intervention (e.g., start heat pump).	EXECUTE	Prosumer's Energy Node Interface	Prosumer's Energy Node Interface	-	-
6	Send flexibility instruction	Instruct user	In this alternative step, the flexibility instruction is executed via the prosumer who first needs to take some action (e.g., plug the EV in order to charge it).	EXECUTE	Prosumer's Energy Node Interface	Prosumer's Energy Node Interface	-	-

Scenario								
Scenario name:		Sc.4 - Update execution status						
Step No.	***Event***	***Name of process/ activity***	***Description of process/ activity***	***Service***	***Information producer (actor)***	***Information receiver (actor)***	***Information Exchanged (IDs)***	***Requirement, R-IDs***
7	Instruct device OR Instruct user	Send flexibility instruction	The energy node updates the EMS about the execution status of the flexibility	REPORT	Prosumer's Energy node interfa	EMS	Inf. 6	QoS.5 Conf.6, Conf.8

		execution status	instruction resulting from the flexibility alignment.		ce			

5 Information exchanged

Information exchanged			
Information exchanged (ID)	***Name of information***	***Description of information exchanged***	***Requirement, R-IDs***
Inf. 1	Send flex request	A flexibility request is a message sent by an EMS to an energy node (device) to inquire for the flexibility it can offer. It has an effective period and a creation time. It identifies the device which sends the request (in this case the EMS).	QoS.2, QoS.3, QoS.4, QoS.5 Sec.4 D.2, D.5 Conf.3, Conf.4, Conf.6, Conf.8 O.X
Inf.2	Send flex offer	A flexibility offer is sent by an energy node to the EMS as a response to a Flex Request, indicating the node's flexibility potential. It identifies the energy node (device or agent) which produced the offer and includes a link to the flex request which generated this offer. The flex offer also has an effective period and a creation time. Flexibility offers can include an Incentive Table, a Flexibility Profile, Time Series and Datapoints to indicate measurements and tariffs.	QoS.2, QoS.3, QoS.4, QoS.5 Sec.2, Sec.4 D.2, D.5 Conf.3, Conf.4, Conf.6, Conf.8 O.X
Inf.3	Send flexibility instruction	A flexibility instruction is the message that the EMS sends to the energy node about how it should operate according to the energy optimization plan. It has an identifier, an effective period, a creation time and includes a link to the flex request which generated this instruction. It also includes an activation plan expressed in time-series and a cost defined as a datapoint. It can have an execution time and period of validity.	QoS.2, QoS.3, QoS.4, QoS.5 Sec.2, Sec.4 D.5 Conf.6, Conf.8 O.X
Inf. 6	Send flexibility instruction execution status	The instruction status is an update about the current state of execution. Example values can be accepted, rejected, aborted, revoked, new, started, succeeded.	QoS.5 Conf.6, Conf.8

6 Requirements

Quality of Service Requirements		
Categories ID	**Category name for requirements**	**Category description**
QoS	Quality of Service	Generic properties that service/SUC should provide – quality attributes.
Requirement	**Requirement name**	**Requirement description**

R-ID		
QoS.2	Elapsed time response requirements for exchanging data	More than 10 seconds
QoS.3	Availability of information flows	Continuous availability not required but must be available at specific times or under specific conditions
QoS.4	Accuracy of data requirements	Age of data needs to be knowable Adequate accuracy can be assumed
QoS.5	Frequency of data exchanges	Upon event

Security Requirements		
Categories ID	**Category name for requirements**	**Category description**
Sec	Security	Authentication of user, confidentiality, integrity, prevention of denial of service, non-repudiation or accountability, error management.
Requirement R-ID	**Requirement name**	**Requirement description**
Sec.2	Eavesdropping: Ensuring confidentiality, avoiding illegitimate use of data, and preventing unauthorized reading of data, is:	Quite important
Sec.4	Authentication and Access Control mechanisms commonly used with this data exchange	Public key encryption (e.g. SSL/TLS)

Data Management Requirements		
Categories ID	**Category name for requirements**	**Category description**
D	Data Management	Type of source of data, correctness or validity of data, timeliness or time stamping of data, volume of data, synchronization, or consistency of data across systems, timely access to data, validation of data across organizational boundaries, transaction management, data naming, identification, formats across disparate systems, maintenance of data and databases.
Requirement R-ID	**Requirement name**	**Requirement description**
D.2	Correctness of source data	Source data is always correct (e.g. by definition)
D.5	Management of data across organizational boundaries	Data exchanges go across organizational boundaries

Discovery and Configuration Requirements		
Categories ID	**Category name for requirements**	**Category description**

Conf	Configuration	Locations, distances, communication layout, commonly used communication protocol media, network bandwidth, existing protocols, number of devices, systems, volume of data items, expected growth, etc.
Requirement R-ID	**Requirement name**	**Requirement description**
Conf.3	Number of Information Producers	Few to a hundred
Conf.4	Number of Information Receivers	Two to a few
Conf.6	Data exchange methods	Other: REST API (client-server)
Conf.8	Commonly used communication protocol	Natively REST, other protocols (e.g., MODBUS, MQTT) supported via semantic adapters.

Other Requirements		
Categories ID	**Category name for requirements**	**Category description**
O	Regulatory obligation related to privacy	2016/679 GDPR (General Data Protection Regulation)
Requirement R-ID	**Requirement name**	**Requirement description**
O.2	All constraints also apply.	Personal data may not be processed unless there is at least one legal basis to do so.
O.3	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.
O.4	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.
O.5	Data retention policy	Personal data may not be transferred to a third-party if the data subject does not agree and the third party provide appropriate safeguard.
O.X	All constraints also apply.	All requirements in this category.

7 Common Terms and Definitions

Common Terms and Definitions	
Term	**Definition**
Energy nodes	Hardware such as batteries, heat pumps, PVs, EV-chargers, smart meters and other energy (flexibility) assets with interoperable interface/connection and owned by the Prosumer
EMS	Energy Management System

BMS	Building Management System
EV	Electric Vehicle
PV	Photo Voltaic
HP	Heat Pump
DSO	Distribution System Operator
V2G	Vehicle-to-Grid. A technology that allows energy from a vehicle's battery to flow to the grid.

5 SUC-NL-02.1 – ANOMALY AND FAULT DETECTION IN THE LOCAL GRID

1 Description of the use case

1.1 Name of the use case

ID	Area / Domain(s) / Zones(s)	Name of Use Case
SUC-NL-02.1	Local grid resilience at business park	Anomaly and fault detection in the local grid

1.2 Version management

Version Management			
Version No.	Date	Name of Author(s)	Changes
1	04.09.2024	S. Lathouwers (TNO)	First version
2	09.09.2024	S. Lathouwers (TNO)	Updated sequence diagram & corresponding
3	01.10.2024	W.Beelen (AB) and L. Daniele (TNO)	Update 1.4-1.6 and requirements. Updated SUC name according to naming convention

1.3 Scope and objectives of use case

Scope and Objectives of Use Case	
Scope	Implement a system to detect anomalies and faults in the local grid at Electricity Campus Arnhems Buiten and informing stakeholders about these anomalies such that they can be resolved thereby improving the resilience of the local grid.
Objective(s)	1. Implement a system for detecting anomalies 2. Assess the severity and potential impact of anomalies and faults. 3. Update the status of anomalies and faults. 4. Resolve anomalies and faults.
Related business case(s)	BUC-NL-02 – Enhance local grid resilience through detection & prevention

1.4 Narrative of use case

Narrative of Use Case
Short description
Based on historical and current data of the grid, we use data analysis and algorithms to suggest recommendations for predictive maintenance and provide real-time alerts for any anomalies or faults in the grid.
Complete description
The Electricity Campus is a business park where the electricity grid is owned and managed by Arnhems Buiten, which functions as a local Distribution System Operator (DSO). This use case describes a system designed to monitor and control various energy nodes, providing real-time data insights through dashboards. The system will cater to multiple stakeholders, including prosumers (owners and/or users of energy nodes) and Arnhems Buiten.

This use case outlines the process of proactively detecting, assessing, and resolving anomalies and faults within a local energy grid. By leveraging real-time data analytics, the system aims to ensure the grid's reliability, safety, and efficient operation. The process begins with the continuous collection of data from various sources within the grid, including sensors, meters, and communication devices. This data is then analyzed using advanced algorithms to identify deviations from normal patterns or expected behavior. Once anomalies are detected, the system assesses their severity and potential impact, considering factors such as the affected area, duration, and consequences. Detected anomalies and faults are categorized and updated in a database, allowing for efficient tracking and management. Relevant personnel or systems are immediately notified of critical issues, enabling prompt response and resolution. To address anomalies and faults effectively, the system may initiate specific actions, such as isolating affected components, coordinating repair procedures, or consulting with external experts. After resolution, the system verifies that the issue has been successfully addressed and the grid is operating normally. By monitoring the grid for anomalies and faults, this use case helps to prevent disruptions, minimize downtime, and ensure the overall reliability and efficiency of the local energy grid. **Key Objective**: Use real-time monitoring and historical data analysis to improve the resilience of the local grid by timely notifying stakeholders of anomalies and/or faults.

1.5 Key performance indicators (KPI)

ID	*Name*	*Description*	*Reference to mentioned use case objectives*
OB1	Different types of IoT/edge devices to be exploited in Demo Areas e.g., Smart Meter, HEMS, Sensors, inverter	Number of devices that are monitored on functioning (operation)	Objective 1
OB4	Users involved in the piloting activities	Number of (end) users using the system to resolve anomalies and faults	Objective 4
KPI11	Increased grid operational performance	Not to be measured in CAIDI	Objective 2-3-4

1.6 Use case conditions

Use case conditions
Assumptions
- Prosumers have or will have the necessary equipment to offer flexibility (e.g., smart meters, controllable loads, energy storage systems). - The Digital System and Infrastructure can run anomaly detection algorithms. - There will be a reliable communication infrastructure in place to support real-time data exchange between all actors.
Prerequisites
- Installation of smart meters and necessary equipment at prosumer. - Development and deployment of the Prosumer's interface and Dashboards for the System Integrator and Local DSO. - Training for prosumers and aggregators on how to use the system effectively. - Selection of service providers for the creation of a grid management system. - Procurement of necessary hardware. - Development of the grid energy management platform.

1.7 Further Information to the use case for classification / mapping

Classification Information
Relation to other use cases
This SUC relies on information provided by SUC-NL-01.1
Level of depth
Prioritisation
Generic, regional or national relation
Nature of the use case
System use case
Further keywords for classification
Anomaly detection, predictive maintenance, fault detection

1.8 General Remarks

General Remarks

2 Diagrams of use case

Diagram(s) of use case

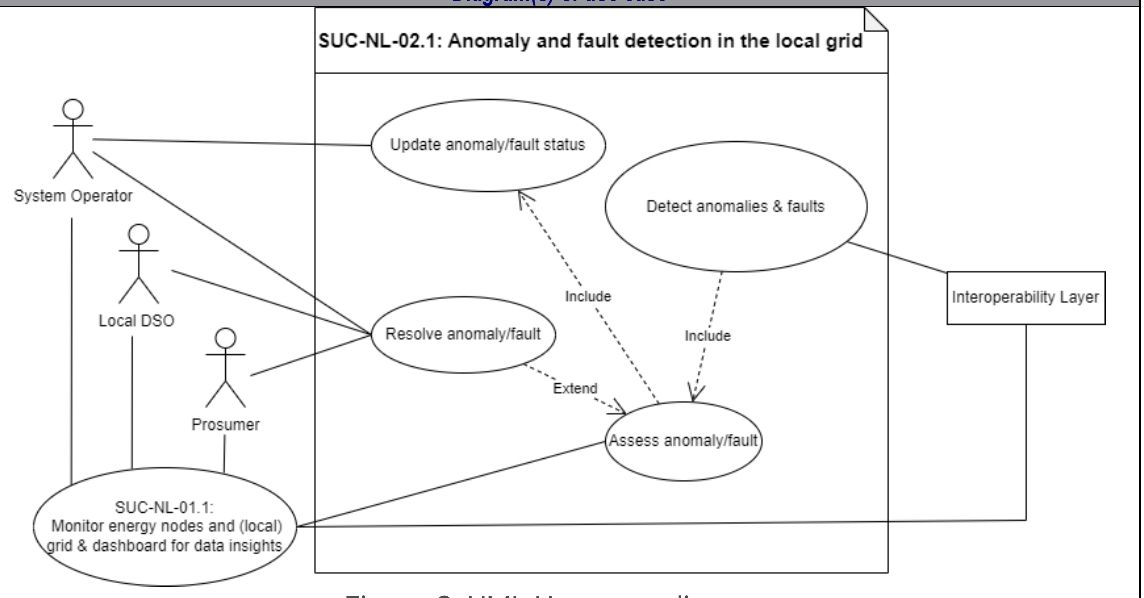


Figure 9: UML Use case diagram

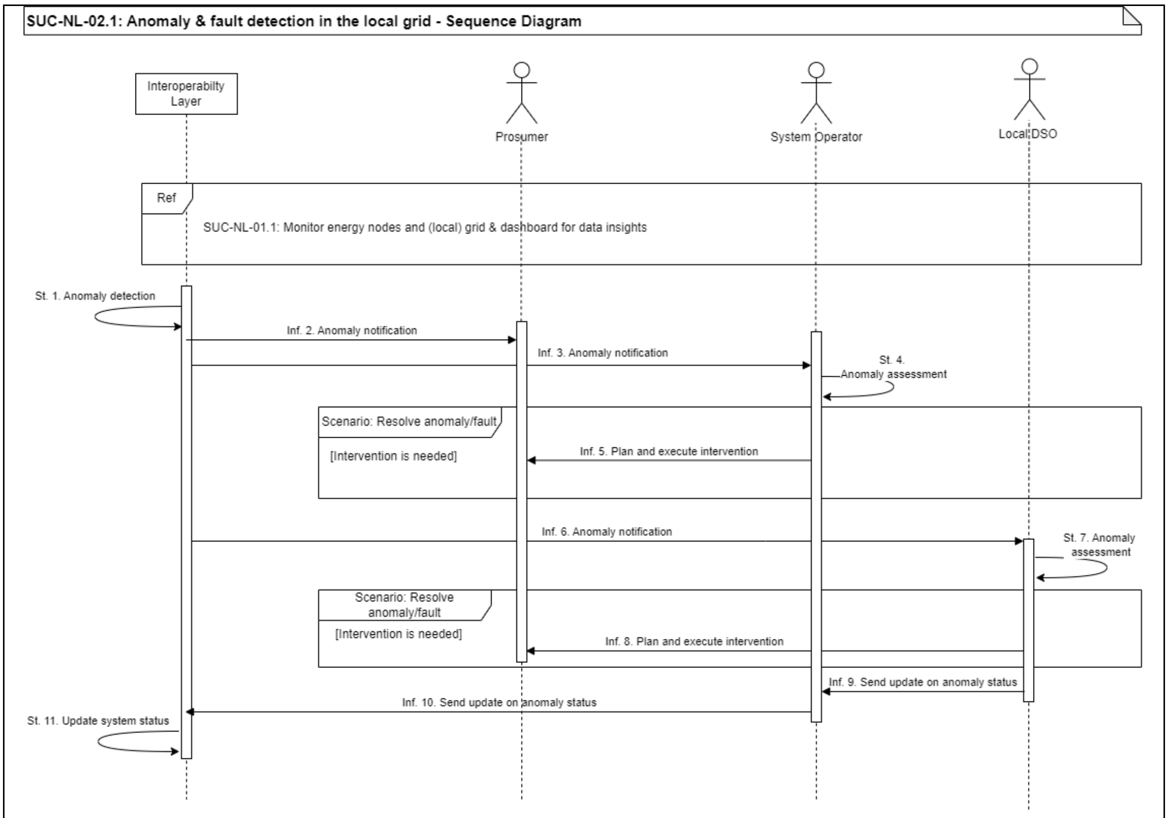


FIGURE 10: UML SEQUENCE DIAGRAM

3 Technical details

3.1 Actors

Actors			
Actor Name	***Actor Type***	***Actor Description***	***Further information specific to this use case***
Interoperability layer	Logic actor	A system responsible for sharing data between participants in an interoperable manner.	TNO and VU/A as main contributors An anomaly detection algorithm/service is dedicated within the Interoperability Layer to provide anomaly and fault detection of the local grid
Prosumer	Business Actor	A party that consumes and/or generates electricity.	The combination of: - Visitor or tenant, paying (in)direct, via Grid operator) energy bill for using energy for charging EV, or using office (facilities). - Owner of buildings and (e.g. connected) PV,

			charging stations and batteries) - Visiting EV User connection car to grid (V2G or normal charging), tenants of office space and/or Arnhems Buiten as Building owner
System Operator	Operator	A party responsible for installing, maintaining, testing, certifying and decommissioning the energy nodes (such as smart meters etc.)	Exact scope of the operator must be defined and therefore a party has to be selected during the project
Local DSO	Operator	A party responsible for providing access to the local grid.	Local/decentral DSO. Owner of the Mid and Low voltage grid. Arnhems Buiten

3.2 References

References						
No.	***Reference Type***	***Reference***	***Status***	***Impact on use case***	***Originator / organisation***	***Link***

4 Step by step analysis of use case

4.1 Overview of scenarios

Scenario conditions						
No.	**Scenario name**	**Scenario description**	**Primary actor**	**Triggering event**	**Pre-condition**	**Post-condition**
Sc. 1	Detect anomalies & faults	Use historical and current data of the local grid to detect anomalies/faults.	Digital System and Infrastructure	An anomaly is detected by an algorithm.	The energy usage is continuously monitored, and this data is exchanged using the Digital System and Infrastructure.	If an anomaly or fault occurs, this is detected by the system.
Sc. 2	Assess anomaly/fault	When an anomaly/fault has been detected, it needs to be assessed to determine how to resolve it.	System Operator / Local DSO	A notification has been received indicating an anomaly/fault has occurred.	An anomaly/fault has been detected and notifications about this have been sent.	It has been determined whether an intervention is needed to resolve the anomaly/fault.
Sc. 3	Resolve anomaly/fault	When it has been determined how to resolve an anomaly/fault, this needs to be executed.	Local DSO	An anomaly has been detected for which intervention is needed for it to be resolved	An anomaly has been detected and the assessment shows that intervention is	Anomaly/fau It is resolved through interaction by a person.

					needed to resolve it.	
Sc. 4	Update anomaly/fault status	Update the status of the anomaly to indicate that it has been resolved.	Local DSO	An anomaly has just been resolved.	An anomaly was detected, assessed and resolved.	The Digital System and Infrastructure is updated to reflect the new state of the system.

4.2 Steps – Scenarios

Scenario								
Scenario name:		Sc.1 Detect anomalies & faults						
Step No.	**Event**	**Name of process/ activity**	**Description of process/ activity**	**Service**	**Information producer (actor)**	**Information receiver (actor)**	**Information Exchanged (IDs)**	**Requirement, R-IDs**
1	Timer	Anomaly detection	The energy consumption/production on the network is continuously monitored. At regular intervals, algorithms are run to detect any anomalies/faults within this data.	CREATE	Interoperability Layer	–	–	QoS.2, QoS.5 Sec.2, Sec.3

Scenario								
Scenario name:		Sc.2 Assess anomaly/fault						
Step No.	**Event**	**Name of process/ activity**	**Description of process/ activity**	**Service**	**Information producer (actor)**	**Information receiver (actor)**	**Information Exchanged (IDs)**	**Requirement, R-IDs**
2	Sc. 2 (Anomaly is detected)	Anomaly notification	An anomaly has been detected. A notification is sent to the Prosumer's interface.	REPORT	Interoperability Layer	Prosumer	Inf. 2	QoS.2, QoS.3, QoS.4, QoS.5 Sec.2, Sec.3, Sec.4, Sec.5 D.2, D.3, D.5 Conf.3, Conf.4, Conf.7, Conf.8 O.X
3	Sc. 2 (Anomaly is detected)	Anomaly notification	An anomaly has been detected. A notification is sent to the (dashboard of) the System Operator.	REPORT	Interoperability Layer	System Operator	Inf. 3	QoS.2, QoS.3, QoS.4, QoS.5 Sec.2, Sec.3,

								Sec.4, Sec.5 D.2, D.3, D.5 Conf.3, Conf.4, Conf.7, Conf.8 O.X
4	Anomaly notification (5)	Anomaly assessment	The System Operator assesses the anomaly & system in detail to determine whether action needs to be taken to resolve the anomaly.	EXECUTE	System Operator	-	-	QoS.2, QoS.5 Sec.2, Sec.3
6	Sc. 2 (Anomaly is detected)	Anomaly notification	An anomaly has been detected. A notification is sent to the dashboard of the Local DSO.	REPORT	Interoperability Layer	Local DSO	Inf. 6	QoS.2, QoS.3, QoS.4, QoS.5 Sec.2, Sec.3, Sec.4, Sec.5 D.2, D.3, D.5 Conf.3, Conf.4, Conf.7, Conf.8 O.X
7	Anomaly notification (9)	Anomaly assessment	The Local DSO assesses the anomaly & the system in detail to determine whether action needs to be taken to resolve the anomaly.	EXECUTE	Local DSO	-	-	QoS.2, QoS.5 Sec.2, Sec.3

Scenario								
Scenario name:		Sc.3 Resolve anomaly/fault						
Step No.	**Event**	**Name of process/ activity**	**Description of process/ activity**	**Service**	**Information producer (actor)**	**Information receiver (actor)**	**Information Exchanged (IDs)**	**Requirement, R-IDs**
5	System Operator determined anomaly assessment (Sc. 2)	Plan and execute intervention	If the System Operator determines that an intervention is needed to resolve an anomaly, (s)he plans and executes how this should be done, possibly together with the Prosumer.	REPORT	System Operator	Prosumer	Inf. 5	QoS.2, QoS.3, QoS.4, QoS.5 Sec.2, Sec.3, Sec.4, Sec.5 D.2, D.3, D.5 Conf.3, Conf.4, Conf.7, Conf.8 O.X
8	Local DSO determined anomaly assessment (Sc. 2)	Plan and execute intervention	If the Local DSO determines that an intervention is needed to resolve an anomaly, (s)he plans and executes how this should be done, possibly together with the Prosumer.	REPORT	Local DSO	Prosumer	Inf. 8	QoS.2, QoS.3, QoS.4, QoS.5 Sec.2, Sec.3, Sec.4, Sec.5 D.2, D.3, D.5 Conf.3, Conf.4, Conf.7, Conf.8 O.X

Scenario								
Scenario name:		Sc.4 Update anomaly/fault status						
Step No.	**Event**	**Name of process/ activity**	**Description of process/ activity**	**Service**	**Information producer (actor)**	**Information receiver (actor)**	**Information Exchanged (IDs)**	**Requirement, R-IDs**
9	Anomaly has been resolved (with or without intervention)	Send update on anomaly status	The Local DSO sends an update to the System Operator on the anomaly status to inform the System Operator that it has been resolved or no intervention is needed.	REPORT	Local DSO	System Operator	Inf. 9	QoS.2, QoS.3, QoS.4, QoS.5 Sec.2, Sec.3, Sec.4, Sec.5 D.2, D.3, D.5 Conf.6, Conf.7, Conf.8 O.X
10	Send update on anomaly status (13)	Send update on anomaly status	The Dashboard (System Operator view) shares the update of the anomaly with the Digital System and Infrastructure.	REPORT	System Operator	Interoperability Layer	Inf. 10	QoS.2, QoS.3, QoS.4, QoS.5 Sec.2, Sec.3, Sec.4, Sec.5 D.2, D.3, D.5 Conf.6, Conf.7, Conf.8 O.X
11	Send update on anomaly status (14)	Update system status	The Digital System and Infrastructure changes the status of the anomaly to indicate that it has been resolved.	CHANGE	Interoperability Layer	-	-	QoS.2, QoS.5 Sec.2, Sec.3

5 Information exchanged

Information exchanged			
Information exchanged (ID)	*Name of information*	*Description of information exchanged*	*Requirement, R-IDs*
Inf. 2, 3, 6	Anomaly notification	Notification of an anomaly. It will indicate which device(s) is involved, what anomaly/fault has been detected (description of the error) and the date/time.	QoS.2, QoS.3, QoS.4, QoS.5 Sec.2, Sec.3, Sec.4, Sec.5 D.2, D.3, D.5 Conf.3, Conf.4, Conf.7, Conf.8 O.X
Inf 5, 8	Plan and execute intervention	Plan on how to resolve the intervention. This includes which steps need to be taken to resolve the anomaly.	QoS.2, QoS.3, QoS.4, QoS.5 Sec.2, Sec.3, Sec.4, Sec.5 D.2, D.3, D.5 Conf.3, Conf.4, Conf.7, Conf.8 O.X
Inf. 9, 10	Send update on anomaly status	Notification indicating which anomaly has been resolved. It will share the anomaly identifier.	QoS.2, QoS.3, QoS.4, QoS.5 Sec.2, Sec.3, Sec.4, Sec.5 D.2, D.3, D.5 Conf.6, Conf.7, Conf.8 O.X

6 Requirements

Quality of Service Requirements		
Categories ID	**Category name for requirements**	**Category description**
QoS	Quality of Service	Generic properties that service/SUC should provide – quality attributes.
Requirement R-ID	**Requirement name**	**Requirement description**
QoS.2	Elapsed time response requirements for exchanging data	More than 10 seconds
QoS.3	Availability of information flows	Continuous availability not required but must be available at specific times or under specific conditions
QoS.4	Accuracy of data requirements	Age of data needs to be knowable Adequate accuracy can be assumed
QoS.5	Frequency of data exchanges	Upon event

Security Requirements		
Categories ID	**Category name for requirements**	**Category description**
Sec	Security	Authentication of user, confidentiality, integrity, prevention of denial of service, non-repudiation or accountability, error management.
Requirement R-ID	**Requirement name**	**Requirement description**
Sec.2	Eavesdropping:	Quite important

	Ensuring confidentiality, avoiding illegitimate use of data, and preventing unauthorized reading of data, is:	
Sec.3	Information integrity violation: Ensuring that data is not changed or destroyed is:	Quite important
Sec.4	Authentication and Access Control mechanisms commonly used with this data exchange	Public key encryption (e.g. SSL/TLS)
Sec.5	Network security measures commonly used with this data exchange	Other: IP Whitelist

Data Management Requirements		
Categories ID	**Category name for requirements**	**Category description**
D	Data Management	Type of source of data, correctness or validity of data, timeliness or time stamping of data, volume of data, synchronization, or consistency of data across systems, timely access to data, validation of data across organizational boundaries, transaction management, data naming, identification, formats across disparate systems, maintenance of data and databases.
Requirement R-ID	**Requirement name**	**Requirement description**
D.2	Correctness of source data	Source data is always correct (e.g. by definition)
D.3	Up-to-date management	Other: Measurement data is not expected to be updated, since it is timestamped ______
D.4	Data consistency and synchronization management across systems	No synchronization
D.5	Management of data across organizational boundaries	Data exchanges go across organizational boundaries
D.6	Data maintenance effort: human versus automation	Data maintenance is mostly automated but requires occasional intervention

Discovery and Configuration Requirements		
Categories ID	**Category name for requirements**	**Category description**
Conf	Configuration	Locations, distances, communication layout, commonly used communication protocol media, network bandwidth, existing protocols, number of devices, systems, volume of data items, expected growth, etc.
Requirement R-ID	**Requirement name**	**Requirement description**
Conf.2	Distance between entities	Many hundreds of kilometers
Conf.3	Number of Information Producers	Few to a hundred

Conf.4	Number of Information Receivers	Two to a few
Conf.5	Communication media	Other: Sensor communication (can be Zigbee, Bluetooth, WiFi etc.)
Conf.6	Data exchange methods	Publish-subscribe Other: REST API (client-server)
Conf.7	Communication access services requirements	Request-response
Conf.8	Commonly used communication protocol	Include here the communication protocols used for the information exchange. - REST API (JSON) - Knowledge Engine (Graph patterns)

Other Requirements		
Categories ID	**Category name for requirements**	**Category description**
O	Regulatory obligation related to privacy	2016/679 GDPR (General Data Protection Regulation)
Requirement R-ID	**Requirement name**	**Requirement description**
O.2	All constraints also apply.	Personal data may not be processed unless there is at least one legal basis to do so.
O.3	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.
O.4	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.
O.5	Data retention policy	Personal data may not be transferred to a third-party if the data subject did not agree and the third party provide appropriate safeguard.
O.X	All constraints also apply.	All requirements in this category.

7 Common Terms and Definitions

Common Terms and Definitions	
Term	**Definition**
Energy nodes	Hardware such as batteries, heat pumps, PVs, EV-chargers, smart meters and other energy (flexibility) assets with interoperable interface/connection and owned by the Prosumer
EMS	Energy Management System
BMS	Building Management System
EV	Electric Vehicle
PV	Photo Voltaic

HP	Heat Pump
DSO	Distribution System Operator
Anomaly	Behaviour of a system that deviates from the system's usual behaviour.
Fault	An error that occurs within a system.
Predictive maintenance	Techniques to determine when maintenance should be performed, thereby hoping to save costs and/or prevent unexpected system failures.

6 SUC-NL-02.2 – PREDICTIVE MAINTENANCE

1 Description of the use case

1.1 Name of the use case

ID	Area / Domain(s) / Zones(s)	Name of Use Case
SUC-NL-02.2	Local grid resilience at business park	Predictive maintenance

1.2 Version management

Version Management			
Version No.	**Date**	**Name of Author(s)**	**Changes**
1	23-05-2024	W.Beelen and S. Lathouwers	Draft outline of use case
2	8-9-2024	W.Beelen (AB)	Input form diagrams and content added
3	10-09-2024	L.Daniele (TNO)	Added use case and sequence diagrams, actors, scenarios and information exchanged
4	11-09-2024	L.Daniele (TNO)	Added scenarios' steps
6	18-09-2024	L.Daniele (TNO)	Updated use case and sequence diagrams, scenarios, steps and information exchanged to incorporate Trialog's feedback
7	24-09-2024	L.Daniele (TNO)	Use case diagram simplified according to Trialog's feedback
8	01-10-2024	TNO, VU and AB	Added requirements and extended scope and narratives

1.3 Scope and objectives of use case

Scope and Objectives of Use Case	
Scope	This use case describes the process of utilizing predictive maintenance techniques to identify potential faults or failures in the grid infrastructure, enabling proactive maintenance actions to be taken.
Objective(s)	1. Predict Maintenance for the end user and local DSO 2. Inform local DSO and/or service provider to coordinate maintenance activities
Related business case(s)	BUC-NL-02 Enhance local grid resilience through detection & prevention

1.4 Narrative of use case

Narrative of Use Case
Short description
Based on SUC-NL-01.1 and SUC-NL-02.1 with the use of AI/ML it should help to predict possible near future failure/anomalies that make it possible for the "problem owner" to act proactively.
Complete description
This use case focuses on leveraging AI/ML algorithms to predict potential failures or performance degradation in decentralized energy resources (DERs) within a grid. By analyzing historical sensor data and operational data, the system aims to optimize maintenance schedules, reduce unplanned downtime, and improve overall grid reliability. **Key steps in the process can include:** 1. **Data Collection:** Gathering real-time sensor data from DERs such as solar panels, electric vehicles, batteries, inverters, and heat pumps. 2. **Data Preprocessing:** Cleaning, normalizing, and preparing the collected data for analysis. 3. **Feature Engineering:** Extracting relevant features from the data, such as sensor readings, operational parameters, and environmental conditions. 4. **Model Development:** Selecting or developing appropriate AI/ML algorithms (e.g., time series analysis, machine learning models) for predictive maintenance. 5. **Model Training:** Training the selected models using historical data to learn patterns and correlations. 6. **Prediction:** Using the trained models to predict the likelihood of failures or performance degradation in DERs. 7. **Prioritization:** Ranking predicted failures or performance degradation based on their severity and potential impact on the grid. 8. **Maintenance Planning:** Developing optimized maintenance schedules based on the predicted issues. 9. **Execution:** Implementing planned maintenance activities to prevent or mitigate predicted failures. By implementing this predictive maintenance approach, the decentralized grid can benefit from: • **Reduced unplanned downtime:** Proactive maintenance can help prevent unexpected equipment failures. • **Optimized resource allocation:** Maintenance resources can be allocated more effectively based on predicted needs. • **Improved grid reliability:** By addressing potential issues before they occur, the overall reliability of the grid can be enhanced. • **Extended equipment lifespan:** Regular maintenance can help prolong the lifespan of DERs.

1.5 Key performance indicators (KPI)

ID	***Name***	***Description***	***Reference to mentioned use case objectives***
OB1	Different types of IoT/edge devices to be exploited in Demo Areas e.g., Smart Meter, HEMS, Sensors, inverter	Number of devices that are monitored on functioning (operation) and can become part of the predictive maintenance scope	Objective 1
OB 4	Users involved in the piloting activities	Number of (end) users using the algorithm to respond and act on their	Objective 1,2

		energy nodes	
KPI11	Increased grid operational performance	Not to be measured in CAIDI	Objective 2

1.6 Use case conditions

Use case conditions
Assumptions
• Grid infrastructure is operational. • Predictive maintenance system is configured and running. • Sensor data is being collected from relevant grid components.
Prerequisites
- Potential faults or failures have been identified. - Maintenance tasks have been prioritized and scheduled. - Grid reliability and efficiency have been improved.

1.7 Further Information to the use case for classification / mapping

Classification Information
Relation to other use cases
Part of BUC-NL-02. Data monitoring (SUC-NL-01.1) and Anomaly detection (SUC-NL-02.1) are needed
Level of depth
Prioritisation
Generic, regional or national relation
Nature of the use case
System use case
Further keywords for classification

1.8 General Remarks

General Remarks

2 Diagrams of use case

Diagram(s) of use case

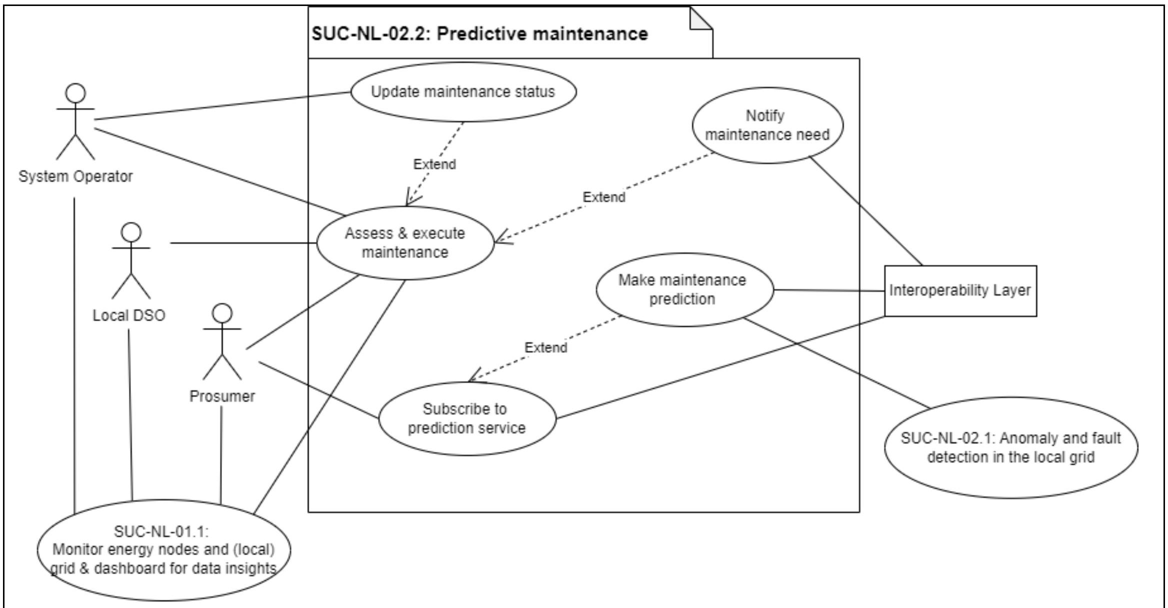


Figure 11: UML Use case diagram

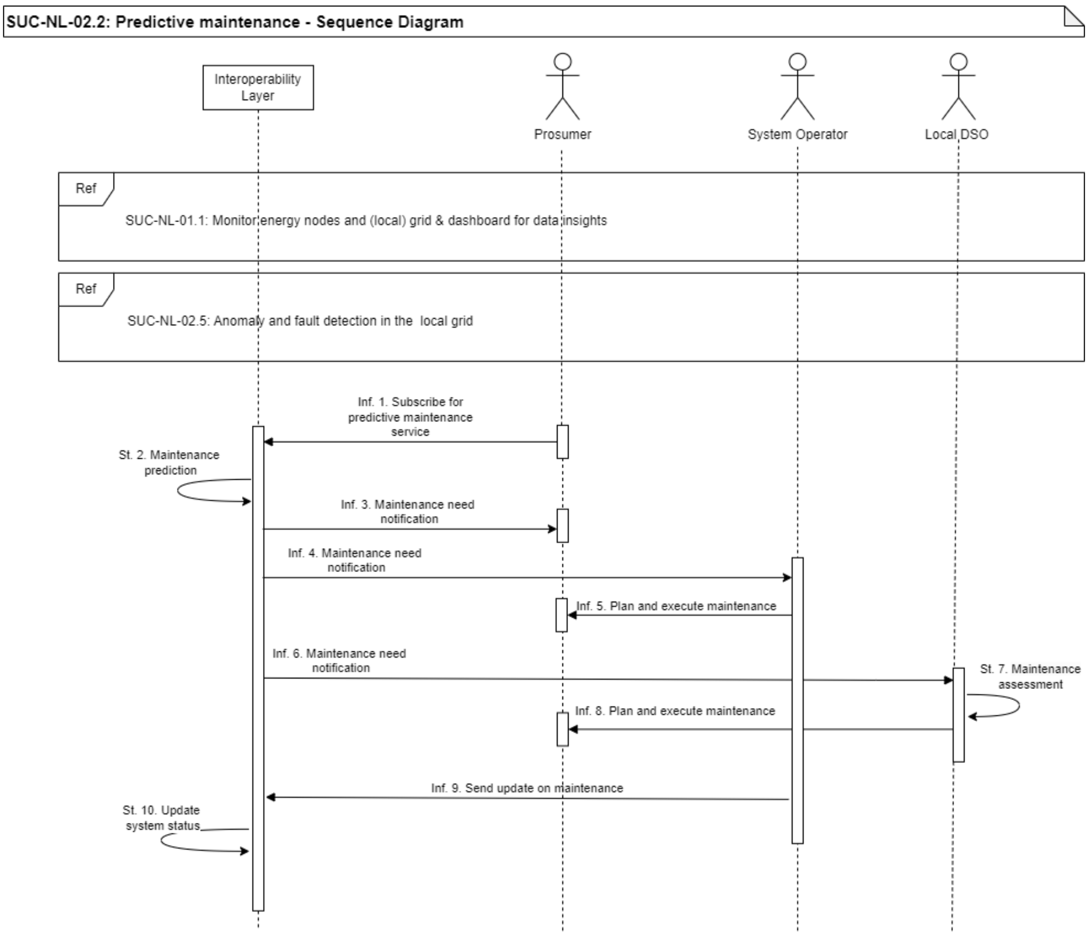


FIGURE 12: UML SEQUENCE DIAGRAM

3 Technical details

3.1 Actors

Actors			
Actor Name	***Actor Type***	***Actor Description***	***Further information specific to this use case***
Interoperability Layer	Logic actor	A system responsible for sharing data between participants in an interoperable manner.	TNO and VU/A as main contributors A predictive maintenance algorithm/service is dedicated within the Interoperability Layer to provide maintenance predictions
Prosumer	Business Actor	A party that consumes and/or generates electricity.	The combination of: - Visitor or tenant, paying (in)direct, via Grid operator) energy bill for using energy for charging EV, or using office (facilities). - Owner of buildings and (e.g. connected) PV, charging stations and batteries) - Visiting EV User connection car to grid (V2G or normal charging), tenants of office space and/or Arnhems Buiten as Building owner
System Operator	Operator	A party responsible for installing, maintaining, testing, certifying and decommissioning the energy nodes (such as smart meters etc.)	Exact scope of the operator has to be defined and therefore a party has to be selected during the project
Local DSO	Operator	A party responsible for providing access to the local grid.	Local/decentral DSO. Owner of the Mid and Low voltage grid. Arnhems Buiten

3.2 References

References						
No.	***Reference Type***	***Reference***	***Status***	***Impact on use case***	***Originator / organisation***	***Link***

4 Step by step analysis of use case

4.1 Overview of scenarios

Scenario conditions						
No.	**Scenario name**	**Scenario description**	**Primary actor**	**Triggering event**	**Pre-condition**	**Post-condition**
Sc.1	Subscribe to	A predictive maintenance	Prosumer	When the prosumer	Connection to energy nodes	Predictive maintenanc

	prediction service	service is requested by the prosumer to the interoperability layer		initiates the process by subscribing to the service	established (SUC1) and availability of predictive maintenance to the prosumer	e service is active for one or more energy nodes of the prosumer.
Sc. 2	Make maintenanc e prediction	Use historical and current data of the local grid and energy nodes to predict maintenance (also based on anomalies/faults detected in SUCNL-02.5)	Maintenance Prediction Service	Maintenance need is predicted by an algorithm.	The energy usage and nodes status is continuously monitored, and this data is exchanged using the Interoperabilit y Layer	A maintenanc e need is predicted by the system.
Sc. 3	Notify maintenanc e need	Once a maintenance prediction has been provided a notification for a maintenance need notification is sent to both the System Operator and the Local DSO	Interoperabilit y Layer	A maintenance prediction has been received.	A maintenance need is predicted by the system.	A maintenanc e need notification is sent to the interested parties.
Sc. 4	Assess and execute maintenanc e	When a maintenance need has been predicted, it needs to be assessed, and an intervention planned and executed.	System Operator/ Local DSO	A notification has been received indicating a maintenance need.	A maintenance need has been predicted and notifications about this have been sent.	Maintenance is executed through interaction by a person.
Sc. 5	Update maintenanc e status	Update the status of the maintenance to indicate if it has been executed successfully.	System Operator	The maintenance of an energy node is executed	A maintenance need was predicted, assessed and executed.	The Interoperabil ity Layer is updated to reflect the new state of the system.

4.2 Steps – Scenarios

Scenario								
Scenario name:		Sc.1 Subscribe to prediction service						
Step No.	**Event**	**Name of process/ activity**	**Description of process/ activity**	**Service**	**Information producer (actor)**	**Information receiver (actor)**	**Information Exchanged (IDs)**	**Requirement, R-IDs**
1	Prosumer wants to subscribe to a prediction service	Subscribe for predictive maintenance service	A predictive maintenance service is requested by the prosumer to the interoperability layer	EXECUTE	Prosumer	Interoperability Layer	Inf.1	QoS.4, QoS.5 Sec.2, Sec.3, Sec.4, Sec.5 D.2, D.5, D.6 Conf.3, Conf.4, Conf.6, Conf.7, Conf.8 O.X

Scenario								
Scenario name:		Sc.2 Make maintenance prediction						
Step No.	**Event**	**Name of process/ activity**	**Description of process/ activity**	**Service**	**Information producer (actor)**	**Information receiver (actor)**	**Information Exchanged (IDs)**	**Requirement, R-IDs**
2	Timer	Maintenance prediction	The energy consumption/production on the network is continuously monitored. At regular intervals, algorithms are run to predict any maintenance need on the various anergy nodes (also based on anomalies/faults detected in SUC5)	CREATE	Interoperability Layer	-	-	QoS.2, QoS.5 Sec.2, Sec.3

Scenario								
Scenario name:		Sc.3 Notify maintenance need						
Step No.	Event	Name of process/ activity	Description of process/ activity	Service	Information producer (actor)	Information receiver (actor)	Information Exchanged (IDs)	Requirement, R-IDs
3	Sc. 2 (Provide maintenance prediction)	Maintenance need notification	A maintenance need has been predicted. A notification is sent to the Prosumer as response to the previous subscription to the service.	REPORT	Interoperability Layer	Prosumer	Inf. 3	QoS.2, QoS.3, QoS.4, QoS.5 Sec.2, Sec.3, Sec.4, Sec.5 D.2, D.3, D.5 Conf.3, Conf.4, Conf.7, Conf.8 O.X
4	Sc. 2 (Provide maintenance prediction)	Maintenance need notification	A maintenance need has been predicted. A notification is sent to the System Operator	REPORT	Interoperability Layer	System Operator	Inf. 4	QoS.2, QoS.3, QoS.4, QoS.5 Sec.2, Sec.3, Sec.4, Sec.5 D.2, D.3, D.5 Conf.3, Conf.4, Conf.7, Conf.8 O.X
5	Sc. 2 (Provide maintenance prediction)	Maintenance need notification	A maintenance need has been predicted. A notification is sent to the Local DSO	REPORT	Interoperability Layer	Local DSO	Inf. 6	QoS.2, QoS.3, QoS.4, QoS.5 Sec.2, Sec.3, Sec.4, Sec.5 D.2, D.3, D.5 Conf.3, Conf.4, Conf.7, Conf.8 O.X

Scenario								
Scenario name:	Sc.4 Assess and execute maintenance							
Step No.	**Event**	**Name of process/ activity**	**Description of process/ activity**	**Service**	**Information producer (actor)**	**Information receiver (actor)**	**Information Exchanged (IDs)**	**Requirement, R-IDs**
6	Maintenance need notification (4)	Plan and execute intervention	An intervention for maintenance by the System Operator is planned with the Prosumer and executed.	EXECUTE	System Operator	Prosumer	Inf. 5	QoS.2, QoS.3, QoS.4, QoS.5 Sec.2, Sec.3, Sec.4, Sec.5 D.2, D.3, D.5 Conf.3, Conf.4, Conf.7, Conf.8 O.X
7	Maintenance need notification (5)	Maintenance need assessment	The Local DSO assesses the maintenance need in detail before execution	EXECUTE	Local DSO	-	-	QoS.2, QoS.5 Sec.2, Sec.3
8	Maintenance need assessment	Plan and execute intervention	An intervention for maintenance by the Local DSO is planned with the Prosumer and executed.	EXECUTE	Local DSO	Prosumer	Inf. 8	QoS.2, QoS.3, QoS.4, QoS.5 Sec.2, Sec.3, Sec.4, Sec.5 D.2, D.3, D.5 Conf.3, Conf.4, Conf.7, Conf.8 O.X

Scenario

Scenario name:		Sc.5 Update maintenance status						
Step No.	**Event**	**Name of process/ activity**	**Description of process/ activity**	**Service**	**Information producer (actor)**	**Information receiver (actor)**	**Information Exchanged (IDs)**	**Requirement, R-IDs**
9	Maintenance is executed (Sc. 4)	Send update on maintenance	The System Operator is the party that updates the Interoperability Layer with the status of the maintenance after the execution.	REPORT	System Operator	Interoperability Layer	Inf. 9	QoS.2, QoS.3, QoS.4, QoS.5 Sec.2, Sec.3, Sec.4, Sec.5 D.2, D.3, D.5 Conf.6, Conf.7, Conf.8 O.X
10	Send update on maintenance	Update system status	The Interoperability Layer updates the status of the maintenance for the node(s) in the system.	CHANGE	Interoperability Layer	-	-	QoS.2, QoS.5 Sec.2, Sec.3

5 Information exchanged

Information exchanged			
Information exchanged (ID)	***Name of information***	***Description of information exchanged***	***Requirement, R-IDs***
Inf. 1	Subscribe for predictive maintenance service	Registration data about the prosumer who subscribes for the service and for which energy node(s), including data about these nodes such as their type, identifier, manufacturer, location (building), etc.	QoS.4, QoS.5 Sec.2, Sec.3, Sec.4, Sec.5 D.2, D.5, D.6 Conf.3, Conf.4, Conf.6, Conf.7, Conf.8 O.X
Inf. 3,4, 6	Maintenance need notification	Notification of a maintenance need. It will indicate which energy node(s) (device, building, etc.) is involved and maintenance information (e.g., type of maintenance and intervention, last maintained, manufacturer info). Eventually also if an anomaly/fault has been detected (description of the error) and the date/time.	QoS.2, QoS.3, QoS.4, QoS.5 Sec.2, Sec.3, Sec.4, Sec.5 D.2, D.3, D.5 Conf.3, Conf.4, Conf.7, Conf.8 O.X
Inf. 5, 8	Plan and execute maintenance	Plan on how to make the intervention. This includes which steps need to be taken to execute the maintenance.	QoS.2, QoS.3, QoS.4, QoS.5 Sec.2, Sec.3, Sec.4, Sec.5 D.2, D.3, D.5 Conf.3, Conf.4, Conf.7, Conf.8 O.X
Inf. 9	Send update on maintenance	Notification indicating information about the maintenance that has been executed. It will share the type of maintenance identifier.	QoS.2, QoS.3, QoS.4, QoS.5 Sec.2, Sec.3, Sec.4, Sec.5 D.2, D.3, D.5 Conf.6, Conf.7, Conf.8 O.X

6 Requirements

Quality of Service Requirements		
Categories ID	**Category name for requirements**	**Category description**
QoS	Quality of Service	Generic properties that service/SUC should provide – quality attributes.
Requirement	**Requirement name**	**Requirement description**

R-ID		
QoS.2	Elapsed time response requirements for exchanging data	More than 10 seconds
QoS.3	Availability of information flows	Continuous availability not required but must be available at specific times or under specific conditions
QoS.4	Accuracy of data requirements	Age of data needs to be knowable Adequate accuracy can be assumed
QoS.5	Frequency of data exchanges	Upon event

Security Requirements		
Categories ID	**Category name for requirements**	**Category description**
Sec	Security	Authentication of user, confidentiality, integrity, prevention of denial of service, non-repudiation or accountability, error management.
Requirement R-ID	**Requirement name**	**Requirement description**
Sec.2	Eavesdropping: Ensuring confidentiality, avoiding illegitimate use of data, and preventing unauthorized reading of data, is:	Quite important
Sec.3	Information integrity violation: Ensuring that data is not changed or destroyed is:	Quite important
Sec.4	Authentication and Access Control mechanisms commonly used with this data exchange	Public key encryption (e.g. SSL/TLS)
Sec.5	Network security measures commonly used with this data exchange	Other: IP Whitelist

Data Management Requirements		
Categories ID	**Category name for requirements**	**Category description**
D	Data Management	Type of source of data, correctness or validity of data, timeliness or time stamping of data, volume of data, synchronization, or consistency of data across systems, timely access to data, validation of data across organizational boundaries, transaction management, data naming, identification, formats across disparate systems, maintenance of data and databases.
Requirement R-ID	**Requirement name**	**Requirement description**
D.2	Correctness of source data	Source data is always correct (e.g. by definition)
D.3	Up-to-date management	Other: Measurement data is not expected to be

		updated, since it is timestamped ______
D.4	Data consistency and synchronization management across systems	No synchronization
D.5	Management of data across organizational boundaries	Data exchanges go across organizational boundaries
D.6	Data maintenance effort: human versus automation	Data maintenance is mostly automated buy requires occasional intervention

Discovery and Configuration Requirements		
Categories ID	**Category name for requirements**	**Category description**
Conf	Configuration	Locations, distances, communication layout, commonly used communication protocol media, network bandwidth, existing protocols, number of devices, systems, volume of data items, expected growth, etc.
Requirement R-ID	**Requirement name**	**Requirement description**
Conf.2	Distance between entities	Many hundreds of kilometers
Conf.3	Number of Information Producers	Few to a hundred
Conf.4	Number of Information Receivers	Two to a few
Conf.5	Communication media	Other: Sensor communication (can be Zigbee, Bluetooth, WiFi etc.)
Conf.6	Data exchange methods	Publish-subscribe Other: REST API (client-server)
Conf.7	Communication access services requirements	Request-response
Conf.8	Commonly used communication protocol	Include here the communication protocols used for the information exchange. - REST API (JSON) - Knowledge Engine (Graph patterns)

Other Requirements		
Categories ID	**Category name for requirements**	**Category description**
O	Regulatory obligation related to privacy	2016/679 GDPR (General Data Protection Regulation)
Requirement R-ID	**Requirement name**	**Requirement description**
O.2	All constraints also apply.	Personal data may not be processed unless there is at least one legal basis to do so.
O.3	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.
O.4	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.
O.5	Data retention policy	Personal data may not be transferred to a third-party if the data subject did not agree and the third party provide appropriate safeguard.
O.X	All constraints also apply.	All requirements in this category.

7 Common Terms and Definitions

Common Terms and Definitions	
Term	**Definition**
Energy nodes	Hardware such as batteries, heat pumps, PVs, EV-chargers, smart meters and other energy (flexibility) assets with interoperable interface/connection and owned by the Prosumer
EMS	Energy Management System
BMS	Building Management System
EV	Electric Vehicle
PV	Photo Voltaic
HP	Heat Pump
DSO	Distribution System Operator
Anomaly	Behaviour of a system that deviates from the system's usual behaviour.
Fault	An error that occurs within a system.
Predictive maintenance	Techniques to determine when maintenance should be performed, thereby hoping to save costs and/or prevent unexpected system failures.

HEDGE-IoT

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

D2.2 Functional Specifications of the HEDGE-IoT system

|Annex Document 5 - Portuguese Pilot SUCs|

31/10/2024

Co-funded by the European Union

This project has received funding from the European Union's Horizon Europe research and innovation programme under the Grant Agreement number 101136216. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Climate, Infrastructure and Environment Executive Agency. Neither the European Union nor the granting authority can be held responsible for them.

PROJECT INFORMATION

<table>
<tr><td>Project Number</td><td colspan="3">101136216</td></tr>
<tr><td>Project Acronym</td><td colspan="3">HEDGE-IoT</td></tr>
<tr><td>Project Full title</td><td colspan="3">Holistic Approach towards Empowerment of the Digitalization of the Energy Ecosystem through adoption of IoT solutions</td></tr>
<tr><td>Project Start Date</td><td colspan="3">01 January 2024</td></tr>
<tr><td>Project Duration</td><td colspan="3">42 months</td></tr>
<tr><td>Funding Instrument</td><td>Horizon Europe Framework Programme</td><td>Type of action</td><td>HORIZON-IA HORIZON Innovation Actions</td></tr>
<tr><td>Call</td><td colspan="3">HORIZON-CL5-2023-D3-01-15</td></tr>
<tr><td>Topic</td><td colspan="3">Supporting the green and digital transformation of the energy ecosystem and enhancing its resilience through the development and piloting of AI-IoT Edge-cloud and platform solutions</td></tr>
<tr><td>Coordinator</td><td colspan="3">European Dynamics Luxembourg SA</td></tr>
</table>

DELIVERABLE INFORMATION

<table>
<tr><td>Deliverable No.</td><td colspan="8">D2.2</td></tr>
<tr><td>Deliverable Title</td><td colspan="8">Functional Specifications of the HEDGE-IoT system – Annex Document 5 – Portuguese Pilot SUCs</td></tr>
<tr><td>Work-Package No.</td><td colspan="8">WP2</td></tr>
<tr><td>Work-Package Title</td><td colspan="8">Stakeholders' Requirements and System Specifications</td></tr>
<tr><td>Lead Beneficiary</td><td colspan="8">TRIALOG</td></tr>
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<tr><td>Due date</td><td colspan="8">31/10/2024</td></tr>
<tr><td>Deliverable Type</td><td>X</td><td>Document, Report (R)</td><td></td><td>Data management</td><td></td><td>Websites, press & media</td><td></td><td>Other</td></tr>
</table>

				plan (DMP)		action (DEC)		
Dissemination Level	X	Public (PU)		Sensitive (SEN)		Classified		
	PU: Public, fully open SEN: Sensitive, limited under the conditions of the Grant Agreement Classified R-UE/EU-R – EU RESTRICTED under the Commission Decision No2015/444 Classified C-UE/EU-C – EU CONFIDENTIAL under the Commission Decision No2015/444 Classified S-UE/EU-S – EU SECRET under the Commission Decision No2015/444							

Document Revision History

Version	Date	Description of change	List of contributor(s)
0.1	25/10/2024	Compilation of all the pilot SUCs	Léo Cornec (Trialog)
0.2	28/10/2024	Review by Institut Jozefstefan	Aleksandra Raskovska (JSI)
1.0	30/10/2024	Final document version for integration to Deliverable D2.2	Léo Cornec (Trialog)

EXECUTIVE SUMMARY

This document is an annex of HEDGE-IoT deliverable D2.2 titled "Functional Specifications of the HEDGE-IoT system" document. It provides specifications for the System Use Cases (SUCs) of the pilot.

Each SUC was defined by pilot members, based on the corresponding Business Use Case (BUC) and the IEC 62559-2 template, with support from the task leader for the methodology.

This document will be updated later in the project based on additional work and feedback. For the HEDGE-IoT project, the following sections and subsections of the IEC 62559-2 template were defined as mandatory to be completed by the pilot demonstrators for the SUCs:

1. Description of the use case
    1.1. Name of the use case
    1.2. Scope and objectives of the use case
    1.3. Narrative of the use case
2. Diagrams of the use case
3. Technical details
    3.1. Actors
4. Step-by-step analysis of use case
    4.1. Overview of scenarios
    4.2. Steps - scenarios
5. Information exchanged
6. Requirements

The following table links the BUCs and the SUCs of the pilot:

BUC ID & BUC name	SUC ID	SUC name
BUC-PT-01 GreenVale: Harnessing the potential of energy communities by leveraging Federated Learning strategies	SUC-PT-01.1	Connect flexibility providers across the DPP flexibility value chain
	SUC-PT-01.2	Enable Data Exchange via Data Spaces
	SUC-PT-01.3	Mobilizing Energy Flexibility
	SUC-PT-01.4	Activation of Energy Flexibility
BUC-PT-02 Participation of industrial and residential energy communities in ancillary services market for the TSO	SUC-PT-02.1	Bidding & Selection
	SUC-PT-02.2	aFRR/mFRR Activation
	SUC-PT-02.3	aFRR / mFRR Settlement
BUC-PT-03 Flexibility aggregation at tertiary buildings	SUC-PT-03.1	Integrate flexible assets from commercial buildings
	SUC-PT-03.2	Default valorization scenario based on price hedging
	SUC-PT-03.3	TSO valorization scenario

1 SUC-PT-01.1 CONNECT FLEXIBILITY PROVIDERS ACROSS THE DIGITAL PLATFORM PROVIDER (DPP) FLEXIBILITY VALUE CHAIN

1 Description of the use case

1.1 Name of the use case

ID	Area / Domain(s)	Name of Use Case
SUC-PT-01.1	Energy Flexibility	Connect flexibility providers across the DPP flexibility value chain

1.2 Version management

Version Management			
Version No.	**Date**	**Name of Author(s)**	**Changes**
0.1	29.05.2024	David Rua (INESC TEC) Fábio Coelho (INESC TEC) Vasco Campos (INESC TEC)	First complete draft.
0.2	3.06.2024	David Rua (INESC TEC) Fábio Coelho (INESC TEC) Vasco Campos (INESC TEC)	Scope/Objectives section, Complete description section, diagrams section.
0.3	9.07.2024	David Rua (INESC TEC) Fábio Coelho (INESC TEC) Vasco Campos (INESC TEC)	Final version.
0.4	17.10.2024	David Rua (INESC TEC) Fábio Coelho (INESC TEC) Vasco Campos (INESC TEC)	Harmonization with new T2.6 guidelines for the "requirements" section and new use case diagram. Updated look and feel.

1.3 Scope and objectives of use case

Scope and Objectives of Use Case	
Scope	Exploitation of the energy flexibility of citizen's energy communities. Advances towards the creation of energy and non-energy services.

Objective(s)	1: Link consumers with suppliers/installers/O&M service providers of flexible DER to participate in the value chain and exploit flexibility business models.
Related business case(s)	BUC-PT-01– GreenVale: Harnessing the potential of energy communities by leveraging Federated Learning strategies.

1.4 Narrative of use case

Narrative of Use Case
Short description
The current SUC details the first and second stages of the Flexibility Energy Value Chain embodied by the EdgeConnect Platform, the system used by the Digital Platform Provider (DPP). The system holds services to onboard consumers/prosumers, service providers, most notably Flexibility Service Providers (FSPs), Resource Aggregators (Community Managers), Market Operators and TSOs. In brief, this SUC details how to: • **Link consumers with flexible assets to participate in the flexibility value chain. [Flexibility Enablement]** Consumers/prosumers (asset owners) register their flexible assets to participate in the value chain to take their flexibility potential to market. Flexibility service providers capture/provide that flexibility potential in return for incentives. • **Integrate flexible assets and services in the EdgeConnect (DPP flexibility value chain platform). [Integration/Enablement]** Flexibility Service providers integrate their operational platforms with the EdgeConnect to collect the flexibility potential from prosumers. Prosumers’ flexible assets are integrated by the Flexibility Service Provider in their technical platforms.
Complete description
The current SUC details the first and second stages of the EdgeConnect platform from the DPP. The system holds services to onboard consumers/prosumers, service providers, most notably Flexibility Service Providers (FSPs), Resource Aggregators (Community Managers), Market Operators and grid operators (i.e., TSO for this case). Consumers/Prosumers contribute with their flexibility by making available data and metadata about the flexible assets they own or have been provided with and show availability to receive recommendations on services with incentives. Afterwards, they decide on the subscription of services. This SUC details how to: ▪ **Link consumers with flexible assets to participate in the EdgeConnect platform (DPP). [Flexibility Enablement]** Consumers/prosumers (asset owners) register/make their flexible assets available to participate in the value chain, taking their flexibility potential to market. Service providers capture/provide that flexibility potential in return for the available flexibility. o (what)(why) Consumers (asset owners) make their flexibility potential available to service providers in exchange for benefits, incentives, and services. Service Providers collect the flexibility potential from the consumers or agree to install assets. o (when) Consumers (asset owners) do this when they join the EdgeConnect platform (DPP) by registering their flexible assets and registering to any existing service. o (expectation) Asset owners want to collect a return on investment of the installed assets or linked incentive. Service providers/Resource Aggregators expect to use the energy generation or flexibility potential of the available loads. o Conditions: a. Consumers already have flexible assets within their premises, which are already capable of exporting information about their state and receiving instructions to

change their consumption pattern; or there is a service or system capable of relaying that information.

b. Consumers already have flexible assets within their premises, but they are not connected or do not have smart features. In this case, a retrofit is needed.
c. Service providers offer services with business models exploring flexibility which provide flexible assets to consumers.

- **Integrate flexible assets and services in the EdgeConnect (DPP) flexibility value chain. [Integration/Enablement]**
  Consumers/prosumers (asset owners) allow technical platforms to communicate information to be used to compute their flexibility potential and to receive commands to activate or change their appliance's scheduling.
  - (what)(why) Consumers/prosumers allow the technical platform of the Flexibility Service Provider representing them to use the data from their installed devices and allow flexible assets to receive commands that modulate or change their scheduling.
  - (when) During onboarding of the service on a specific technical integration step or whenever authorisations have been revoked and are underway to be reinstated.
  - (expectation) Participation in the flexibility market is conducted through a service provider. (Resource Aggregator) that will command flexible assets to change their consumption profiles.
  - Conditions:
    a. Consumers are onboarded on a service from a registered service provider.
    b. Consumers hold an EMS service or have granted consent for a service provider platform to use their data.
    c. Flexible assets (owned or installed by the service provider) are within the premises of the consumer and enabled.

The SUC decomposes in 4 main actions. Steps 1.a to 1.d occur in parallel for each role:

1. All stakeholders onboard the EdgeConnect platform (DPP), during which they provide relevant personal/business data that will allow them to be matched and their details shared among them while respecting terms and conditions and data usage limitations imposed by GDPR.

    a. Consumers/ Prosumers onboard the service and provide personal and location details, together with the portfolio of flexible assets or the absence of given flexible assets. They provide a technical specification on how to activate their flexible assets.
    b. Consumers/prosumers or service providers representing them make the metering data and complementary information available to allow a characterisation of the consumption.
    c. Resource Aggregators (Community Managers) onboard the service and provide community characteristics such as main location, geographical boundaries, and available services (e.g., community planning, sizing).
    d. TSOs register and detail basic identification information and geographical influence area. TSOs provide identical information as Resource Aggregators.

2. All stakeholders agree with the terms and conditions of the EdgeConnect platform (DPP), firming a usage contract between them and the platform operator. Further contractual relationships may exist in the scope of the other services.

3. Stakeholders (when applicable) supply billing information to be part of the integrated cash-flow management mechanism. It departs from the financial settlement process derived from market operation to charge/distribute revenues because of market operation.

4. Consumers/prosumers subscribe to EMS service and allow it to connect and provide data to external parties.

1.5 Key performance indicators (KPI)

ID	Name	Description	Reference to mentioned use case objectives
SUC-PT-01-1	*Number of community participants*	*Number of participants that subscribed to flexibility services.*	Obj 1
SUC-PT-01-2	*Number of flexible assets registered*	*Number of flexible assets registered by consumers/prosumers on EdgeConnect*	Obj 1
SUC-PT-01-3	*Different types of IoT/edge devices to be exploited in Demo Areas*	Types of IoT/edge devices integrated in EdgeConnect	Obj 1
SUC-PT-01-4	*Users involved in the piloting*	Number of users in the Portuguese Demo, based on the installation of edge/IoT devices	Obj 1
SUC-PT-01-5	*% of planned usage of HEDGE-IoT tools/data services (e.g., transactions, periodicity) in field demos*	% of HEDGE-IoT tools and data services used within this SUC	Obj 1
SUC-PT-01-6	*Increased RES and IoT deployment for providing flexibility services*	Amount of RES and IoT devices integrated in EdgeConnect	Obj 1
SUC-PT-01-7	*IoT/Edge/Fog sites uptime and availability*	Uptime of Edge devices (assets) registered on EdgeConnect	Obj 1
SUC-PT-01-8	*Increased RES investments from residential users firmed with DERs enable by IoT*	Increase in the amount invested by community participants in RES	Obj 1

1.6 Use case conditions

Use case conditions
Assumptions
The energy and non-energy services are not detailed in this SUC (just their relationship in the value-chain). The business models and services of energy stakeholders are not described in this SUC.
Prerequisites
Service providers have their own technical platforms, which they integrate with the interfaces for the DPP. Consumers have an internet connection and interface with the systems via their browsers, mobile applications, or other available interfaces/means. Consumers have flexible assets with connectivity capabilities that enable activation. Consumers subscribe to an EMS service or an equivalent service.

1.7 Further Information to the use case for classification/mapping

Classification Information
Relation to other use cases
BUC-PT-01– Explore the energy flexibility of communities of citizens toward the creation of energy and non-energy services.
Level of depth

System use case (SUC) which describes the functionality/technological solutions of (a part of) a business process in detail.
Prioritisation
High Level of Priority – To be demonstrated in Portugal.
Generic, regional or national relation
Generic (Regional scope for demonstration)
Nature of the use case
Flexibility Services
Further keywords for classification
Flexibility value-chain, energy services

1.8 General Remarks

General Remarks
This SUC embodies a DPP concept that is a flexibility value chain enabler. The implementation considers the support of a cloud service provider and framework of services. XaaS approach is to be prioritized and should tentatively be adopted for all services.

2 Diagrams of use case

Diagram(s) of use case

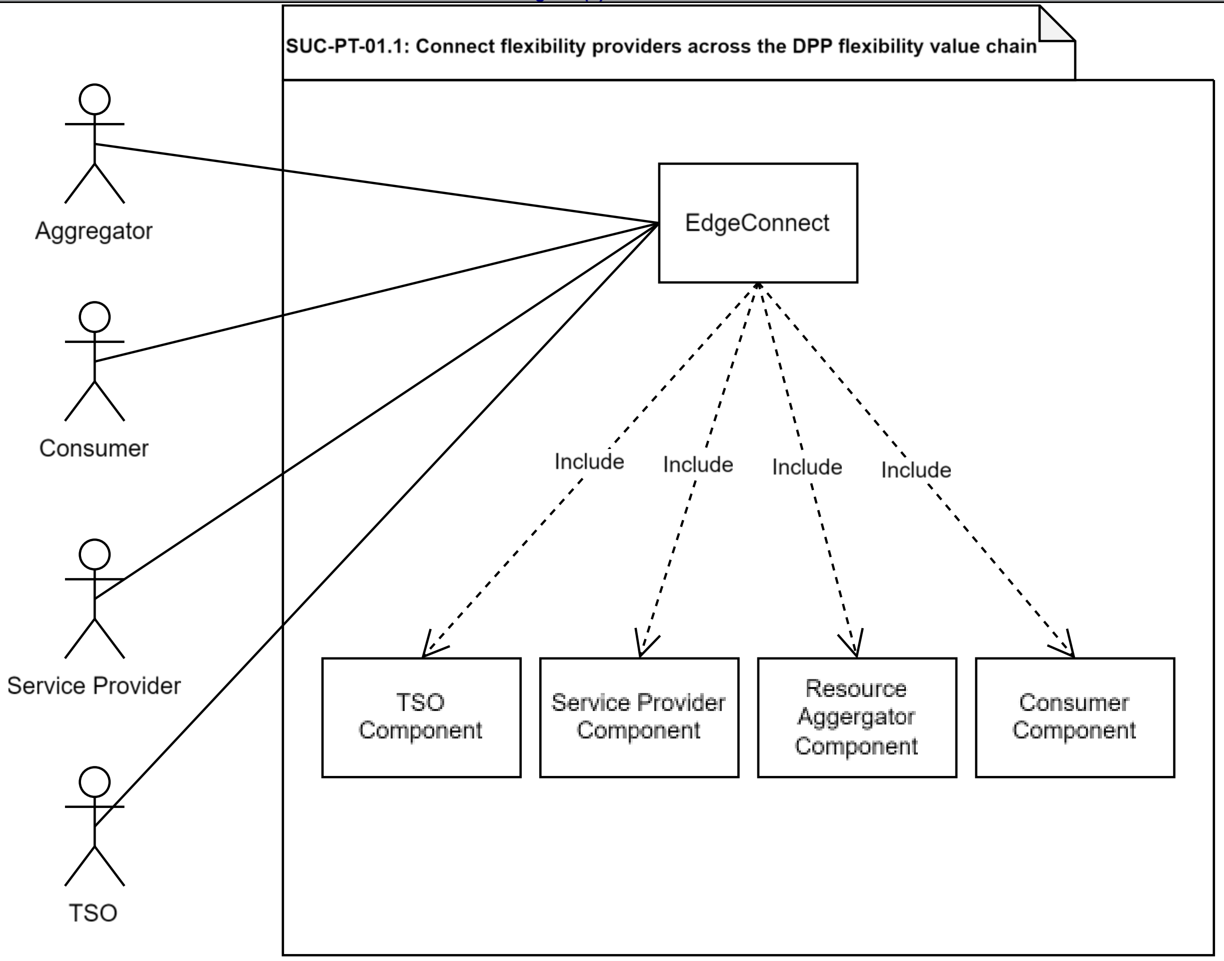


FIGURE 1 – SUC-PT-01.1 USE CASE DIAGRAM

Diagram(s) of use case

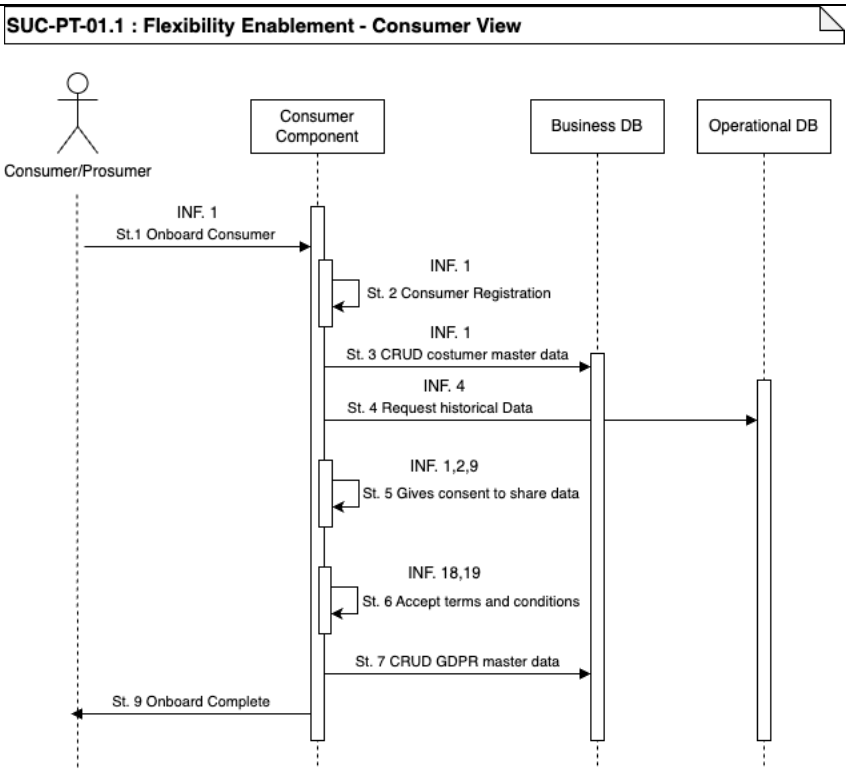


FIGURE 2 – FLEXIBILITY ENABLEMENT – CONSUMER VIEW

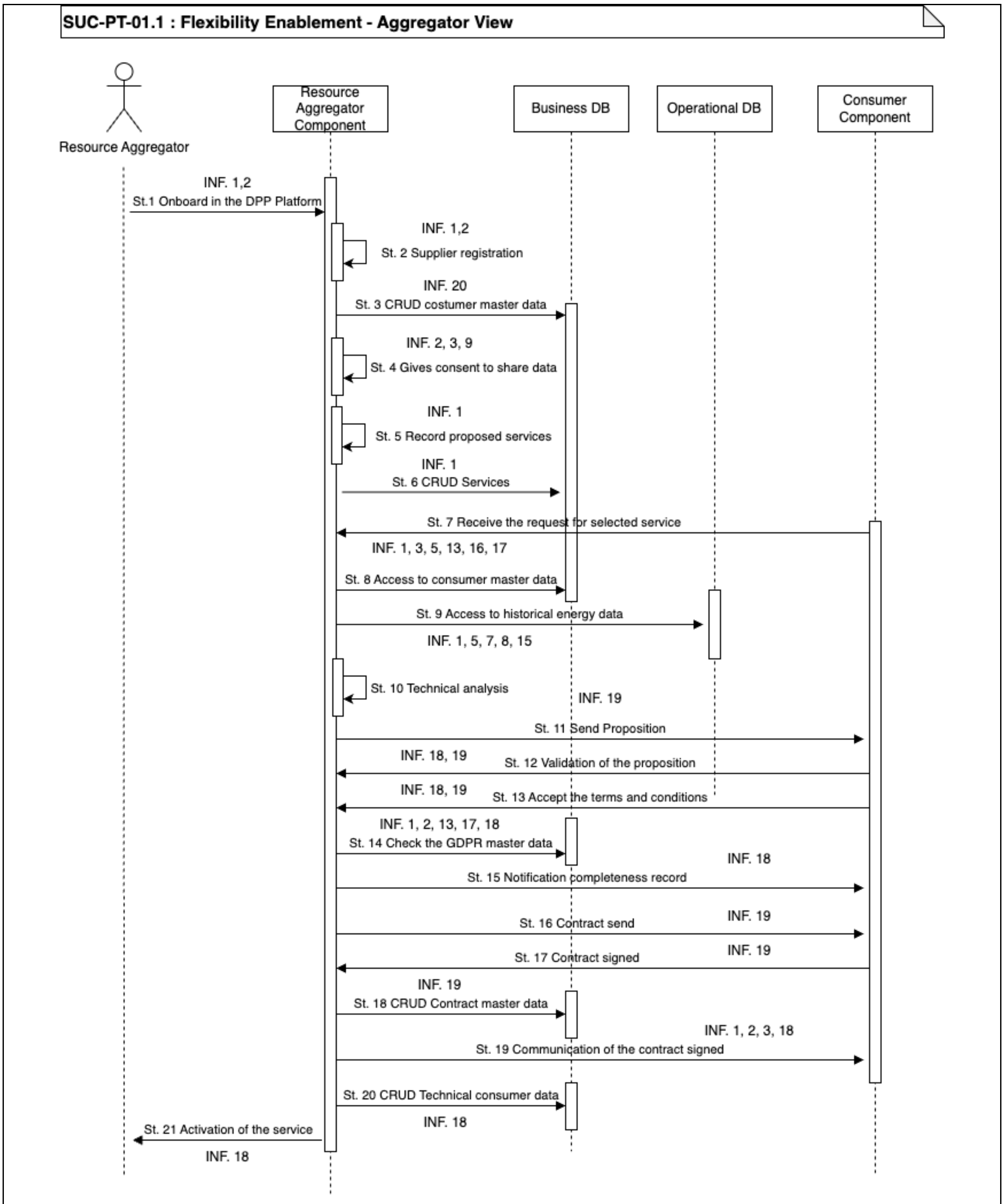


FIGURE 3 – FLEXIBILITY ENABLEMENT – RESOURCE AGGREGATOR VIEW

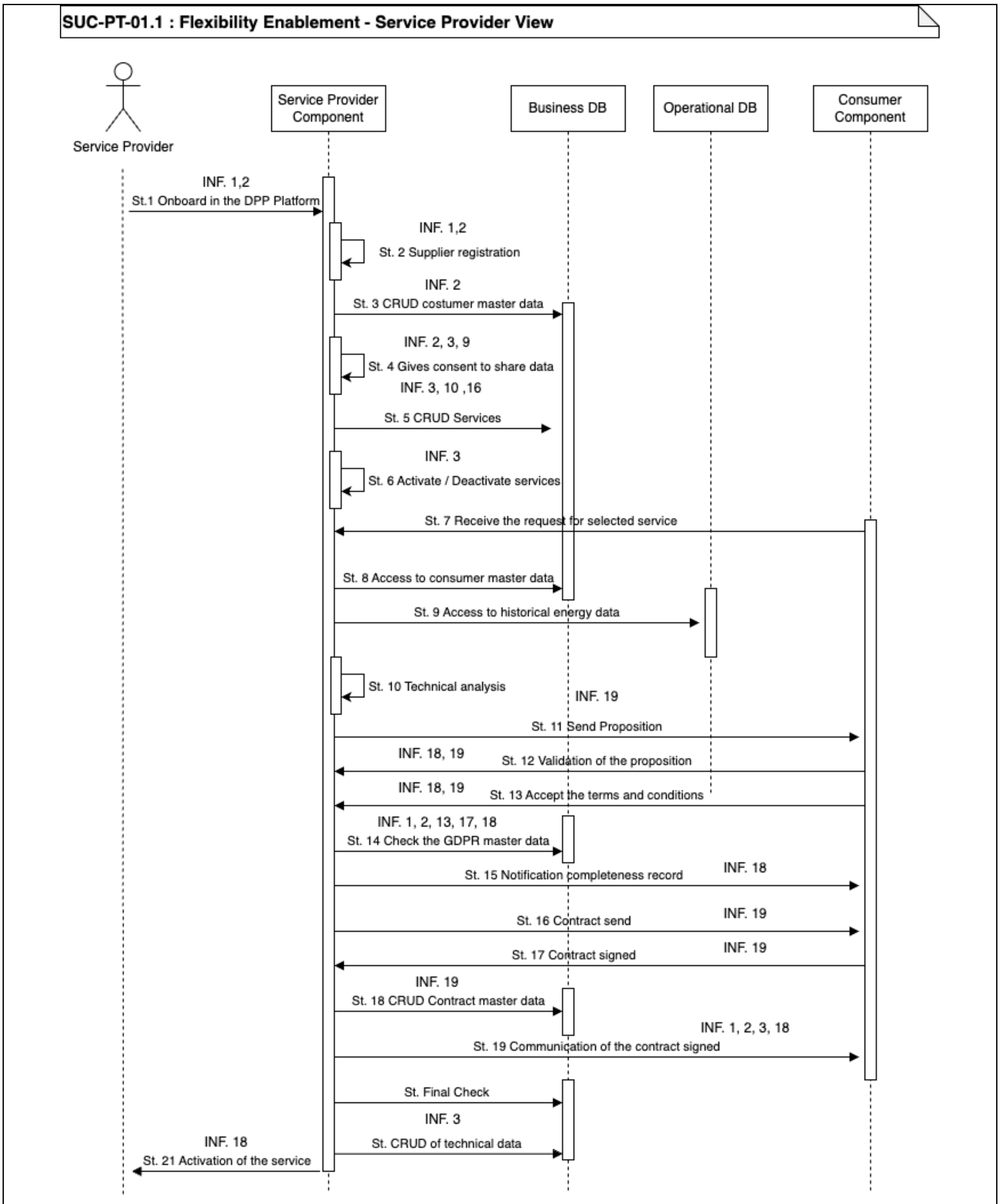


FIGURE 4 – FLEXIBILITY ENABLEMENT – SERVICE PROVIDER VIEW

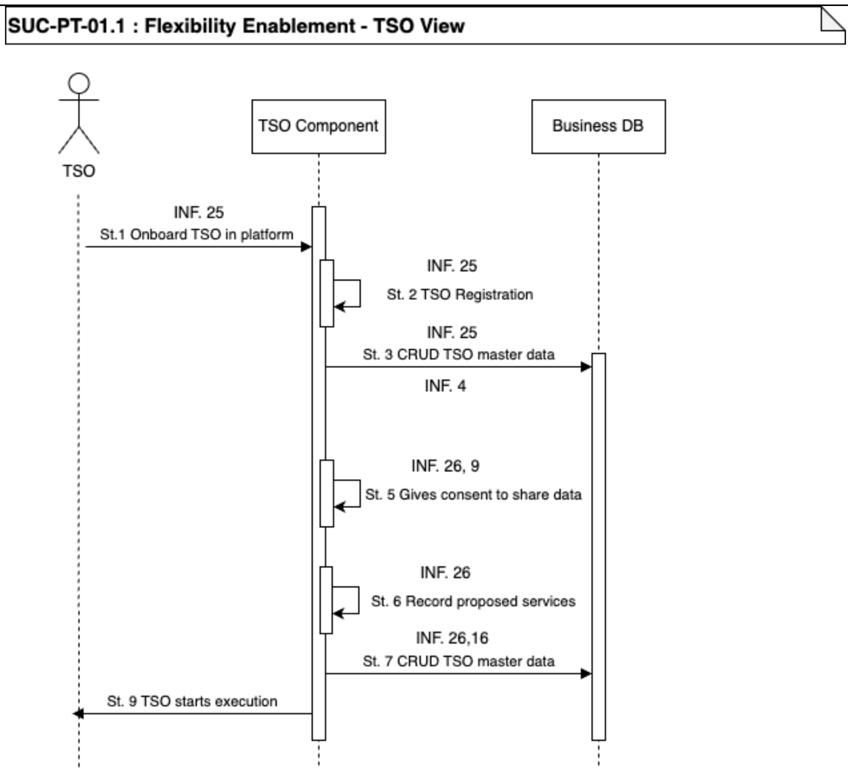


FIGURE 5 – FLEXIBILITY ENABLEMENT – TSO VIEW

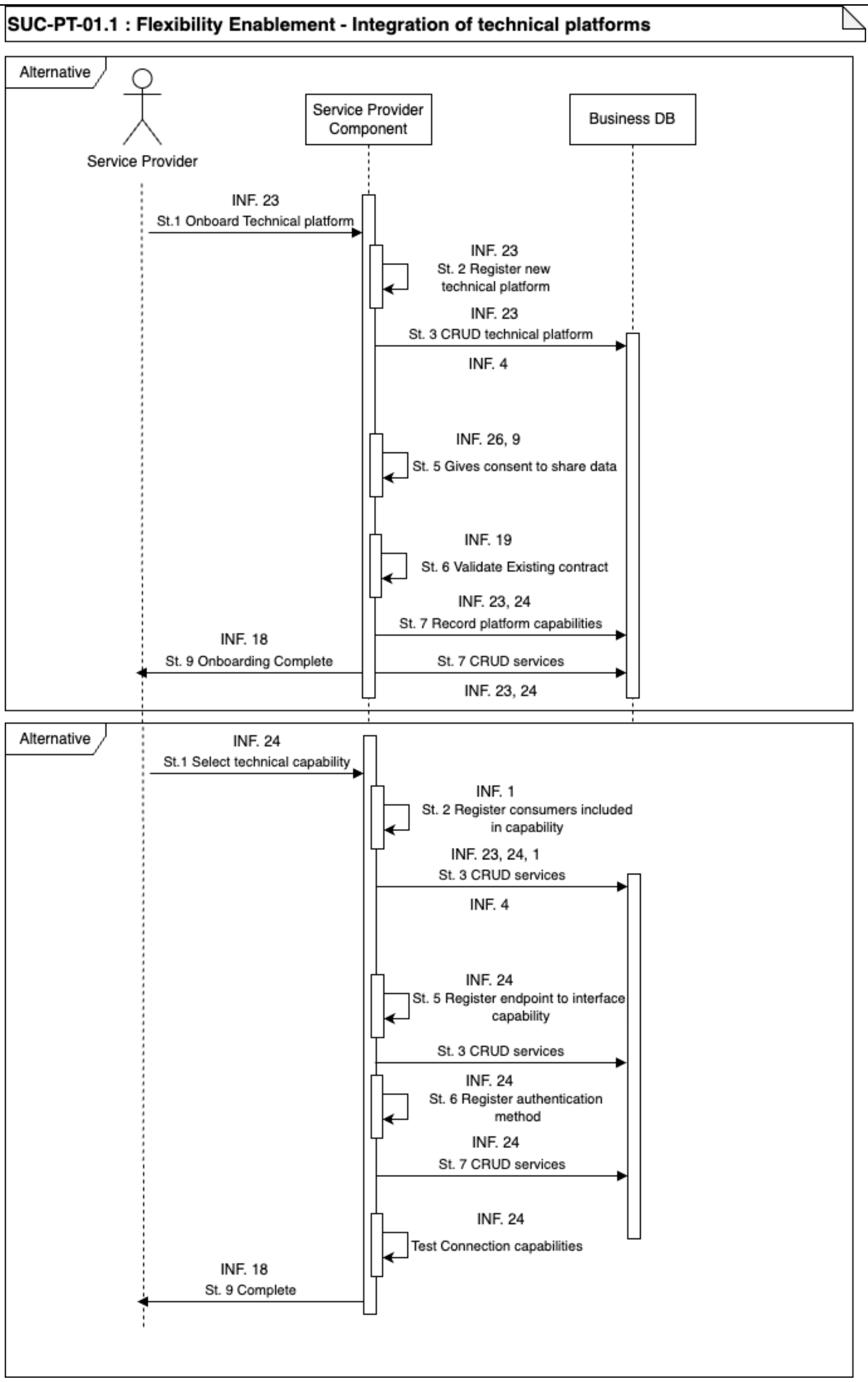


FIGURE 6 – INTEGRATION OF TECHNICAL PLATFORMS FROM CONSUMER AND SERVICE PROVIDER.

3 Technical details

3.1 Actors

Actors			
Actor Name	**Actor Type**	**Actor Description**	**Further information specific to this use case**
DPP Platform	Business Actor	The ICT/SW/DP Provider supports other entities with ICT (Information and Communications Technology), Software (SW) or Digital Platforms (DP).	INESC TEC
Consumer	Business Actor	Consumer/prosumer that has contracted energy services.	CEVE
TSO	Operator Actor	Transmission System Operator (considering its technical platforms)	REN, RDNESTER
Service Provider	Operator Actor	Platform (often technical) that makes services available on behalf of service providers.	CEVE, ELERGONE
DPP Platform (Resource Aggregator Component)	Logical Actor (Role)	Aggregator functions within the DPP.	INESC TEC
DPP Platform (Consumer Component)	Logical Actor (Role)	Customer functions within the DPP.	INESC TEC
DPP Platform (Service provider Component)	Logical Actor (Role)	Service provider functions within the DPP.	INESC TEC
DPP Platform (TSO Component)	Logical Actor (Role)	TSO functions within the DPP.	INESC TEC
DPP Platform (Operational DB)	Logical Actor (Role)	Data management service functions within the DPP.	INESC TEC
DPP Platform(Business DB)	Logical Actor	Repository (catalogue) service that hosts energy services.	INESC TEC

3.2 References

References						
No.	**References Type**	**Reference**	**Status**	**Impact on use case**	**Originator / organisation**	**Link**
1	Technical Report	Harmonized Electricity Market Role Model (HEMRM)	Public	Role Model	BRIDGE	https://energy.ec.europa.eu/system/files/2021-06/bridge_wg_regulation_eu_bridge_hemrm_report_2020-2021_0.pdf
2	Regulation	GDPR	Public	Requirements	EU	https://eur-lex.europa.eu/eli/reg/2016/679/oj

4 Step by step analysis of use case

4.1 Overview of scenarios

Scenario conditions						
No.	**Scenario name**	**Scenario description**	**Primary actor**	**Triggering event**	**Pre-condition**	**Post-condition**
Sc. 1	Onboard all stakeholders in the DPP. (Success)	All stakeholders: consumer/prosumer, community manager, service provider, SO complete the onboarding process in the DPP. The EMS system (Prosumer) or the technical platforms (other stakeholders) complete the technical integration.	DPP	Each stakeholder profile starts the onboarding process in the DPP and/or the integration procedure.	A record for the specific stakeholder profile and identity does not exist. The DPP service is operational.	A stakeholder record for the profile being registered is added to the DPP database.
Sc.1.1	Onboard all stakeholders on the DPP. (Success) – Consumer View					
Sc. 1.2	Onboard all stakeholders on the DPP. (Success) – Aggregator View					
Sc.1.3	Onboard all stakeholders on the DPP. (Success) – Service Provider View					
Sc.1.4	Onboard all stakeholders on the DPP. (Success) – TSO View					
Sc. 2	Integrate stakeholder's technical platforms in the DPP.	Stakeholders: service providers, SOs, consumers provide the details in integrate their technical platforms, namely their capabilities and connection details.	DPP	Stakeholders completes the onboarding stage and are prompted to complete the technical integration. Optionally, service providers manually trigger the manual configuration	Each stakeholder completed the onboarding process in the DPP.	Stakeholders become able to exchange data and become able to take part in the DPP workflows.

4.2 Steps – Scenarios

Scenario								
Scenario name:		***No. 1.1 – Onboard all stakeholders on the DPP (Success) – Consumer View***						
Step No.	***Event***	***Name of process/ activity***	***Description of process/ activity***	***Service***	***Information producer (actor)***	***Information receiver (actor)***	***Information Exchanged (IDs)***	***Requirement, R-IDs***
St. 1	Onboard consumers in the DPP	Onboard consumers in the Platform	The consumer connects to the platform via web portal	GET	Consumer	DPP (Consumer Component)	Inf.1	O-X, Sec-X, Conf.1, Conf.2, Conf.4, F.1, F.2, F.3, D.2 ,D.3, D.4, D.1
St. 2	Onboard consumers in the DPP	Consumer registration	The customer starts the registration process to the BN by indication its information that will be used later	GET	DPP (Consumer Component)	DPP (Consumer Component)	Inf.1	O-X, Sec-X, F.1,F.2,F.3,D.2
St. 3	Onboard consumers in the DPP	CRUD consumer master data business and technical	The consumer describes the specifications of its house and the equipment's he owns or rent and what are its objectives	CREATE	DPP (Consumer Component)	DPP (Business DB)	Inf.1	O-X, Sec-X, Conf.3, Conf.5, F.1,F.2,F.3, D.1, D.2, D.3, D.4
St. 4	On request	Request historical energy data	The consumer can share its consumption data to get the most accurate recommendation / offering	GET	DPP (Consumer Component)	GBBN (Operational DB)	Inf.4	O-X, Sec-X, Conf.3, Conf.5,F.3, F.4-1, D.1, D.3
St. 5	One time during the duration of the contract	Gives consent to share data	The consumer gives its consent to share its data with the nominated supplier	CREATE	DPP (Consumer Component)	DPP (Consumer Component)	Inf.1, Inf.2, Inf.9	O-X, D.2, F.1, F.2, F.3, F.7, Sec.1, Sec.2, Sec.4
St. 6	On request	Accept terms and conditions	The consent master data is updated for the period of the contract	EXECUTE	DPP (Consumer Component)	DPP (Consumer Component)	Inf.18, Inf.19	O-X, F.1, F.2, F.3, F.9, F.11, F.12, F.13
St. 7	On request	CRUD GDPR master data	Store information about consumer consent	EXECUTE	DPP (Consumer Component)	DPP (Business DB)		Conf.3, Conf.5
St.8	On request	Onboarding complete	Consumer is activated	EXECUTE	DPP (Consumer Component)	Consumer		Conf.1, Conf.2, Conf.4

Scenario								
Scenario name :		***No. 1.2 – Onboard all stakeholders on the DPP and integrate EMS or operational platforms (Success) – Resource Aggregator View***						
Step No.	***Event***	***Name of process/ activity***	***Description of process/ activity***	***Service***	***Information producer (actor)***	***Information receiver (actor)***	***Information Exchanged (IDs)***	***Requirement, R-IDs***
St. 1	Onboard aggregator in	Onboard in the DPP	The resource aggregator connects via the web portal	GET	Resource Aggregator	DPP	Inf.1, Inf.2	O-X, Sec-X, F.2, F.3, D.1, D.2, D.3, D.4, Conf.1, Conf.2, Conf.4

	the DPP							
St. 2	Onboard aggregator in the DPP	Supplier registration	The resource aggregator starts the registration process to the BN by indication its information that will be used later	GET	DPP (Resource Aggregator Component)	DPP (Resource Aggregator Component)	Inf.1, Inf.2	O-X, Sec-X, F.2, F.3, D.2
St. 3	Onboard aggregator in the DPP	CRUD supplier master data business and technical	The resource aggregator registers its information's in the BN	CREATE	DPP (Resource Aggregator Component)	DPP (Business DB)	Inf.20	O-X, Sec-X, Conf.3, Conf.5, F.2, F.3, D.1, D.2, D.3, D.4
St. 4	Onboard aggregator in the DPP	Gives consent to share data	The resource aggregator gives consent to publish its information's	GET	DPP (Resource Aggregator Component)	DPP (Resource Aggregator Component)	Inf.2, Inf.3, Inf.9	O-X, D.1, D.2, D.3, F.1, F.2, F.3, F.7, Sec.1, Sec.2, Sec.4
St. 5	On request	Record proposed services	The resource aggregator defines the geographical scope, area, and grid where he can propose services	GET	DPP (Resource Aggregator Component)	DPP (Resource Aggregator Component)	Inf.1	O-X, D.2, F.1, F.2, F.3, F.14, D.1, D.2, D.3, D.4
St. 6	Recuring until the aggregator defines area	CRUD services	Resource aggregator updates the grid master data	REPEAT	DPP (Resource Aggregator Component)	DPP (Resource Aggregator Component)	Inf.1	O-X, D.2,F.1, F.2, F.3, F.14, D.1, D.2, D.3, D.4
St. 7	On request	Receive the request for selected service	The resource aggregator receives a request from a consumer to access to one service	GET	DPP (Resource Aggregator Component)	DPP (Consumer Component)	Inf.1, Inf.3, Inf.5, Inf.13, Inf.16, Inf.17	O-X, F.1, F.2, F.3, F.6, F.9, F.10, F.11, Sec.1, Sec.2, D.2, D.3
St. 8	On request	Access to consumer master data	The resource aggregator selects the consumer characteristic and access to consumers information's	GET	DPP (Resource Aggregator)	DPP (Business DB)	Inf.1, Inf.7, Inf.8	O-X, Conf.3, Conf.5, F.1, F.2, F.3, F.6, F.9, F.10, F.11, F.14, Sec.1, Sec.2, D.2, D.3
St. 9	On request	Access to historical energy data	The resource aggregator wants to know more about the consumer, the assets, the timing, possible contracts and metering data.	GET	DPP (Resource Aggregator Component)	DPP (Operational DB)	Inf.1, Inf.5, Inf.7, Inf.8, Inf.15	O-X, Conf.3, Conf.5, F.1, F.2, F.3, F.6, F.9, F.10, F.11, Sec.1, Sec.2, D.2, D.3
St. 10	On request	Technical analysis	The resource aggregator evaluates business potential	EXECUTE	DPP (Resource Aggregator Component)	DPP (Resource Aggregator Component)		O-X, F.1, F.2, F.3, F.9, F.11, F.12, F.13
St. 11	Recuring until contract acceptation	Send proposition	The resource aggregator sends the offering	EXECUTE	DPP (Resource Aggregator Component)	DPP (Consumer Component)	Inf.19	O-X, F.1, F.2, F.3, F.9, F.11, F.12, F.13

St. 12	On request	Validation of the proposition	The consumer accepts terms and conditions of the service	EXECUTE	DPP (Consumer Component)	DPP (Resource Aggregator Component)	Inf.18, Inf.19	O-X, F.1, F.2, F.3, F.9, F.11, F.12, F.13
St. 13	On request	Accept terms and conditions	The consent master data is updated for the period of the contract	EXECUTE	DPP (Consumer Component)	DPP (Resource Aggregator Component)	Inf.18, Inf.19	O-X, F.1, F.2, F.3, F.9, F.11, F.12, F.13
St. 14	On request	Check GDPR master data	The consent master data is updated for the period of the contract	CREATE	DPP (Resource Aggregator Component)	DPP (Operational DB)	Inf.1, Inf.2, Inf.13, Inf.17, Inf.18	O-X, Conf.3, Conf.5, F.1, F.2, F.3, F.9, F.11, F.12, F.14, D.2, D.3
St. 15	On request	Notification completeness record	The resource aggregator notifies the suppler about the completeness of the contract	EXECUTE	DPP (Resource Aggregator Component)	DPP (Consumer Component)	Inf.18	O-X, F.1, F.2, F.3, F.9, F.11, F.12, F.14, D.2, D.3
St. 16	On request	Contract send	The resource aggregator sends the contract	EXECUTE	DPP (Resource Aggregator Component)	DPP (Consumer Component)	Inf.19	F.1, F.2, F.3, F.12, F.15, D.2, D.3
St. 17	On request	Contract signed	The contract is signed	GET	DPP (Consumer Component)	DPP (Resource Aggregator Component)	Inf.19	F.1, F.2, F.3, F.12, F.15, D.2, D.3
St. 18	On request	CRUD Contract meter data	The business master data are recorder into the BN to follow the contract execution	CREATE	DPP (Resource Aggregator)	DPP (Business DB)	Inf.19	Conf.3, Conf.5F.1, F.2, F.3, F.12, F.15, D.2, D.3
St. 19	On request	Communication of the contract signed	The consumer signs the contract	EXECUTE	DPP (Resource Aggregator Component)	DPP (Consumer Component)	Inf.1, Inf.2, Inf.3, Inf.18	F.1, F.2, F.3, F.12, F.15
St. 20	On request	CRUD of technical data	Resource aggregator updates the consumer's technical master data	CREATE	DPP (Resource Aggregator)	DPP (Business DB)	Inf.18	Conf.3, Conf.5F.1, F.2, F.3, F.12, F.15, D.2, D.3
St. 21	On request	Activation of the service	The resource aggregator starts the service execution	EXECUTE	DPP (Resource Aggregator Component)	Resource Aggregator	Inf.18	O-X. Sec-X, Conf.1, Conf.2, Conf.4F.1, F.2, F.3, F.12, F.15, F.16, D.2, D.3, D.4

Scenario								
Scenario name :	**No. 1.3 – Onboard all stakeholders on the DPP and integrate EMS or operational platforms (Success) – Service Provider View**							
Step No.	**Event**	**Name of process/ activity**	**Description of process/ activity**	**Service**	**Information producer (actor)**	**Information receiver (actor)**	**Information Exchanged (IDs)**	**Requirement, R-IDs**
St. 1	Onboard service provider in the DPP	Onboard supplier in the DPP	The service provider connects to the BN via a mobile application or via the web portal	GET	Service Provider	DPP (Service provider component)	Inf.1, Inf.2	Conf.1, Conf.2, Conf.4, O-X, Sec-X, F.2, F.3, D.1, D.2, D.3, D.4
St. 2	Onboard service provider in the DPP	Supplier registration	The service provider starts the registration process to the BN by indication its information that will be used later	GET	DPP (Service provider component)	DPP (Service provider component)	Inf.1, Inf.2	O-X, Sec-X, F.2, F.3, D.2
St. 3	Onboard service provider in the DPP	CRUD Supplier master data business and technical	The service provider registers its information's in the BN	CREATE	DPP (Service provider component)	DPP (Business DB)	Inf.2	O-X, Conf.3, Conf.5, Sec-X, F.2, F.3, D-X
St. 4	Onboard service provider in the DPP	Gives consent to share data	The service provider gives consent to publish its information's	GET	DPP (Service provider component)	DPP (Service provider component)	Inf.2, Inf.3, Inf.9	O-X, D.2, F.1, F.2, F.3, F.7, Sec.1, Sec.2, Sec.4, D.1, D.2, D.3, D.4
St. 5	Recuring until the service provider defines services	CRUD services	Service provider updates the service master data	REPEAT	DPP (Service provider component)	DPP (Business DB)	Inf.3, Inf.10, Inf.16,	O-X, Conf.3, Conf.5, D.2, D.3, F.1, F.2, F.3, F.6, F.10, F.12, D-X
St. 6	Recuring until the service provider defines services	Activate / Deactivate services	The service provider defines from the list of service the one that are active or not and for which period	REPEAT	DPP (Service provider component)	DPP (Service provider component)	Inf.3	F.1, F.2, F.3, F.12, F.15, F.16, D.2, D.3
St. 7	On request	Receive the request for selected service	The service provider receives a request from a consumer to access to one service	EXECUTE	DPP (Service provider component)	DPP (Consumer component)		
St. 8	On request	Access to costumer master data	The service provider selects the consumer characteristic and access to consumers information's	EXECUTE	DPP (Service provider component)	DPP (Business DB)		Conf.3, Conf.5
St. 9	On request	Access to historical energy data	The service provider wants to know more about the consumer, the assets, the timing, possible contracts and metering data.	EXECUTE	DPP (Service provider component)	DPP (Operational DB)		Conf.3, Conf.5
St.	On request	Technical	The service provider evaluates	EXECUTE	DPP (Service	DPP (Service		

10		analysis	business potential		provider component)	provider component)		
St. 11	Recuring until contract acceptation	Send proposition	The service provider sends the offering	EXECUTE	DPP (Service provider component)	DPP (Consumer Component)	Inf.19	O-X, F.1, F.2, F.3, F.9, F.11, F.12, F.13
St. 12	On request	Validation of the proposition	The service provider accepts terms and conditions of the service	EXECUTE	DPP (Consumer Component)	DPP (Service provider component)	Inf.18, Inf.19	O-X, F.1, F.2, F.3, F.9, F.11, F.12, F.13
St. 13	On request	Accept terms and conditions	The consent master data is updated for the period of the contract	EXECUTE	DPP (Consumer Component)	DPP (Service provider component)	Inf.18, Inf.19	O-X, F.1, F.2, F.3, F.9, F.11, F.12, F.13
St. 14	On request	Check GDPR master data	The consent master data is updated for the period of the contract	CREATE	DPP (Service provider component)	DPP (Business DB)	Inf.1, Inf.2, Inf.13, Inf.17, Inf.18	O-X, F.1, F.2, F.3, F.9, F.11, F.12, F.14, D.2, D.3
St. 15	On request	Notification completeness record	The service provider notifies the suppler about the completeness of the contract	EXECUTE	DPP (Service provider component)	DPP (Consumer Component)	Inf.18	O-X, F.1, F.2, F.3, F.9, F.11, F.12, F.14, D.2, D.3
St. 16	On request	Contract send	The service provider sends the contract	EXECUTE	DPP (Service provider component)	DPP (Consumer Component)	Inf.19	F.1, F.2, F.3, F.12, F.15, D.2, D.3
St. 17	On request	Contract signed	The contract is signed	GET	DPP (Consumer Component)	DPP (Service provider component)	Inf.19	F.1, F.2, F.3, F.12, F.15, D.2, D.3
St. 18	On request	CRUD Contract meter data	The business master data is recorder into the BN to follow the contract execution	CREATE	DPP (Service provider component)	DPP (Business DB)	Inf.19	Conf.3, Conf.5, F.1, F.2, F.3, F.12, F.15, D.2, D.3
St. 19	On request	Communication of the contract signed	The consumer signs the contract	EXECUTE	DPP (Service provider component)	DPP (Consumer Component)	Inf.1, Inf.2, Inf.3, Inf.18	F.1, F.2, F.3, F.12, F.15
St. 20	On request	Final Check	Validates final conditions for service	EXECUTE	DPP (Service provider component)	DPP (Business DB)		Conf.3, Conf.5
St. 21	Recuring until the service provider defines services	CRUD of technical consumer data	Service provider updates the service master data	REPEAT	DPP (Service provider component)	DPP (Business DB)	Inf.3	Conf.3, Conf.5, F.1, F.2, F.3, F.12, F.15, F.16, D-X
St. 22	On request	Activation of Service	The service provider starts execution.	EXECUTE	DPP (Service provider component)	Service Provider		O-X. Sec-X, Conf.1, Conf.2, Conf.4

Scenario								
Scenario name :	**No. 1.4 – Onboard all stakeholders on the DPP (Success) – TSO View**							
Step No.	**Event**	**Name of process/ activity**	**Description of process/ activity**	**Service**	**Information producer (actor)**	**Information receiver (actor)**	**Information Exchanged (IDs)**	**Requirement, R-IDs**
St. 1	On request	Onboard TSO in the DPP	The TSO connects to the Platform.	GET	TSO	DPP (TSO Component)	Inf.25	O-X, Sec-X, F.2, F.3, D-X, Conf.1, Conf.2, Conf.4
St. 2	On request	TSO registration	The TSO starts the registration process to the DPP	EXECUTE	DPP (TSO Component)	DPP (TSO Component)	Inf.25	O-X, Sec-X, F.2, F.3,D-X
St. 3	Recuring	CRUD TSO master data	TSO data is registered	CREATE	DPP (TSO Component)	DPP (Business DB)	Inf.25	O-X, Sec-X, F.2, F.3, ,D-X
St. 4	On request	Gives consent to publish TSO identification data	The TSO gives consent to publish information that is visible by the DPP.	GET	DPP (TSO Component)	DPP (TSO Component)	Inf.26, Inf.9	O-X, D.2, F.1, F.2, F.3, F.7, Sec.1, Sec.2, Sec.4, D-X
St. 5	On request	Record proposed services	The TSO provides details about the services offered and the details	EXECUTE	DPP (TSO Component)	DPP (TSO Component)	Inf.26	O-X, F.1, F.2, F.3, F.10, F.12, D-X
St. 6	On request	CRUD services	DPP updates TSO service master data	REPEAT	DPP (TSO Component)	DPP (Business DB)	Inf.26, Inf.16	O-X, Conf.3, Conf.5, D-X, F.1, F.2, F.3, F.10, F.12
T. 7	On request	TSO starts Execution	TSO receives service execution.	EXECUTE	DPP (TSO Component)	TSO		O-X, Sec-X, Conf.1, Conf.2, Conf.4

Scenario								
Scenario name :	**No. 2 – Integrate stakeholder's operational platforms in the DPP (Success)**							
Step No.	**Event**	**Name of process/ activity**	**Description of process/ activity**	**Service**	**Information producer (actor)**	**Information receiver (actor)**	**Information Exchanged (IDs)**	**Requirement, R-IDs**
St. 1	On request	Onboard technical platform	The service provider starts the process to onboard the technical platform	CREATE	Service Provider	DPP (Service provider component)	Inf.23	O-X, Sec-X, Conf.1, Conf.2, Conf.4, F.2, F.3
St. 2	On request	Register new technical platform	The service provider starts the process of technical integration by supplying technical data.	EXECTUE	DPP (Service provider component)	DPP (Service provider component)	Inf.23	O-X, Sec-X, F.2, F.3, D.3
St. 3	Recuring	CRUD technical platform master data	The platform's details are recorded in the master database.	CREATE	DPP (Service provider component)	DPP (Business DB)	Inf.23	O-X, Conf.3, Conf.5, Sec-X, F.2, F.3, D-X
St. 4	On request	Give consent to share data	The service provider gives consent to publish platform's details.	EXECUTE	DPP (Service provider component)	DPP (Service provider component)	Inf.9	O-X, Sec-X, F.2, F.3, D.3
St. 5	On request	Validate existing business contract	A verification is done to ensure a valid contract is available.	EXECUTE	DPP (Service provider component)	DPP (Service provider component)	Inf.19	O-X, Sec-X, F.2, F.3, D.2, D.3, D.4

St. 6	On request	Record platform capabilities	Platform's capabilities and processed.	EXECUTE	DPP (Service provider component)	DPP (Service provider component)	Inf.23, Inf.24	O-X, Sec-X, F.2, F.3, D.3, D.5
St. 7	Recuring	CRUD services	The platform's capabilities are recorded in the master database.	CREATE	DPP (Service provider component)	DPP (Business DB)	Inf.23, Inf.24	O-X, Conf.3, Conf.5, Sec-X, F.2, F.3, D-X
St. 8	On request	Onboarding complete	The onboarding is confirmed	GET	DPP (Service provider component)	Service Provider	Inf.18	O-X, Sec-X, F.2, F.3, D.3
St. 9	On request	Select technical capability	Technical capabilities are added to the record of a technical platform. Capabilities are selected from a pre-established list	EXECUTE	Service Provider	DPP (Service provider component)	Inf.24	O-X, Sec-X, F.2, F.3, D.3, D.5
St. 10	On request	Register consumers included in capability	The consumer IDs to be consider in the influence area of this platform is collected and pre-processed.	REPEAT	DPP (Service provider component)	DPP (Service provider component)	Inf.1,	O-X, Sec-X, F.2, F.3, D-1, D.3, D.4, D.5
St. 11	Recuring	CRUD services	The platform's capabilities are recorded in the master database.	CREATE	DPP (Service provider component)	DPP (Business DB)	Inf.23, Inf.24, Inf.1	O-X, Conf.3, Conf.5, Sec-X, F.2, F.3, D-X
St. 12	On request	Register endpoint details to interface with capability	The technical details for the capability being registered are collected, namely the URL and any call parameters. REST Full endpoints are considered as default.	EXECUTE	DPP (Service provider component)	DPP (Service provider component)	Inf.24	O-X, Sec-X, F.2, F.3, D.3, D.5
St. 13	Recuring	CRUD services	Technical details for the capability are recorded in the master database.	CREATE	DPP (Service provider component)	DPP (Business DB)	Inf.24	O-X, Conf.3, Conf.5, Sec-X, F.2, F.3, D-X
St. 14	On request	Register authentication method	Preferred authentication method and details are recorded pre-processed.	EXECUTE	DPP (Service provider component)	DPP (Service provider component)	Inf.24	O-X, Sec-X, F.2, F.3, D.3, D.5
St. 15	Recuring	CRUD services	Technical details for authentication are recorded in the master database.	CREATE	DPP (Service provider component)	DPP (Business DB)	Inf.24	O-X, Conf.3, Conf.5, Sec-X, F.2, F.3, D-X
St. 16	On request	Test connection capabilities	Connection is tested	EXECUTE	DPP (Service provider component)	DPP (Service provider component)	Inf.24	O-X, Sec-X, F.2, F.3
St. 17	On request	Complete technical integration	Operation completion acknowledgement is sent.	GET	DPP (Service provider component)	Service Provider	Inf.18	O-X, Sec-X, Conf.1, Conf.2, Conf.4, F.2, F.3

5 Information exchanged

Information exchanged			
Information exchanged (ID)	**Name of information**	**Description of information exchanged**	**Requirement, R-IDs**
Inf.1	Consumer profile	Basic information to register a consumer, including personal identification: name, surname, location, email account	O-X
Inf.2	Service provider profile	Basic information to register a service provider, including identification: name, location, email (as username), contact, type of services	O-X
Inf.3	Service available by service provider	Information that details a service, namely: name, API URL (if applicable), description, targets (client types, geographic locations), contact person, support centre contacts, conditions.	F.10
Inf.4	Metering Data	Metering data account for active power consumption in periods of 15 minutes for spanning several hours (ideally 24)	F.4-1
Inf.5	Semantic representation of consumer	Consumer representation in RDF format accounting to its characteristics namely location	F.12
Inf.6	Service List	A list composed by Inf.3 messages	F.10
Inf.7	Flexible asset	Description of a flexible asset	F.5
Inf.8	List of Flexible asset	A list composed by Inf.7 messages	F.7, F9
Inf.9	Consent	One stakeholder provides consent to other stakeholder in scope of a service.	O-1, O-4
Inf.10	Flexibility capacity	The measurable capacity to be flexible (i.e., change consumption profile) of an asset.INF	O-X, F.8, F.9
Inf.11	Aggregated flexibility capacity	Grouping of flexibility capacity by aggregating several loads represented by Inf.10 messages. Can represent one household or a group of households.	O-X, F.8, F.9
Inf.12	Tips and advice for service	Tips and direct advice towards flexibility and sustainable energy consumption.	O-X, F.9
Inf.13	Service subscription	Service onboarding details that pair a consumer with a service provider.	O-X, F.6, F.10
Inf.14	Payment invoice	Cash flow output generating an invoice	O-X, F.14
Inf.15	Historical data	Consumer's historical metering data in 15 minutes periods.	O-X, F.15
Inf.16	Service terms and conditions	Services specific terms and conditions	O-X
Inf.17	Form acknowledgement	Stakeholder accepts/reject action. This is multi scope. Can	O-X

		be used for several purposes. Context is enclosed in request.	
Inf.18	Acknowledgment notification	Acknowledges operation success. This is multi scope. Can be used for several purposes. Context is enclosed in request.	O-X
Inf.19	Service Contract	Service provider's contract to onboard another stakeholder	O-X
Inf.20	Aggregator Profile	Basic information to register an aggregator, including identification: name, location, email (as username), contact, type of services, geographical interest area.	O-X
Inf.21	Flexibility Model	Flexibility model details included in a service.	
Inf.22	Flexibility offering	Flexibility offering resulting from the pre-qualification process.	
Inf.23	Technical platform details	The identification of a technical platform, including capabilities and description and capabilities	
Inf.24	Technical platform capability	Technical details on how to activate one given capability, namely type and endpoint details of the destination system or authentication details.	
Inf.25	TSO profile		
Inf.26	Service available by TSO		
Inf.27	Consumer/ prosumer subscribes services	Service onboarding details that pair a consumer with a service provider	

6 Requirements

Quality of Service Requirements		
Categories ID	**Category name for requirements**	**Category description**
QoS	Quality of Service	Generic properties that service/SUC should provide – quality attributes.
Requirement R-ID	**Requirement name**	**Requirement description**
QoS.1	Elapsed time response requirements for exchanging data	1-2 seconds
QoS.2	Logging access	Any access to the data is logged in the database.
QoS-X	All constraints also apply.	All requirements in this category.

Security Requirements		
Categories ID	**Category name for requirements**	**Category description**
Sec	Security	Authentication of user, confidentiality, integrity, prevention of denial of service, non-repudiation or accountability, error management.
Requirement R-ID	**Requirement name**	**Requirement description**

Sec.1	Eavesdropping: Ensuring confidentiality, avoiding illegitimate use of data, and preventing unauthorized reading of data, is:	Crucial
Sec.2	Authentication and Access Control mechanisms for services	Authentication Pair and secondary channel validation,
Sec.3	Network security measures commonly used with this data exchange	Firewall with Access Control Lists Reverse proxy server
Sec.4	Acknowledge timeout	One minute for any M2M communication.
Sec-X	All constraints also apply.	All requirements in this category.

	Data Management Requirements	
Categories ID	**Category name for requirements**	**Category description**
D	Data Management	Type of source of data, correctness or validity of data, timeliness or time stamping of data, volume of data, synchronization, or consistency of data across systems, timely access to data, validation of data across organizational boundaries, transaction management, data naming, identification, formats across disparate systems, maintenance of data and databases.
Requirement R-ID	**Requirement name**	**Requirement description**
D.1	Management of data across organizational boundaries	Data exchanges go across organizational boundaries
D.2	Data persistence	Data is persistently stored in the platform database
D.3	Data validation	All data must be validated on each data exchange
D.4	Data validation from multiple sources	Data items are mapped according to their source
D.5	Management of data formats in data exchanges	Data is always converted at the information receiver site
D-X	All constraints also apply.	All requirements in this category.

	Discovery and Configuration Requirements	
Categories ID	**Category name for requirements**	**Category description**
Conf	Configuration	Locations, distances, communication layout, commonly used communication protocol media, network bandwidth, existing protocols, number of devices, systems, volume of data items, expected growth, etc.
Requirement R-ID	**Requirement name**	**Requirement description**
Conf.1	Communication media	Wireless required
Conf.2	Data exchange with EdgeConnect API	Client-server
Conf.3	EdgeConnect DB query	Through database
Conf.4	EdgeConnect API communication Protocol	HTTP/2
Conf.5	EdgeConnect DB communication Protocol	TCP/IP

Other Requirements	

Categories ID	Category name for requirements	Category description
O	Regulatory obligation related to privacy	2016/679 GDPR (General Data Protection Regulation)
F	Functional	Essential functionalities that build the core concept of the service/SUC.
Requirement R-ID	**Requirement name**	**Requirement description**
O.1	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.
O.2	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.
O.3	Data retention policy	Personal data may not be transferred to a third-party if the data subject did not agree and the third party provide appropriate safeguard.
O.4	Data processing consent	Personal data may not be processed unless there is at least one legal basis to do so.
O-X	All constraints also apply.	All requirements in this category.
F.1	Login in the DPP	Stakeholder is successfully logged into the DPP.
F.2	Registration in the DPP	Stakeholder is registered on the DPP platform.
F.3	Access to the service	Stakeholder can access DPP services.
F.4	Consumer/prosumer energy consumption data	Mandatory, measured in 15 min intervals
F.4-1	Consumer/prosumer PV production data	Optional
F.4-2	Consumer/prosumer geographical coordinates for the energy consumed	Mandatory
F.5	Consumer flexible assets available	At least one With approved pre-qualification
F.6	Digital service available on the DPP platform	One Targets the specified consumer
F.7	Service provider controls assets of subscribed consumers/prosumers	Mandatory for all assets
F.8	Consumers/prosumers are able to share their flexibility capacity with third-party services	Mandatory
F.9	Consumers/prosumers have a profile that characterises them	List of assets Contracted power Energy retailer Energy tariff
F.10	Digital services available on the DPP platform	At least one
F.11	Unique ID for grid users and aggregator	Mandatory
F.12	Request metadata sent to semantic system	Mandatory
F.13	Consumer is subscribed to service	One specific service
F.14	Access to consumer's geographical location	Mandatory

F.15	Service contract between stakeholders on the DPP platform	Mandatory
F.16	Permission to activate/deactivate the subscription of a service	Mandatory

7 Common Terms and Definition

Common Terms and Definitions	
Term	**Definition**
CRUD	Create-Remove-Update-Delete
DPP	Digital Platform Provider
GDPR	General Data Protection Regulation
M2M	Machine-to-machine
MGMT	Management
O&M	Operations and Maintenance
QoS	Quality-of-Service
SO	System Operator
TSO	Transmission System Operator

2 SUC-PT-01.2 ENABLE DATA EXCHANGE VIA DATA SPACES

1 Description of the use case

1.1 Name of the use case

ID	Area / Domain(s) / Zones(s)	Name of Use Case
SUC – PT-01.2	Flexibility Services	Enable Data Exchange via Data Spaces

1.2 Version management

Version Management			
Version No.	**Date**	**Name of Author(s)**	**Changes**
0.1	19.04.2024	David Rua (INESC TEC) Fábio Coelho (INESC TEC) Vasco Campos (INESC TEC)	First draft, scope, objectives.
0.2	26.05.2024	David Rua (INESC TEC) Fábio Coelho (INESC TEC) Vasco Campos (INESC TEC)	First diagram mocks.
0.3	03.06.2024	David Rua (INESC TEC) Fábio Coelho (INESC TEC) Vasco Campos (INESC TEC)	Consolidated version.
0.4	10.07.2024	David Rua (INESC TEC) Fábio Coelho (INESC TEC) Vasco Campos (INESC TEC)	Final Version
0.5	17.10.2024	David Rua (INESC TEC) Fábio Coelho (INESC TEC) Vasco Campos (INESC TEC)	Harmonization with new T2.6 guidelines for the "requirements" section and new use case diagram. Updated look and feel.

1.3 Scope and objectives of use case

Scope and Objectives of Use Case	
Scope	Exploitation of energy flexibility in energy communities enabled in an interoperable way. Need for a clear and unambiguous communication and data models between all the actors involved in the energy flexibility market.
Objective(s)	The system use case unfolds the following objectives: 1. All systems adhere to the data space protocol to exchange data. 2. Identify and publish the data assets' descriptions as data producers. 3. Model data assets to interoperable standards. 4. Establish data usage contracts, scoping permissions to consume data as data consumers. 5. Exchange the required data assets
Related business case(s)	BUC-PT-01– GreenVale: Harnessing the potential of energy communities by leveraging Federated Learning strategies.

1.4 Narrative of use case

Narrative of Use Case
Short description
This System Use Case sets the procedure for all data exchange among participants' systems, adhering to the data spaces technology stack. One reference implementation will be adopted and set the key steps as to: onboard the data space, publish data assets along with their characteristics (describing metadata), requesting data from the data space as to acquire a contract setting the trusted exchange and triggering the data transaction to transfer the data linked to that negotiated context (smart contract).
Complete description
Participants are always scoped in terms of their active role in each data transaction. This implies that the same system actor may interchangeably play the role of data provider and data consumer, depending on if it, respectively, provides or consumes data. 1. **Acquire Data Space identities.** Each system participates in a dataspace being equipped with identity certificates that identified their organizations and connectors. The link implies that one given organization may hold several connector identities, but there is a 1:1 relationship between one connector identity and the organization it corresponds to. Identities are collected from the active DAPS – Dynamic Attribute Provisioning System. 2. **Publish data assets to the data set – data producer.** Data providers use their data space connectors to publish the available assets. The data producer may equip the asset in an envelope of policy rules that will later govern the time, purpose and addressee (among other policy types) that may use the asset. 3. **Create an interoperable representation of assets and systems** Service providers create interoperable representations of their assets using a pre-defined ontology or the interface made available by the open data connector. 4. **Request data from the Data Space – data consumer.** Data consumers browse the available assets in the dataspace by querying the dataspace broker system. The required asset after being located requires its ID and the corresponding connector making it available as data producer to be identified for step 4. 5. **Obtains consent for data sharing – data consumer.** Data consumer issues a data sharing request, identifying the desired asset to the connector holding it. The Data provider connector validates the issued identities, the scope for the request and if the usage policies (if present) are applicable, issuing and signing a smart contract that will bind the data exchange transaction. 6. **Exchange data via data transaction – data consumer .** Data consumer issues a request to the data producer connector, request the asset to be transferred, scoping the cleared context of the smart contract. While the contract context is valid, the asset may be transferred.

1.5 Key performance indicators (KPI)

ID	Name	Description	Reference to mentioned use case objectives
SUC-PT-02-1	*Number of services onboarded using the connector*	The number of services onboarded, using the data space connector, by all actors that integrate this SUC.	Obj 1, 2
SUC-PT-02-2	*Number of data assets published*	The number of data assets published on the data space by all actors of the SUC.	Obj 2
SUC-PT-02-3	*Number of transactions*	The number of transactions made by the services using the selected connector.	Obj 2, 4, 5
SUC-PT-02-4	*Real-time data sharing among stakeholders*	Percentage of service providers sharing real-time data	Obj 5

1.6 Use case conditions

Use case conditions
Assumptions
The following assumptions should be taken into consideration: • In this SUC, an asset is a data asset (i.e., a file, a data payload, a data set, a persisted result set from an outstanding database query). • The role of service provider and service consumer is interchangeable and cumulative. This means that a given ICT service, depending on its role in the data exchange by act as data consumer (when requesting data) or data provider (whenever providing/serving data).
Prerequisites
The following pre-requisites should be taken into consideration: • System actors may already have their data space identities (i.e., organization and connector(s)) ready. • A data connector reference implementation is chosen and adopted by all actors. • An ontology is defined for the representation of the interoperable data models.

1.7 Further Information to the use case for classification / mapping

Classification Information
Relation to other use cases
BUC-PT-01– GreenVale: Harnessing the potential of energy communities by leveraging Federated Learning strategies. SUC-PT-01.1- Connect flexibility providers across the DPP flexibility value chain SUC-PT-01.3- Mobilizing Energy Flexibility SUC-PT-01.4- Activation of Energy Flexibility
Level of depth
System use case (SUC) use case which describes in detail the functionality/technological solutions of (a part of) a business process.
Prioritisation
High Level of Priority – To be demonstrated in Portugal.
Generic, regional or national relation
Generic (Regional scope for demonstration)
Nature of the use case

Flexibility Services, Interoperability enablement
Further keywords for classification
Flexibility value-chain, energy services

2 Diagrams of use case

Diagram(s) of use case
The presented diagram covers the data space usage scheme and already scopes it with the Resource Aggregator Context. This material is extracted from CEEDS Data Space Blueprint.

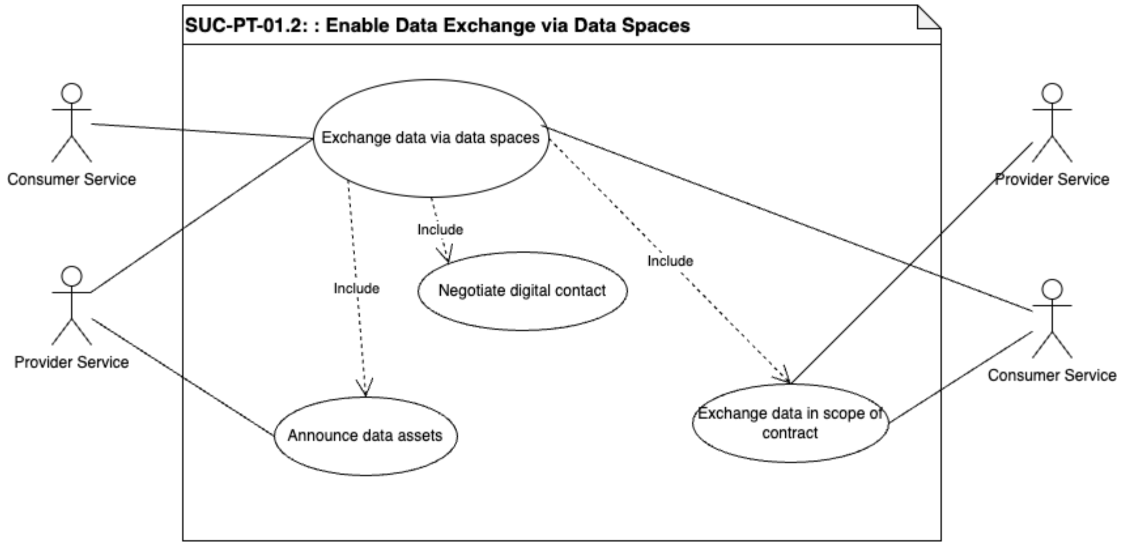


FIGURE 7 – UML USE CASE DIAGRAM

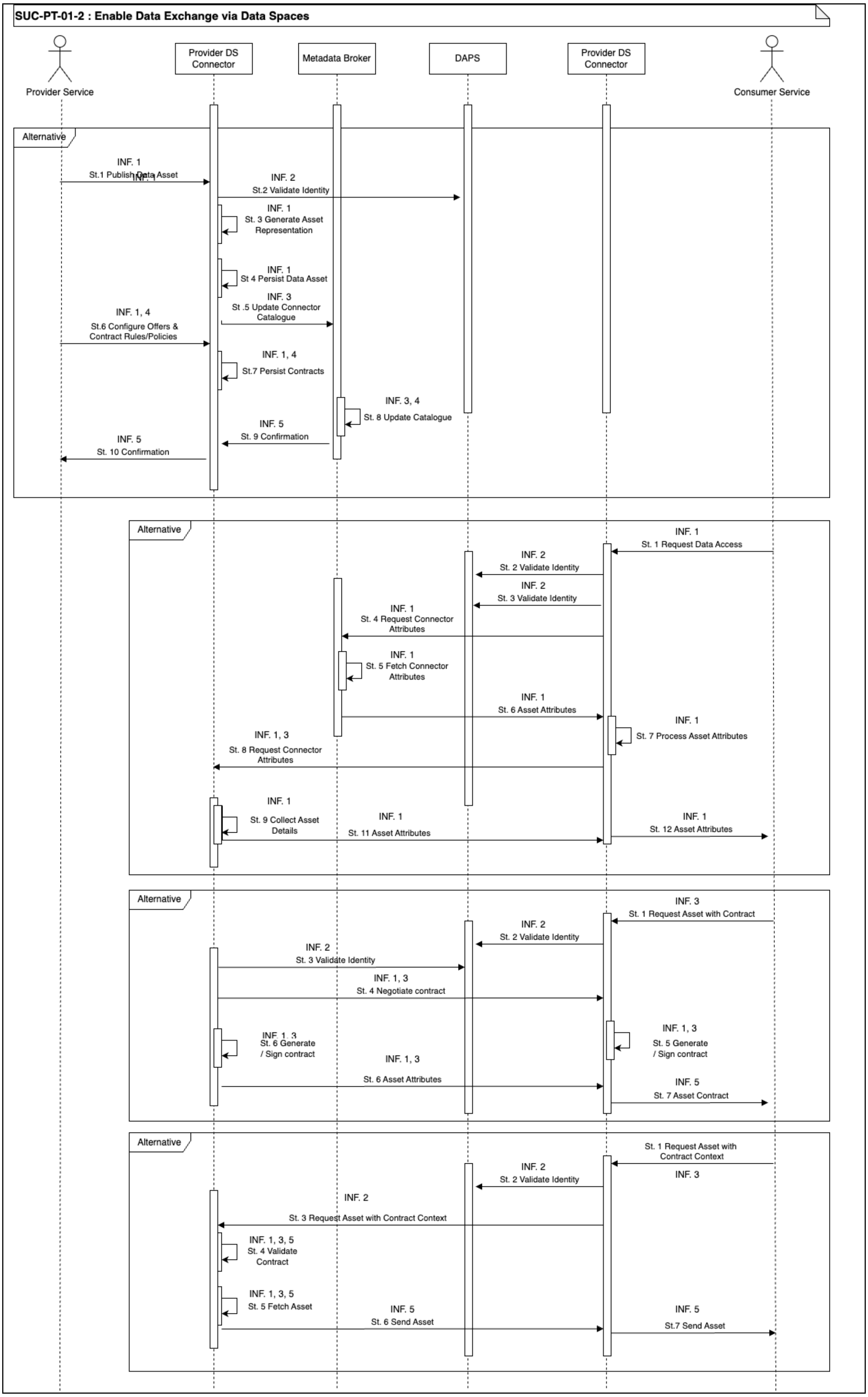

SUC-PT-01-2 : Enable Data Exchange via Data Spaces
Provider Service
Provider DS Connector
Metadata Broker
DAPS
Provider DS Connector
Consumer Service
Alternative
INF. 1
St.1 Publish Data Asset
INF. 2
St.2 Validate Identity
INF. 1
St. 3 Generate Asset Representation
INF. 1
St 4 Persist Data Asset
INF. 3
St .5 Update Connector Catalogue
INF. 1, 4
St.6 Configure Offers & Contract Rules/Policies
INF. 1, 4
St.7 Persist Contracts
INF. 3, 4
St. 8 Update Catalogue
INF. 5
St. 9 Confirmation
INF. 5
St. 10 Confirmation
Alternative
INF. 1
St. 1 Request Data Access
INF. 2
St. 2 Validate Identity
INF. 2
St. 3 Validate Identity
INF. 1
St. 4 Request Connector Attributes
INF. 1
St. 5 Fetch Connector Attributes
INF. 1
St. 6 Asset Attributes
INF. 1
St. 7 Process Asset Attributes
INF. 1, 3
St. 8 Request Connector Attributes
INF. 1
St. 9 Collect Asset Details
INF. 1
St. 11 Asset Attributes
INF. 1
St. 12 Asset Attributes
Alternative
INF. 3
St. 1 Request Asset with Contract
INF. 2
St. 2 Validate Identity
INF. 2
St. 3 Validate Identity
INF. 1, 3
St. 4 Negotiate contract
INF. 1, 3
St. 6 Generate / Sign contract
INF. 1, 3
St. 5 Generate / Sign contract
INF. 1, 3
St. 6 Asset Attributes
INF. 5
St. 7 Asset Contract
Alternative
St. 1 Request Asset with Contract Context
INF. 3
INF. 2
St. 2 Validate Identity
INF. 2
St. 3 Request Asset with Contract Context
INF. 1, 3, 5
St. 4 Validate Contract
INF. 1, 3, 5
St. 5 Fetch Asset
INF. 5
St. 6 Send Asset
INF. 5
St.7 Send Asset

FIGURE 8 – UML SEQUENCE DIAGRAM

3 Technical details

3.1 Actors

Actors			
Actor Name	***Actor Type***	***Actor Description***	***Further information specific to this use case***
Provider DS Connector	Logical Actor	This actor represents a service that will provide data in the context of one data exchange transaction. The ICT/SW/DP Provider supports other entities with ICT (Information and Communications Technology), Software (SW) or Digital Platforms (DP).	INESC TEC, CEVE, REN, RDNESTER
Consumer DS Connector	Logical Actor	This actor represents a service that will consume data in the context of one data exchange transaction. The ICT/SW/DP Provider supports other entities with ICT, Software or Digital Platforms . It should not be confused with the consumer.	INESC TEC, CEVE, REN, RDNESTER
DAPS	Logical Actor	System that is responsible to provide cryptographic identities to run the data space	INESC TEC
Metadata Broker	Logical Actor	System that provides a catalogue of data and metadata about the data assets available in the data space. It also links to the ownership of the data space participants and whose DS connectors make them available.	INESC TEC
Provider Service	Logical Actor	A service that is linked with the Provider DS Connector role and makes data assets available in the data space	INESC TEC, CEVE, REN, RDNESTER
Consumer Service	Logical Actor	A service that is linked with the Consumer DS Connector role and consumes data assets available in the data space	INESC TEC, CEVE, REN, RDNESTER

3.2 References

References						
No.	***Reference Type***	***Reference***	***Status***	***Impact on use case***	***Originator / organisation***	***Link***
1	Reports	Blueprint of the Common European Energy Data Space	Public	High	Int:Net CSA (INESC TEC as contributor)	https://zenodo.org/records/10964387
2	Regulation	GDPR	Public	Requirements	EU	https://eur-lex.europa.eu/eli/reg/2016/679/oj
3	Technical Report	Harmonized Electricity Market Role Model (HEMRM)	Public	Role Model	BRIDGE	

4 Step by step analysis of use case

4.1 Overview of scenarios

Scenario conditions						
No.	**Scenario name**	**Scenario description**	**Primary actor**	**Triggering event**	**Pre-condition**	**Post-condition**
1	Exchange data via data space enabled infrastructure.	Stakeholders acting as data consumers and data providers engage in this process to exchange data assets. The data exchange process is guided by a transaction context that is governed by a digital contract.	Data Provider	Data consumer requests data assets.	Data assets are published and linked to a data space connector.	Data assets are exchanged in the context of contract bound transaction.

4.2 Steps – Scenarios

Scenario								
Scenario name:		***No. 1.1 – Enable Data exchange via Data Spaces***						
Step No.	***Event***	***Name of process/ activity***	***Description of process/ activity***	***Service***	***Information producer (actor)***	***Information receiver (actor)***	***Information Exchanged (IDs)***	***Requirement, R-IDs***
St. 1	On request	Publish Data Asset	Publish the asset in the connector catalogue.	EXECUTE	Provider Service	ProviderDSConnector	Inf.1	Sec-X, D-X, F.1, O-X, Conf.1-3
St. 2	On request	Validate Identity	Identity validation by means of digital contracts.	EXCUTE	ProviderDS Connector	DAPS	Inf. 2	Sec-X, D-X, QoS.1, F.2
St. 3	Recuring until asset persisted.	Generate Asset Representation	Generate asset representation and prepare to push that information to the metadata broker.	REPEAT	ProviderDS Connector	ProviderDSConnector	Inf. 1	Sec-X, D-X, F.1
St. 4	Recuring until asset persisted.	Persist Data Asset	Persist data asset on the connector	REPEAT	ProviderDS Connector	ProviderDSConnector	Inf.1	Sec-X, D-X, F.1, O-X
St. 5	On request	Update Connector Catalogue	Update the connector self-description on the metadata broker.	EXECUTE	ProviderDS Connector	Metadata Broker	Inf. 3	Sec-X, D-X, QoS.1
St. 6	On request	Configure Offers & Contract rules/policies	Configure the contract offers and set policies for each data asset.	EXECUTE	Provider Service	ProviderDSConnector	Inf. 1, Inf. 4	Sec-X, D-X, Conf.1-3
St. 7	Recuring until asset persisted.	Persist Contracts	Persist data contract information and log transactions in the connector.	REPEAT	ProviderDS Connector	ProviderDSConnector	Inf. 1, Inf.4	Sec-X, D-X, F.2, O-X
St. 8	Recuring until asset persisted.	Update Catalogue	Update data asset catalogue in the metadata broker with the updated connector self-descriptions.	REPEAT	ProviderDS Connector	Metadata Broker	Inf.3, Inf.4	Sec-X, D-X, QoS.1, F.1, O-X
St. 9	On request	Confirmation	Push confirmation to requester service.	EXECUTE	Metadata Broker	ProviderDSConnector	Inf.5	Sec-X, D-X
St.10	On request	Asset Attributes	Push confirmation to requester service.	EXECUTE	ProviderDS Connector	Provider Service	Inf.5	Sec-X, D-X, Conf.1-3

Scenario							
Scenario name:		**No. 1.2 – Consumer – Request Asset**					
Step No.	**Event**	**Name of process/ activity**	**Description of process/ activity**	**Service**	**Information producer (actor)**	**Information receiver (actor)**	**Information Exchanged (IDs)**	**Requirement, R-IDs**
St. 1	On request	Request Data Asset	Request the asset in the connector catalogue.	EXECUTE	Consumer Service	ConsumerDSConnector	Inf.1	Sec-X, D-X, F.1, Conf.1-3
St. 2	On request	Validate Identity	Identity validation by means of digital contracts.	EXCUTE	ConsumerDSConnector	DAPS	Inf. 2	Sec-X, D-X, QoS.1, F.2
St. 3	On request	Request Connector Attributes	Request connector attributes that are exported.	EXECUTE	ConsumerDSConnector	Metadata Broker	Inf. 3	Sec-X, D-X, QoS.1
St. 4	Recuring until asset persisted.	Fetch Connector Attributes	Fetch Connector attributes from the metadata broker system.	REPEAT	Metadata Broker	Metadata Broker	Inf. 1	Sec-X, D-X, QoS.1
St. 5	Recuring until asset persisted.	Persist Data Asset	Persist data asset on the connector	REPEAT	ProviderDS Connector	ProviderDSConnector	Inf.1	Sec-X, D-X, F.1, O-X
St. 6	On request	Asset Attributes	Asset attributes with the details in the connector	EXECUTE	Metadata Broker	ConsumerDSConnector	Inf. 1	Sec-X, D-X
St. 7	Recurring until processing is completed	Process Asset Attributes	Process the asset attributes and keep it in the connector	REPEAT	ConsumerDSConnector	ConsumerDSConnector	Inf. 1	Sec-X, D-X, F.1
St. 8	On request	Request connector self-description and asset info	Request information about the assets available and the connector contract offerings for the asset.	EXECUTE	ConsumerDSConnector	ProviderDSConnector	Inf.1, Inf.3	Sec-X, D-X
St. 9	Recurring until asset details are collected	Collect asset details	Collect asset details and payload.	REPEAT	ProviderDS Connector	ProviderDSConnector	Inf. 1	Sec-X, D-X
St.	On request	Update	Update the connector self-	EXECUTE	ProviderDS	Metadata	Inf. 3	Sec-X, D-X, QoS.1

10		Connector Catalogue	description on the metadata broker.		Connector	Broker		
St.11	On request	Asset Attributes	Push confirmation to requester service.	EXECUTE	ProviderDS Connector	ConsumerDSC onnector	Inf.5	Sec-X, D-X, F.1
St.12	On request	Asset Attributes	Push confirmation to requester service.	EXECUTE	ConsumerD SConnector	Consumer Service	Inf.5	Sec-X, D-X, F.1, Conf.1-3

Scenario								
Scenario name:		***No. 1.3 – Provider/consumer – Contract Agreement***						
Step No.	***Event***	***Name of process/ activity***	***Description of process/ activity***	***Service***	***Information producer (actor)***	***Information receiver (actor)***	***Information Exchanged (IDs)***	***Requirement, R-IDs***
St. 1	On request	Request Asset Contract	Request contract to allow the exchange of the data asset.	EXECUTE	Consumer Service	ConsumerDSC onnector	Inf.3	Sec-X, D-X, F.2, Conf.1-3
St. 2	On request	Validate Identity	Identity validation by means of digital contracts.	EXECUTE	ConsumerD SConnector	DAPS	Inf. 2	Sec-X, D-X, QoS.1, F.2
St. 3	On request	Validate Identity	Identity validation by means of digital contracts.	EXECUTE	ProviderDS Connector	DAPS	Inf. 2	Sec-X, D-X, QoS.1, F.2
St. 4	On request	Negotiate Contract	Generate Contact for the exchange of information	EXECUTE	ConsumerD SConnector	ProviderDSCo nnector	Inf.1, Inf. 3	Sec-X, D-X, F.2
St. 5	Recuring until contract is signed.	Generate/S ign contract	Generate and sign the digital contact to use data asset.	REPEAT	ProviderDS Connector	ProviderDSCo nnector	Inf. 1, Inf 3	Sec-X, D-X
St. 6	Recuring until contract is signed.	Generate/S ign contract	Generate and sign the digital contact to use data asset.	REPEAT	ConsumerD SConnector	ConsumerDSC onnector	Inf. 1, Inf 3	Sec-X, D-X
St.7	On request	Asset Contract	Send signed contract for exchange context.	EXECUTE	ConsumerD SConnector	Consumer Service	Inf.5	Sec-X, D-X, F.1, F.2, Conf.1-3

Scenario								
Scenario name:		***No. 1.4 – Provider/consumer – Exchange Data***						
Step No.	***Event***	***Name of process/ activity***	***Description of process/ activity***	***Service***	***Information producer (actor)***	***Information receiver (actor)***	***Information Exchanged (IDs)***	***Requirement, R-IDs***

St. 1	On request	Request Asset Contract Context	Request asset to be exchanged with contract context.	EXECUTE	Consumer Service	ConsumerDSConnector	Inf.3	Sec-X, D-X, F.1, Conf.1-3
St. 2	On request	Validate Identity	Identity validation by means of digital contracts.	EXECUTE	ConsumerDSConnector	DAPS	Inf. 2	Sec-X, D-X, QoS.1, F.2
St. 3	On request	Request Asset with contract context	Identity validation by means of digital contracts.	EXECUTE	ConsumerDSConnector	ProviderDSConnector	Inf. 2	Sec-X, D-X, F.1
St. 4	Recurring until contract is validated.	Validate Contract	Ensure contract is valid and asset in context is still applicable.	REPEAT	ProviderDSConnector	ProviderDSConnector	Inf.1, Inf. 3, Inf.5	Sec-X, D-X, F.2
St. 5	Recuring until contract is signed.	Fetch Asset	Collect Asset from the local repository.	REPEAT	ProviderDSConnector	ProviderDSConnector	Inf. 1, Inf 3, Inf. 5	Sec-X, D-X
St. 6	On request	Send Asset	Send requested asset.	EXECUTE	ProviderDSConnector	ConsumerDSConnector	Inf.5	Sec-X, D-X
St.7	On request	Send Asset	Send requested asset.	EXECUTE	ConsumerDSConnector	Consumer Service	Inf.5	Sec-X, D-X, Conf.1-3

5 Information exchanged

Information exchanged			
Information exchanged (ID)	***Name of information***	***Description of information exchanged***	***Requirement, R-IDs***
Inf. 1	Data asset representation	One data asset (payload depends on provider service)	
Inf. 2	Metadata Identity information	Identity of participants	
Inf. 3	Connector Self-description	Representation of assets capabilities exported by one given connector.	QoS.1
Inf. 4	Digital contract	Digital contract establishing the policies for data exchange.	QoS.1
Inf. 5	Confirmation	Payload confirmation	

6 Requirements

Quality of Service Requirements		
Categories ID	**Category name for requirements**	**Category description**
QoS	Quality of Service	Generic properties that service/SUC should provide – quality attributes.
Requirement R-ID	**Requirement name**	**Requirement description**
QoS.1	Availability of information flows	Continuous availability not required so long as downtime is scheduled

Security Requirements		
Categories ID	**Category name for requirements**	**Category description**
Sec	Security	Authentication of user, confidentiality, integrity, prevention of denial of service, non-repudiation or accountability, error management.
Requirement R-ID	**Requirement name**	**Requirement description**
Sec.1	Eavesdropping: Ensuring confidentiality, avoiding illegitimate use of data, and preventing unauthorized reading of data, is:	Crucial
Sec.2	Authentication and Access Control mechanisms for services	Authentication Pair and secondary channel validation,
Sec.3	Network security measures commonly used with this data exchange	Firewall with Access Control Lists Reverse proxy server
Sec.4	Acknowledge timeout	One minute for any M2M communication.
Sec-X	All constraints apply	All requirements in this category.

Data Management Requirements		
Categories ID	**Category name for requirements**	**Category description**
D	Data Management	Type of source of data, correctness or validity of data, timeliness or time stamping of data, volume of data, synchronization, or consistency of data across systems, timely access to data,

		validation of data across organizational boundaries, transaction management, data naming, identification, formats across disparate systems, maintenance of data and databases.
Requirement R-ID	**Requirement name**	**Requirement description**
D.1	Management of data across organizational boundaries	Data exchanges go across organizational boundaries
D.2	Data persistence	Data is persistently stored in the platform database
D.3	Data validation	All data must be validated on each data exchange
D.4	Data validation from multiple sources	Data items are mapped according to their source
D.5	Management of data formats in data exchanges	Data is always converted at the information receiver site
D-X	All constraints apply	All requirements in this category.

Discovery and Configuration Requirements		
Categories ID	**Category name for requirements**	**Category description**
Conf	Configuration	Locations, distances, communication layout, commonly used communication protocol media, network bandwidth, existing protocols, number of devices, systems, volume of data items, expected growth, etc.
Requirement R-ID	**Requirement name**	**Requirement description**
Conf.1	Communication media	Wireless required
Conf.2	Data exchange with Connector API	Client-server
Conf.3	Connector API communication Protocol	HTTP/2

Other Requirements		
Categories ID	**Category name for requirements**	**Category description**
O	Regulatory obligation related to privacy	2016/679 GDPR (General Data Protection Regulation)
F	Functional	Essential functionalities that build the core concept of the service/SUC.
Requirement R-ID	**Requirement name**	**Requirement description**
O.1	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.
O.2	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.
O.3	Data retention policy	Personal data may not be transferred to a third-party if the data subject does not

		agree and the third party provides appropriate safeguard.
O.4	Data processing consent	Personal data may not be processed unless there is at least one legal basis to do so.
O-X	All constraints also apply.	All requirements in this category.
F.1	Asset is represented in an interoperable format	Crucial. Example formats: ontological graph patterns, Fiware smart data models, annotated JSON payloads.
F.2	Identity certificates issued in X.509 format	Crucial

7 Common Terms and Definitions

Common Terms and Definitions	
Term	**Definition**
API	Application Programming Interface
DPP	Digital Platform Provider
GDPR	General Data Protection Regulation
M2M	Machine-to-machine
QoS	Quality-of-Service
SO	System Operator
TSO	Transmission System Operator

3 SUC-PT-01.3 MOBILIZING ENERGY FLEXIBILITY

1 Description of the use case

1.1 Name of the use case

ID	Area / Domain(s) / Zones(s)	Name of Use Case
SUC – PT-01.3	Flexibility Services	Mobilizing Energy Flexibility

1.2 Version management

Version Management			
Version No.	**Date**	**Name of Author(s)**	**Changes**
0.1	19.06.2024	David Rua (INESC TEC) Fábio Coelho (INESC TEC) Vasco Campos (INESC TEC)	First draft, scope, objectives.
0.2	26.06.2024	David Rua (INESC TEC) Fábio Coelho (INESC TEC) Vasco Campos (INESC TEC)	First diagram mocks.
0.3	03.07.2024	David Rua (INESC TEC) Fábio Coelho (INESC TEC) Vasco Campos (INESC TEC)	Consolidated version.
0.4	22.07.2024	David Rua (INESC TEC) Fábio Coelho (INESC TEC) Vasco Campos (INESC TEC)	First final version.
0.5	17.09.2024	David Rua (INESC TEC) Fábio Coelho (INESC TEC) Vasco Campos (INESC TEC)	Harmonization with new T2.6 guidelines for the "requirements" section and new use case diagram. Updated look and feel.

1.3 Scope and objectives of use case

Scope and Objectives of Use Case	
Scope	The mobilization of energy flexibility is a fundamental step carried out by service providers to explore their participation in energy markets. The purpose of the use case is to implement strategies to allow the different residential and non-residential participants to elect the assets that will be made available to take part in energy flexibility services within the energy community. The context surrounding this use case encompasses the need to exploit the energy flexibility of citizen energy communities toward the creation of energy and non-energy services.
Objective(s)	This system use case will fulfil the following objectives: 1. Enable the participation of consumers in flexibility services; 2. Determine the types of energy assets that can take part in flexibility services (i.e., heating water storage, electric vehicles, induction hobs, electric ovens, well pumps, HVAC); 3. Set the minimum connectivity and controllability requirements of each device and system participating in flexibility operation; 4. Define the connectivity needs with the digital platform provider; 5. Establish access to incentives to participate in the flexibility services; 6. Register the participation of flexibility assets in an energy management system.

Related business case(s)	BUC-PT-01– GreenVale: Harnessing the potential of energy communities by leveraging Federated Learning strategies.

1.4 Narrative of use case

Narrative of Use Case
Short description
This system use-case sets the fulfilment of technical and operational requirements to allow consumers to participate in services fostered by the Flexibility Service Provider (FSP), through the use of energy management systems, by allocating the flexibility assets and benefitting from incentives that will govern their participation.
Complete description
The use case sets the conditions (technical and operational) to allow the FSP to offer new services capable of mobilizing consumers towards their adoption, ultimately to contribute to the energy system efficiency and security of operation. To ensure that the flexibility from the demand side is mobilized to allow its aggregation and later participation in a flexibility market, there are a specific set of stages that need to be considered to allow consumers, service providers and market operators to be engaged. The stages of the flexibility market operations are ensured by the digital platform EdgeConnect and, regarding the mobilization of energy flexibility, three main stages are described: aggregation, negotiation and market operation. These sets of stages are divided into two main categories: The first is a **one-time-only onboarding** phase and the second one is the **dynamic flexibility value chain operations** that occur periodically. **Onboarding (one-time only):** 1. **The FSP service is posted for pre-qualification** in the digital platform (EdgeConnect). The FSP service must meet specific prerequisites determined by the System Operator (SO), to qualify as a flexibility service. The relevant information is posted by the service and assessed by the SO/Market Operator (MO). 2. **Flexibility services for consumers are posted** on the digital platform (EdgeConnect). The FSP posts a flexibility service, that may be updated (via edgeFlex), in the EdgeConnect that will incentivize the consumers to change their regular operation to a more convenient one, indicating the provided incentives in a time-ahead fashion. a. **Optionally, two aggregators/FSPs can define a special type of contract between themselves called a bilateral agreement**, which will be technically enabled by EdgeConnect. The contract is arranged with the technical and commercial conditions to define the use of flexibility by a third party. Meaning an aggregator with smaller flexible loads can still meet the requirements to market the flexibility, by joining forces with an aggregator with larger flexible loads. 3. **Consumers authorize compliant flexible assets** for supervised energy management to the EdgeConnect. The consumer connects previously integrated assets to a flexibility service, by onboarding it, where the energy management systems will consider them for participation in flexibility services. a. **Assets are submitted to pre-qualification**, where the FSP/SO/MO assess the asset's technical capabilities to provide the flexibility required. b. **FSP sends a contract** with the conditions for the consumer to participate in the flexibility service. c. **Consumer signs the contract**, giving the flexibility service control over its assets.

i. The contract can be regularly updated, which requires consumers to agree to the conditions every time, to guarantee that they can participate in the flexibility service. **Flexibility Value Chain Operations (dynamic):** 1. **[Aggregation] – Aggregator/FSP/Energy Community creates and submits a flexibility bid**, using the pre-qualified flexible assets of its consumers. The bid is then submitted to market negotiation. 2. **[Negotiation] - Flexibility is negotiated in the market**, which is facilitated by EdgeConnect. The flexibility needs of a certain flexibility zone are established by the SO and published. **FSP will determine the necessary participation of the represented consumers** and inform them of the requested participation and which of the assets will be activated. Afterwards, a flexibility bid is prepared and taken to market via EdgeConnect. a. In case the aggregator/FSP does not meet the minimum flexibility requirements to go to market, the **bilateral agreement** is triggered, and the flexibility is grouped and taken to market by a third party (larger aggregator). 3. **[Market Operation] - Market Operator establishes the market results** (winning bids) and allows the SO to select them via EdgeConnect. SO selects the flexibility bids according to its criteria and dispatch them to the aggregator/FSP. The Aggregator/FSP, having its bid selected, enter a contractual agreement with the SO and activate the bid by informing the consumers of their participation, integrating them in an optimal schedule. The agreement and the flexibility baseline are sent to the SO via EdgeConnect.

1.5 Key performance indicators (KPI)

ID	*Name*	*Description*	*Reference to mentioned use case objectives*
KPI-PT-03-1	*Registered participants in flex services*	Number of participants willing to take part of the flexibility services provisioning.	Obj.1
KPI-PT-03-2	*Average number of assets to provide flexibility*	Number of assets selected to take part of the flexibility services	Obj.2, 3, 4, 5, 6
KPI-PT-03-3	*Differentiated incentives to consumers*	Number of differentiated incentives passed to consumers	Obj.2, 3, 4, 5, 6

1.6 Use case conditions

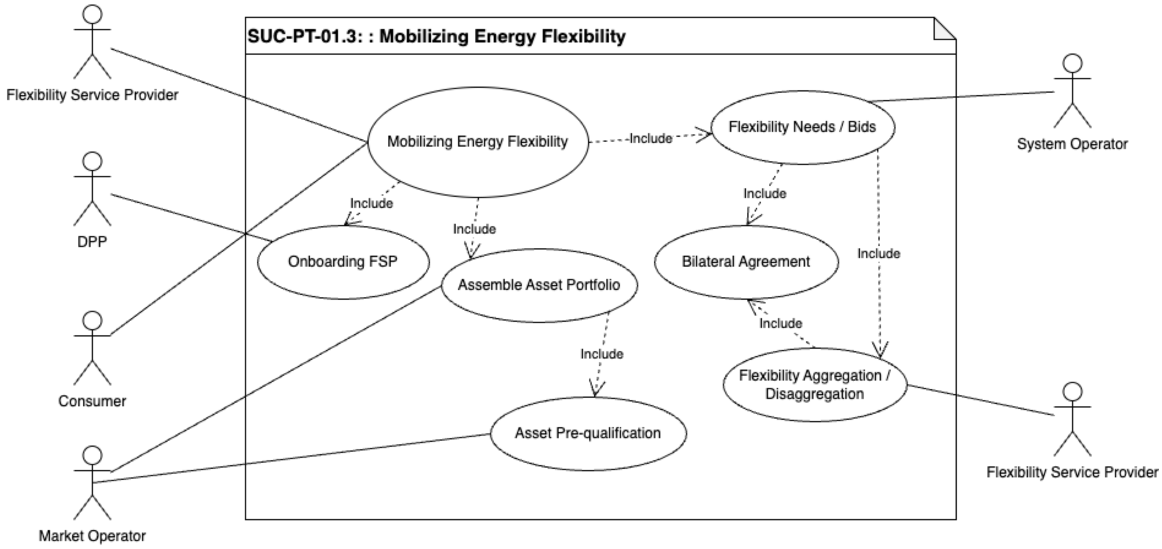
Use case conditions
Assumptions
This SUC is assumed to be linked with SUC-PT-01 and SUC-PT-04. Together, they form an end-to-end process for flexibility procurement. From service/asset onboarding (SUC-PT-01) to the flexibility market operations (SUC-PT-03) to the activation of the flexibility (SUC-PT-04).
Prerequisites
The following prerequisites should be observed: • 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. o Consumers are present in the areas where the FSPs operate.

  - The assets are within the premises of the consumer and have access to the internet around the clock.
- Data exchange has been enabled for all the actors participating in the use case.
- FSPs have a business plan where incentives are clearly defined and it has been exposed to the consumers before the service onboarding.

1.7 Further Information to the use case for classification / mapping

Classification Information
Relation to other use cases
BUC-PT-01: GreenVale: Harnessing the potential of energy communities by leveraging Federated Learning strategies. SUC-PT-01.1: Connect flexibility providers across the DPP flexibility value chain SUC-PT-01.2: Enable data exchange via data spaces SUC-PT-01.4: Activation of energy flexibility
Level of depth
System use case (SUC) use case which describes the functionality/technological solutions of (a part of) a business process in detail.
Prioritisation
High Level of Priority – To be demonstrated in Portugal.
Generic, regional or national relation
Generic (Regional scope for demonstration)
Nature of the use case
Flexibility Services, Interoperability enablement
Further keywords for classification
Flexibility value-chain, energy services

2 Diagrams of use case

Diagram(s) of use case
 FIGURE 9 – UML USE CASE DIAGRAM

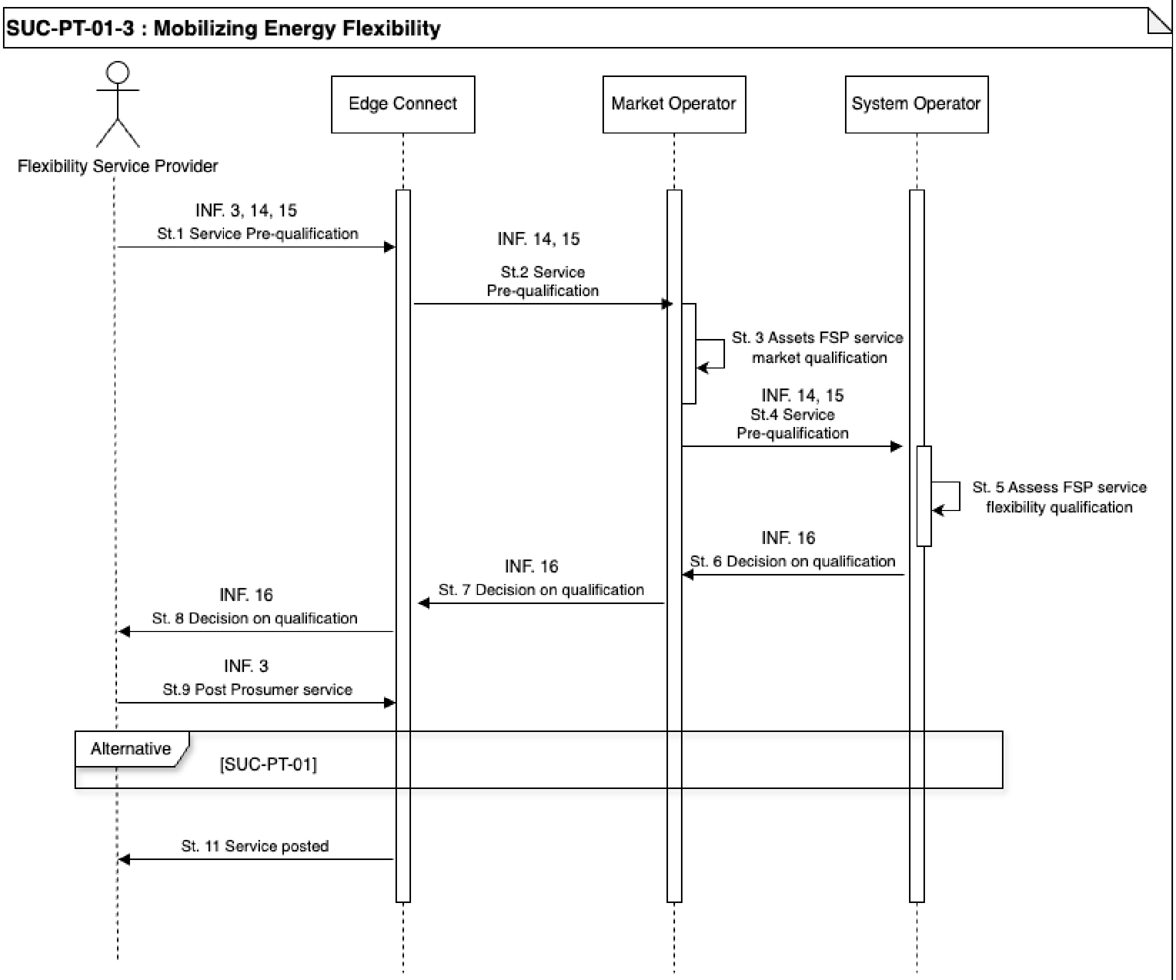


FIGURE 10 – UML SEQUENCE DIAGRAM – FSP SERVICE ONBOARDING

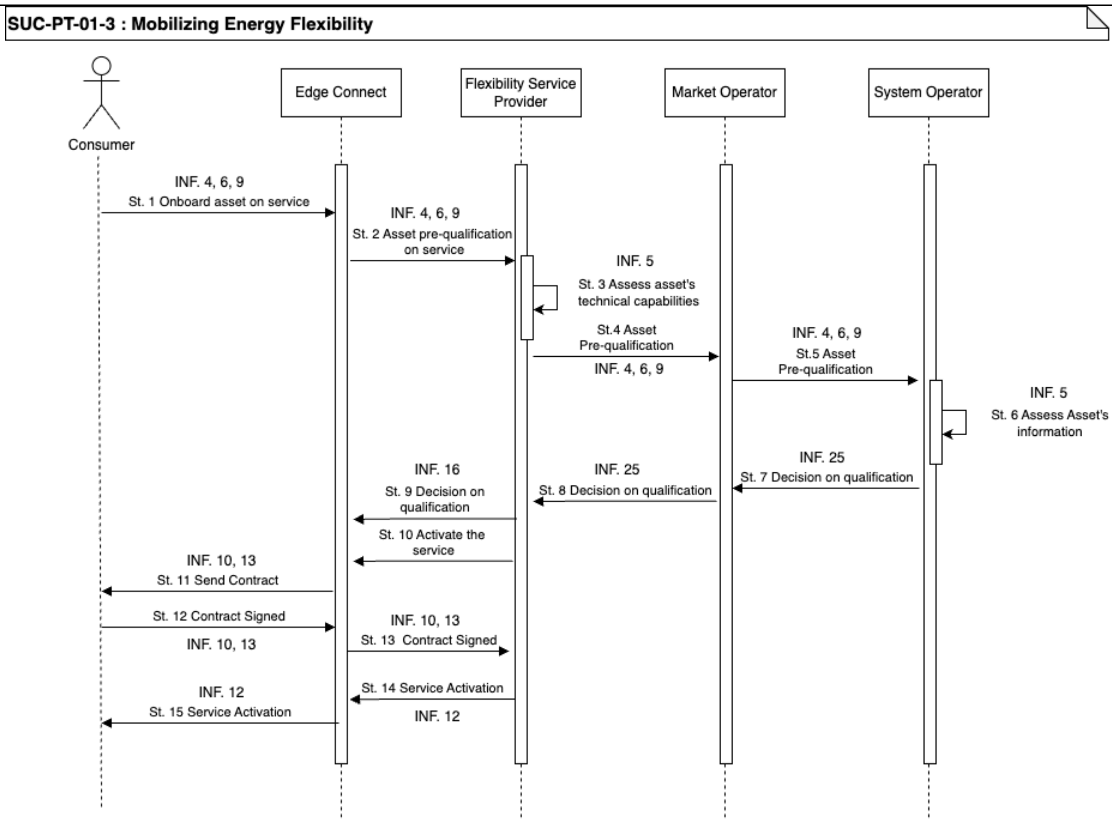


FIGURE 11 – UML SEQUENCE DIAGRAM – CONSUMER ASSET SERVICE ONBOARDING

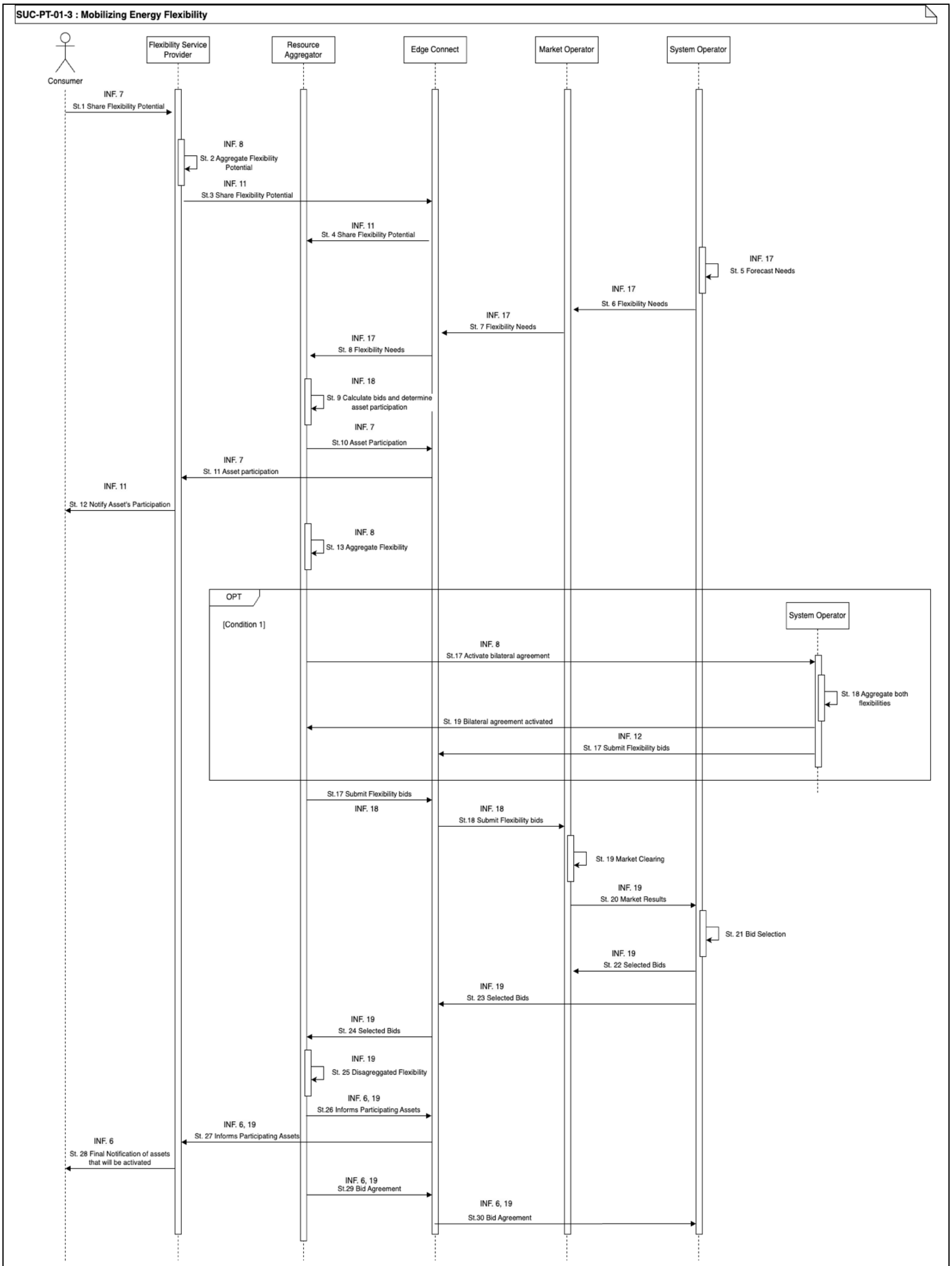


FIGURE 12 – SEQUENCE DIAGRAM – MOBILIZING ENERGY FLEXIBILITY – MARKET OPERATIONS

3 Technical details

3.1 Actors

Actors			
Actor Name	**Actor Type**	**Actor Description**	**Further information specific to this use case**
Consumer	Business actor	A legal representative that has a contractual relationship with a service provider	CEVE
Flexibility Service Provider (FSP)	Business actor	A market service provider that explores the flexibility of consumers' assets for grid services	CEVE, ELERGONE-SONAE
Primary Resource Aggregator	Business actor	A business provider that explores and optimizes the different flexible assets from consumers and optimize their operation.	CEVE, ELERGONE-SONAE
System Operator (SO)	Operator	A system operator is responsible for ensuring the reliable and efficient operation of a power grid. Their primary role involves monitoring, controlling, and optimizing the flow of electricity across the grid to meet demand while maintaining system stability and reliability.	REN, RDNESTER
Market Operator (MO)	Operator	A party that provides a service of collecting offers to sell and bids to buy electricity and matching these offers and bids to determine a market price at the clearing point.	REN, RDNESTER
EdgeConnect (DPP Platform)	Business actor	(The ICT/SW/DP Provider) Supports other entities with ICT (Information and Communications Technology), Software (SW) or Digital Platforms (DP).	INESC TEC

3.2 References

References						
No.	**Reference Type**	**Reference**	**Status**	**Impact on use case**	**Originator / organisation**	**Link**
1	Reports	Blueprint of the Common European Energy Data Space	Public	High	Int:Net CSA (INESC TEC as contributor)	https://zenodo.org/records/10964387

4 Step by step analysis of use case

4.1 Overview of scenarios

Scenario conditions						
No.	**Scenario name**	**Scenario description**	**Primary actor**	**Triggering event**	**Pre-condition**	**Post-condition**
Sc. 1	FSP Service Onboarding	The FSP posts a service, which is pre-qualified by the System Operator, to incentivize consumers with flexible assets to change their regular operations. Optionally, the FSP may enter a bilateral agreement with another FSP.	Flexibility Service Provider (FSP)	The FSP wants to publish a flexibility service to leverage consumer assets.	The service must not exist on the EdgeConnect database. EdgeConnect is operational.	A record for the service is registered on the EdgeConnect database. The decision on the pre-qualification reaches the FSP.
Sc. 2	Consumer Onboarding Asset on Service	Consumers with flexible assets subscribe to flexibility services. The assets are submitted to a pre-qualification and a contract is signed between the consumer and the FSP.	Consumer	Consumer subscribes to a service	The consumer must not be onboarded to the service. Its assets have the technical capabilities to provide flexibility EdgeConnect is operational.	The record of the consumer is associated with the subscribed service on the EdgeConnect database. A contract is signed between the FSP and the consumer.
Sc. 3	Flexibility value chain operations to Mobilize Energy Flexibility	Three main flexibility value chain operations are performed: Aggregation, Negotiation and Market Operation. FSP takes their consumer's flexibility to market, coordinating with the SO to fulfil its needs. Consumers are notified and explicitly declare their participation.	System Operator (SO)	The SO identifies their needs and decides to take them to the flexibility market to solve them.	A need must be identified by the SO and taken to market. FSP must have a service registered on EdgeConnect with onboarded consumers with pre-qualified flexible assets.	A bid agreement is reached between the aggregator and the SO. Participating assets are explicitly authorized for activation by the consumers.

4.2 Steps – Scenarios

Scenario								
Scenario name:		**No.1 – FSP service onboarding**						
Step No.	**Event**	**Name of process/ activity**	**Description of process/ activity**	**Service**	**Information producer (actor)**	**Information receiver (actor)**	**Information Exchanged (IDs)**	**Requirement, R-IDs**
St. 1	Service pre-qualification	Service pre-qualification	The registered FSP requests for pre-qualification of the service to EdgeConnect, by starting the pre-qualification process.	CREATE	Flexibility Service Provider (FSP)	EdgeConnect	Inf. 3, Inf. 14, Inf. 15	O-X, Sec-X, QoS-X, Conf-X
St. 2	Service pre-qualification	Service pre-qualification	The registered FSP requests for pre-qualification of the service to EdgeConnect, by starting the pre-qualification process.	CREATE	EdgeConnect	Market Operator (MO)	Inf. 14, Inf. 15	O-X, Sec-X, QoS-X, Conf-X
St. 3	Market Qualification	Assess FSP service market qualification	Market pre-qualification is done, to check if the service has the necessary communication tools to connect to the market platform as well as the necessary financial guarantees.	EXECUTE	MO	MO		O-X
St. 4	Service pre-qualification	Service pre-qualification	The registered FSP requests for pre-qualification of the service to EdgeConnect, by starting the pre-qualification process.	CREATE	MO	System Operator (SO)	Inf. 14, Inf. 15	O-X, Sec-X
St. 5	Service pre-qualification	Asses FSP service flexibility qualification	The SO assesses the information about the FSP service.	EXECUTE	SO	SO		O-X
St. 6	Service pre-qualification	Decision on qualification	The decision on the service pre-qualification to participate in the market is	CLOSE	SO	MO	Inf. 16	Sec-X

			communicated to the Market Operator.					
St. 7	Service pre-qualification	Decision on qualification	The decision on the service pre-qualification to participate in the market is communicated to EdgeConnect.	CLOSE	MO	EdgeConnect	Inf. 16	QoS-X, Sec-X, Conf-X
St. 8	Service pre-qualification	Decision on qualification	The decision on the service pre-qualification to participate in the market is communicated to the FSP.	CLOSE	EdgeConnect	FSP	Inf. 16	QoS-X, Sec-X, Conf-X
St. 9	Register service on EdgeConnect	Post consumer service	The FSP provides the information of the service it wants to register and activates it on EdgeConnect.	EXECUTE	FSP	EdgeConnect	Inf. 3	F.1, F.2, F.3, F.10, F.12, F.13, D.1, D.2, QoS-X, Sec-X, Conf-X
St. 10	Register service on EdgeConnect	SUC-PT-01.1: Scenario 1.3	Service provider onboarding on the DPP platform (EdgeConnect) and activation of its services.	GET	FSP	EdgeConnect		QoS-X, Sec-X, Conf-X
St. 11	Register service on EdgeConnect	Service activated	The FSP starts the service execution	EXECUTE	EdgeConnect	FSP		QoS-X, Sec-X, Conf-X

Scenario								
Scenario name:		***No. 2 – Consumer Asset Service Onboarding***						
Step No.	***Event***	***Name of process/ activity***	***Description of process/ activity***	***Service***	***Information producer (actor)***	***Information receiver (actor)***	***Information Exchanged (IDs)***	***Requirement, R-IDs***
St. 1	Onboard asset on service	Onboard asset on service	The consumer selects the desired service and starts the onboarding process by sending its assets technical information to EdgeConnect.	EXECUTE	Consumer	EdgeConnect	Inf. 4, Inf. 6, Inf. 9	O-X, D.1, F.1, F.2, F.3, F.5, F.6, Sec-X, QoS-X, Conf-X
St. 2	Asset pre-qualification on service	Asset pre-qualification on service	The FSP receives the list of flexible assets from the consumer that wishes to subscribe to the service.	EXECUTE	EdgeConnect	Flexibility Service Provider (FSP)	Inf. 4, Inf. 6, Inf. 9	O-X, D.1, F.1, F.2, F.3, F.5, F.6, F.11, Sec-X, QoS-X, Conf-X
St. 3	Asset pre-	Assess	The FSP confirms that the	EXECUTE	FSP	FSP	Inf. 5	O-X, D.1

	qualification on service	assets' technical capabilities	asset has the capability to provide flexibility and be remotely controlled.					
St. 4	Asset pre-qualification on service	Asset pre-qualification	Asset information is sent to the Market Operator.	EXECUTE	FSP	Market Operator (MO)	Inf. 4, Inf. 6, Inf. 9	O-X, Sec-X
St. 5	Asset pre-qualification on service	Asset pre-qualification	Asset information is sent to the System Operator.	EXECUTE	MO	System Operator (SO)	Inf. 4, Inf. 6, Inf. 9	O-X, Sec-X
St. 6	Asset pre-qualification on service	Assess assets' information	The SO evaluates the technical information about the assets.	EXECUTE	SO	SO	Inf. 5	O-X
St. 7	Decision on assets' qualification	Decision on assets' qualification	The decision on the asset pre-qualification to participate in the market is communicated to the MO.	CLOSE	SO	MO	Inf.25	O-X, Sec-X
St. 8	Decision on assets' qualification	Decision on assets' qualification	The decision on the asset pre-qualification to participate in the market is communicated to the FSP.	CLOSE	MO	FSP	Inf.25	O-X, Sec-X
St. 9	Decision on assets' qualification	Decision on assets' qualification	The decision on the asset pre-qualification to participate in the market is communicated to EdgeConnect.	CLOSE	FSP	EdgeConnect	Inf.25	O-X, F.1, F.2, F.3, F.5, Sec-X, QoS-X, Conf-X
St. 10	Service activation	Activate the service	The FSP indicates on EdgeConnect that the service is ready to start and provides a contract for the consumer to sign.	EXECUTE	FSP	EdgeConnect		O-X, F.1, F.2, F.3, F.4, F.5, F.11, Sec-X, QoS-X, Conf-X
St. 11	Service activation	Send contract	EdgeConnect sends the service contract to the consumer that subscribed to the service.	GET	EdgeConnect	Consumer	Inf. 10, Inf. 13	O-X, F.1, F.2, F.3, F.4, F.5, F.11, Sec-X, QoS-X, Conf-X
St. 12	Service activation	Contract signed	The contract is signed by the consumer and sent back to EdgeConnect.	CREATE	Consumer	EdgeConnect	Inf. 10, Inf. 13	O-X, F.1, F.2, F.3, F.4, F.5, F.11, Sec-X, QoS-X, Conf-X
St.	Service	Contract	The FSP receives the newly	CREATE	EdgeConne	FSP	Inf. 10, Inf. 13	O-X, F.1, F.2, F.3, F.4,

13	activation	signed	signed contract.		ct			F.5, F.11, Sec-X, QoS-X, Conf-X
St. 14	Service activation	Service activation	The service starts.	EXECUTE	FSP	EdgeConnect	Inf. 12	O-X, F.1, F.2, F.3, F.4, F.5, F.11, Sec-X, QoS-X, Conf-X
St. 15	Service activation	Service activation	Consumer is notified that the service has started its operations.	EXECUTE	EdgeConne ct	Consumer	Inf. 12	O-X, F.1, F.2, F.3, F.4, F.5, F.11, Sec-X, QoS-X, Conf-X

Scenario								
Scenario name:		***No.3 – Flexibility value chain operations to mobilize energy flexibility***						
Step No.	***Event***	***Name of process/ activity***	***Description of process/ activity***	***Service***	***Information producer (actor)***	***Information receiver (actor)***	***Information Exchanged (IDs)***	***Requirement, R-IDs***
St. 1	Share flexibility potential	Share flexibility potential	The consumer periodically shares/updates its flexibility potential with the Flexibility Service Provider (FSP), making it available to be explored.	REPEAT (On Update)	Consumer	Flexibility Service Provider (FSP)	Inf. 7	Sec-X
St. 2	Aggregate flexibility potential	Aggregate flexibility potential	FSP aggregates the flexibility potential of consumers that subscribed its services.	REPEAT (daily)	FSP	FSP	Inf. 8	
St. 3	Share flexibility potential	Share flexibility potential	Shares aggregated flexibility potential of consumer that are subscribed to the FSP's energy service.	EXECUTE	FSP	EdgeConnect	Inf 11.	D.1, F.1, F.2, F.3, F.5, F.11, Sec-X, QoS-X, Conf-X
St. 4	Share flexibility potential	Share flexibility potential	The aggregated flexibility of FSP's service's is sent to a resource aggregator that is subscribed to the service.	EXECUTE	EdgeConne ct	Aggregator	Inf 11.	Sec-X, QoS-X, Conf-X
St. 5	Gather flexibility needs	Forecast needs	SO assesses potential grid constraints (congestions or voltage problems).	CREATE	System Operator (SO)	SO	Inf. 17	Sec-X
St. 6	Gather flexibility needs	Flexibility needs	SO sends flexibility needs to the market operator, assuming it can be used to	EXECUTE	SO	Market Operator (MO)	Inf. 17	Sec-X

			solve constraints.					
St. 7	Gather flexibility needs	Flexibility needs	Flexibility needs are also sent to EdgeConnect by the SO. The flexibility needs can be defined in two ways: either in reservation mode, where the flexibility providers remain available for an activation that may or not take place closer to real time, if the SO decides it needs the flexibility reserved, or in activation mode, where the bid selection includes the flexibility activation that produces new aggregator schedules.	EXECUTE	SO	EdgeConnect	Inf. 17	D.1, F.1, F.2, F.3, Sec-X, QoS-X, Conf-X
St. 8	Gather flexibility needs	Flexibility needs	The aggregator is informed of the SO's needs through EdgeConnect.	EXECUTE	EdgeConnect	Aggregator	Inf. 17	D.1, Sec-X, QoS-X, Conf-X
St.9	Calculate bids	Calculate bids and determine asset participation	The Aggregator uses the flexibility needs to determine its flexibility bids among the pre-qualified assets, determining its assets' participation.	CREATE	Aggregator	Aggregator	Inf. 18	
St. 10	Determine asset participation	Asset participation	Aggregator publishes its assets' participation on EdgeConnect, according to the flexibility needs received from the SO.	CREATE	Aggregator	EdgeConnect	Inf. 7	D.1, F.1, F.2, F.3, Sec-X, QoS-X, Conf-X
St. 11	Determine asset participation	Asset participation	FSP receives the assets' expected participation through EdgeConnect	EXECUTE	EdgeConnect	FSP	Inf. 7	Sec-X, QoS-X, Conf-X
St. 12	Notify consumer of expected participation	Notify of assets' participation	FSP notifies the user that its assets are expected to participate in the flexibility value chain, as established in	REPEAT (until decision on authorization	FSP	Consumer	Inf. 11	Sec-X

			their contract.	n)				
St. 13	Aggregate flexibility	Aggregate flexibility	The aggregator aggregates flexibility considering the authorized assets of consumers subscribed to its service.	EXECUTE	Aggregator	Aggregator	Inf. 8	

Scenario								
Scenario name:	***No.3.1 – Bilateral Agreement***							
St. 17	Bilateral agreement activation	Activate bilateral agreement	The resource aggregator does not meet the minimum requirements to participate in the flexibility market. A previously established bilateral agreement is activated, between the aggregator and the (larger) primary aggregator that will take the flexibility to market.	EXECUTE	Aggregator	Primary Aggregator	Inf. 8	Sec-X
St. 18	Bilateral agreement activation	Aggregate both flexibilities	The primary resource aggregator aggregates both flexibilities (its own and the smaller one from the resource aggregator), creating a joint bid.	EXECUTE	Primary Aggregator	Primary Aggregator		
St. 19	Bilateral agreement activation	Bilateral agreement activated	The bilateral agreement is performed and its activation is confirmed to the resource aggregator that activated the agreement.	EXECUTE	Primary Aggregator	Aggregator	Inf. 12	Sec-X
St. 17	Submit flexibility bids	Submit flexibility bids	Aggregators submit their bids to EdgeConnect.	CREATE	Aggregator	EdgeConnect	Inf. 18	D.1, F.1, F.2, F.3, F.7, F.8, F.11, Sec-X, QoS-X, Conf-X
St. 18	Submit flexibility bids	Submit flexibility bids	Flexibility bids are forwarded to the Market Platform.	EXECUTE	EdgeConnect	MO	Inf. 18	Sec-X, QoS-X, Conf-X

St. 19	Market clearing	Market clearing	The Market Operator performs the market clearing.	EXECUTE	MO	MO		
St. 20	Market results	Market results	The results of market clearing are communicated to the SO, and typically consist in a merit order list based on financial criteria.	EXECUTE	MO	SO	Inf. 19	Sec-X
St. 21	Bid selection	Bid selection	Starting from the merit order list of the previous step, the DSO makes the bids selection based on its technical criteria, qualification process, and communicate the selected bids to the Market Platforms.	EXECUTE	SO	SO		
St. 22	Selected Bids	Selected Bids	Information on the selected bids is sent to the Market Operator.	EXECUTE	SO	MO	Inf. 19	Sec-X
St. 23	Selected Bids	Selected Bids	Information on the selected bids is also sent to EdgeConnect.	EXECUTE	SO	EdgeConnect	Inf. 19	D.1, F.1, F.2, F.3, Sec-X, QoS-X, Conf-X
St. 24	Selected Bids	Selected Bids	The Aggregator receives the selected bids through EdgeConnect. If its offers are selected, the aggregator enters into a contractual agreement with the SO.	EXECUTE	EdgeConnect	Aggregator	Inf. 18, Inf. 19	Sec-X, QoS-X, Conf-X
St. 25	Disaggregate flexibility	Disaggregate flexibility	Aggregator disaggregates the flexibility from the winning bid per asset.	CREATE	Aggregator	Aggregator	Inf. 19	
St. 26	Final selection of participating assets	Participating assets	Aggregator updates its assets' participation on EdgeConnect, according to the winning bid received from the SO.	CHANGE	Aggregator	EdgeConnect	Inf. 6, Inf. 19	D.1, F.1, F.2, F.3, Sec-X, QoS-X, Conf-X

St. 27	Final selection of participating assets	Participating assets	Participating assets are forwarded to the corresponding FSP service.	EXECUTE	EdgeConnect	FSP	Inf. 6	D.1, F.1, F.2, F.3, F.5, F.11, Sec-X, QoS-X, Conf-X
St. 28	Final notification of participating assets	Final notification of assets that will be activated	Notify consumers of its assets confirmed participation on the flexibility value chain.	EXECUTE	FSP	Consumer	Inf. 6	D.1, F.1, F.2, F.3, F.5, F.11, Sec-X
St. 29	Bid agreement	Assets' authorized flexibility	Aggregator asks EdgeConnect for the assets subscribed to its service, that are authorized to participate in the flexibility value chain.	GET	Aggregator	EdgeConnect	Inf. 6, Inf. 19	D.1, F.1, F.2, F.3, F.5, F.11, Sec-X, QoS-X, Conf-X
St. 30	Bid agreement	Bid agreement	The Aggregator sends the signed agreement to EdgeConnect.	CREATE	Aggregator	EdgeConnect	Inf. 6, Inf. 19	D.1, F.1, F.2, F.3, F.6, F.11, Sec-X, QoS-X, Conf-X
St. 31	Bid agreement	Bid agreement	EdgeConnect sends the signed agreement to the SO.	EXECUTE	EdgeConnect	SO	Inf. 6, Inf. 19	F.6, Sec-X, QoS-X, Conf-X

5 Information exchanged

Information Exchanged			
Information exchanged (ID)	**Name of information**	**Description of information exchanged**	**Requirement, R-IDs**
Inf.1	Consumer profile	Basic information to register a consumer, including personal identification: name, surname, location, email account	O-X
Inf.2	Service provider profile	Basic information to register a service provider, including identification: name, location, email (as username), contact, type of services	O-X
Inf.3	Service available by service provider	Information that details a service, namely: name, API URL (if applicable), description, targets (client types, geographic locations), contact person, support centre contacts, conditions.	F.9
Inf.4	Service List	A list composed by Inf.3 messages	F.9
Inf.5	Flexible asset	Description of a flexible asset	F.4
Inf.6	List of Flexible asset	A list composed by Inf.7 messages	F.6, F9
Inf.7	Flexibility capacity	The measurable capacity to be flexible (i.e., change consumption profile) of an asset.INF	O-X, F.7, F.8
Inf.8	Aggregated flexibility capacity	Grouping of flexibility capacity by aggregating several loads represented by Inf.10 messages. Can represent one household or a group of households.	O-X, F.7, F.8
Inf.9	Service subscription	Service onboarding details that pair a consumer with a service provider.	O-X, F.5, F.9, QoS-X
Inf.10	Service terms and conditions	Services specific terms and conditions	O-X, QoS-X
Inf.11	Form acknowledgement	Stakeholder accepts/reject action. This is multi scope. Can be used for several purposes. Context is enclosed in request.	O-X
Inf.12	Acknowledgment notification	Acknowledges operation success. This is multi scope. Can be used for several purposes. Context is enclosed in request.	O-X
Inf.13	Service Contract	Service provider's contract to onboard another stakeholder	O-X, QoS-X
Inf.14	Technical platform details	The identification of a technical platform, including capabilities and description and capabilities	
Inf.15	Technical platform capability	Technical details on how to activate one given capability, namely type and endpoint details of the destination system or authentication details.	

Inf.16	Qualification transaction decision status	The status of a decision of a qualification transaction. Includes the transaction ID, the request and reviewer actor, the object to qualify (asset, service, etc.) and the status of the qualification.	
Inf.17	Flexibility needs	Listed of flexibility needs in the form of forecasted constraints for a certain time interval.	O-X
Inf.18	Flexibility bid	A flexibility bid for a given time interval. It includes data like volume of energy to move, the activation price and if it is divisible or not.	O-X
Inf.19	Selected market bids	A list composed by Inf. 18 messages, which contain the bids selected by a market or system operator.	O-X

6 Requirements

Quality of Service Requirements		
Categories ID	**Category name for requirements**	**Category description**
QoS	Quality of Service	Generic properties that service/SUC should provide – quality attributes.
Requirement R-ID	**Requirement name**	**Requirement description**
QoS.1	Elapsed time response requirements for exchanging data	1-2 seconds
QoS.2	Availability of information flows	Continuous availability not required so long as downtime is scheduled
QoS.3	Logging access	Any access to the data is logged in the database.
QoS.4	Metadata is derived from key data types	Metadata is derived from main types.
QoS-X	All constraints also apply.	All requirements in this category.

Security Requirements		
Categories ID	**Category name for requirements**	**Category description**
Sec	Security	Authentication of user, confidentiality, integrity, prevention of denial of service, non-repudiation or accountability, error management.
Requirement R-ID	**Requirement name**	**Requirement description**
Sec.1	Eavesdropping: Ensuring confidentiality, avoiding illegitimate use of data, and preventing unauthorized reading of data, is:	Crucial
Sec.2	Authentication and Access Control mechanisms for services	Authentication Pair and secondary channel validation,
Sec.3	Network security measures commonly used with this data exchange	Firewall with Access Control Lists Reverse proxy server
Sec.4	Acknowledge timeout	One minute for any M2M communication.
Sec-X	All constraints also apply.	All requirements in this category.

Data Management Requirements		
Categories ID	**Category name for requirements**	**Category description**
D	Data Management	Type of source of data, correctness or validity of data, timeliness or time stamping of data, volume of data, synchronization, or consistency of data across systems, timely access to data, validation of data across organizational boundaries, transaction management, data naming, identification, formats across disparate systems, maintenance of data and databases.
Requirement R-ID	**Requirement name**	**Requirement description**
D.1	Data persistence	Data is persistently stored in the platform database
D.2	Data validation	All data must be validated on each data exchange

Discovery and Configuration Requirements		
Categories ID	**Category name for requirements**	**Category description**
Conf	Configuration	Locations, distances, communication layout, commonly used communication protocol media, network bandwidth, existing protocols, number of devices, systems, volume of data items, expected growth, etc.
Requirement R-ID	**Requirement name**	**Requirement description**
Conf.1	Communication media	Wireless required
Conf.2	Data exchange with EdgeConnect API	Client-server
Conf.3	EdgeConnect API communication Protocol	HTTP/2
Conf-X	All constraints also apply.	All requirements in this category.

Other Requirements		
Categories ID	**Category name for requirements**	**Category description**
O	Regulatory obligation related to privacy	2016/679 GDPR (General Data Protection Regulation)
F	Functional	Essential functionalities that build the core concept of the service/SUC.
Requirement R-ID	**Requirement name**	**Requirement description**
O.1	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.
O.2	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.
O.3	Data retention policy	Personal data may not be transferred to a third-party if the data subject did not

		agree and the third party provide appropriate safeguard.
O.4	Data processing consent	Personal data may not be processed unless there is at least one legal basis to do so.
O-X	All constraints also apply.	All requirements in this category.
F.1	Login in the DPP	Stakeholder is successfully logged into the DPP.
F.2	Registration in the DPP	Stakeholder is registered on the DPP platform.
F.3	Access to the service	Stakeholder can access DPP services.
F.4	Consumer flexible assets available	At least one With approved pre-qualification
F.5	Digital service available on the DPP platform	One Targets the specified consumer
F.6	Service provider controls assets of subscribed consumers/prosumers	Mandatory for all assets
F.7	Consumers/prosumers are able to share their flexibility capacity with third-party services	Mandatory
F.8	Consumers/prosumers have a profile that characterizes them	List of assets Contracted power Energy retailer Energy tariff
F.9	Digital services available on the DPP platform	At least one
F.10	Request metadata sent to semantic system	Mandatory
F.11	Consumer is subscribed to service	One specific service
F.12	Service contract between stakeholders on the DPP platform	Mandatory
F.13	Permission to activate/deactivate the subscription of a service	Mandatory

7 Common Terms and Definitions

Common Terms and Definitions	
Term	**Definition**
DPP	Digital Platform Provider
SO	System Operator
TSO	Transmission System Operator
MO	Market Operator
FSP	Flexibility Service Provider

4 SUC-PT-01.4 ACTIVATION OF ENERGY FLEXIBILITY

1 Description of the use case

1.1 Name of the use case

ID	Area / Domain(s) / Zones(s)	Name of Use Case
SUC – PT-01.4	Flexibility Services	Activation of Energy Flexibility

1.2 Version management

Version Management			
Version No.	Date	Name of Author(s)	Changes
0.1	19.04.2024	David Rua (INESC TEC) Fábio Coelho (INESC TEC) Vasco Campos (INESC TEC)	First draft, scope, objectives.
0.2	26.05.2024	David Rua (INESC TEC) Fábio Coelho (INESC TEC) Vasco Campos (INESC TEC)	First diagram mocks.
0.3	24.07.2024	David Rua (INESC TEC) Fábio Coelho (INESC TEC) Vasco Campos (INESC TEC)	Consolidated version.
0.4	17.09.2024	David Rua (INESC TEC) Fábio Coelho (INESC TEC) Vasco Campos (INESC TEC)	Harmonization with new T2.6 guidelines for the “requirements” section and new use case diagram. Updated look and feel.

1.3 Scope and objectives of use case

Scope and Objectives of Use Case	
Scope	SUC-PT-01.4 – Activation of Energy Flexibility Exploitation of the energy flexibility of citizen’s energy communities. Advances towards the creation of energy and non-energy services focusing on the activation part of the process.
Objective(s)	The system use case unfolds the following objectives: 1. Market platform or system clears the winning bids according to those that have been issued in scope of SUC-PT-01.3. 2. Cleared flexibilities bids are communicated to the System Operator through the EdgeConnect platform, which selected the bids to be activate. 3. The EdgeConnect platform forwards the selected bids for activation to the aggregators/FSP that have issued them (including aggregators that run hold a bilateral agreement with another aggregator. 4. The Aggregators in case of having any bilateral agreements with other aggregators or FSPs communicate validate they were notified to mobilize their contracted loads.
Related business case(s)	BUC-PT-01– GreenVale: Harnessing the potential of energy communities by leveraging Federated Learning strategies.

1.4 Narrative of use case

Narrative of Use Case
Short description
This system use case deals with the activation of the flexibility negotiated in the market, in ensuring that the system operator's technical systems (e.g., ADMS) are able to dispatch activation signals to assets, namely by involving EMS systems, to change the consumption baseline and to be able to provide the aggregated flexibility to the system operator. Aggregators can hold bilateral agreements with other aggregators or flexibility service providers, in which case the activation signals are split between the stakeholders in the contract. Furthermore, this SUC sets the procedures for all data exchanges among participants' systems that adhere to the data spaces technology stack.
Complete description
This system use case deals with the activation of the flexibility negotiated in the market, in ensuring that the system operator technical systems (e.g., ADMS) are able to dispatch activation signals to assets, namely by involving EMS systems, to change the consumption baseline and to be able to provide the aggregated flexibility to the system operator. For cases where aggregators hold bilateral agreements with other aggregators or flexibility service providers (often of smaller scale), the EdgeConnect platform notifies all stakeholders. Nonetheless, aggregators that issued the flexibility bid in the first place validate that their bilateral agreements can be met by validating the technical activation with their counterparts. This System Use Case sets the procedure for all data exchange among participants' systems, adhering to the data spaces technology stack. One reference implementation will be adopted and set the key steps as: onboard the data space, publish data assets along with their characteristics (describing metadata), request data from the data space to acquire a contract setting the trusted exchange and trigger the data transaction to transfer the data linked to that negotiated context (smart contract). This data exchange protocol is adopted primarily for bulk data transfers among organisations (i.e., between different stakeholders). Other standard or interoperable mechanisms can be applied depending on the operational platforms and systems considered. In brief, this SUC details how to: ▪ **Dispatch the activation commands for the selected winning flexibility bids to issuer aggregators**. Systems operators are notified of the flexibility bids that cleared the market, choosing those that are to be activated and notifying the respective aggregators. When applicable, aggregators that hold bilateral agreements validate that the corresponding activations were also applied. ▪ **Validation and settlement operations.** After the activation window closes and the period ends, the validation process uses metering information to ensure the flexibility agreements are met. The remunerations and/or penalties are computed for each aggregator and the billing process is conducted. The process of activating the flexibility is expected to occur daily and is considered to be a day-ahead operation. Every time this daily process is started, by the system operator, the following actions are carried out:

- Activation period starts
- The SO is monitoring the grid in real-time and receives the market clearing results with the winning bids.
- The SO opts for the desired reserved flexibility and the chosen bid need is sent to EdgeConnect
- The EdgeConnect notifies the Aggregator on these requests to activate reserved flexibility
- The Aggregator chooses which assets to activate (optimal portfolio activation) and sends activation signals to the assets
- Assets are activated
- Activation period ends

1.5 Key performance indicators (KPI)

ID	*Name*	*Description*	*Reference to mentioned use case objectives*
KPI-PT-04-01	*End-users' benefits by offering flexibility services*	Measuring the potential electricity cost reduction due to flexibility services	**Obj 1,2,3,4**
KPI-PT-04-02	*Flexibility unlocked and transacted in markets*	Amount of flexibility that is pre-selected by the system operator due to market signals	**Obj 1,2,3**
KPI-PT-04-03	*Number of consumers engaged with flexibility services*	Number of consumers that receive flexibility activation requests	**Obj 3**

1.6 Use case conditions

Use case conditions
Assumptions
This SUC is linked with SUC-PT-01 and SUC-PT-03, which combined they form a process for flexibility procurement.
Prerequisites

The requirements and overall flow detailed assume the following prerequisites:
• A flexibility bid was sent and went through the market clearing detailed in SUC-PT-03.
• Consumers already have their assets registered in EdgeConnect and integrated by the FSP, as detailed in SUC-PT-03.
  o Consumers are present in the areas where the FSPs operate.
  o The assets are within the premises of the consumer and have access to the internet around the clock.
• The consumers have previously signed a contract with the FSP that authorizes the activation of the assets.

1.7 Further Information to the use case for classification / mapping

Classification Information
Relation to other use cases
BUC-PT-01– GreenVale: Harnessing the potential of energy communities by leveraging Federated Learning strategies.

SUC-PT-01.1- Connect flexibility providers across the DPP flexibility value chain SUC-PT-01.3- Mobilizing Energy Flexibility
Level of depth
System use case (SUC) use case which describes in detail the functionality/technological solutions of (a part of) a business process.
Prioritisation
High Level of Priority – To be demonstrated in Portugal.
Generic, regional or national relation
Generic (Regional scope for demonstration)
Nature of the use case
Flexibility Services, Interoperability enablement
Further keywords for classification
Flexibility value-chain, energy services

2 Diagrams of use case

Diagram(s) of use case

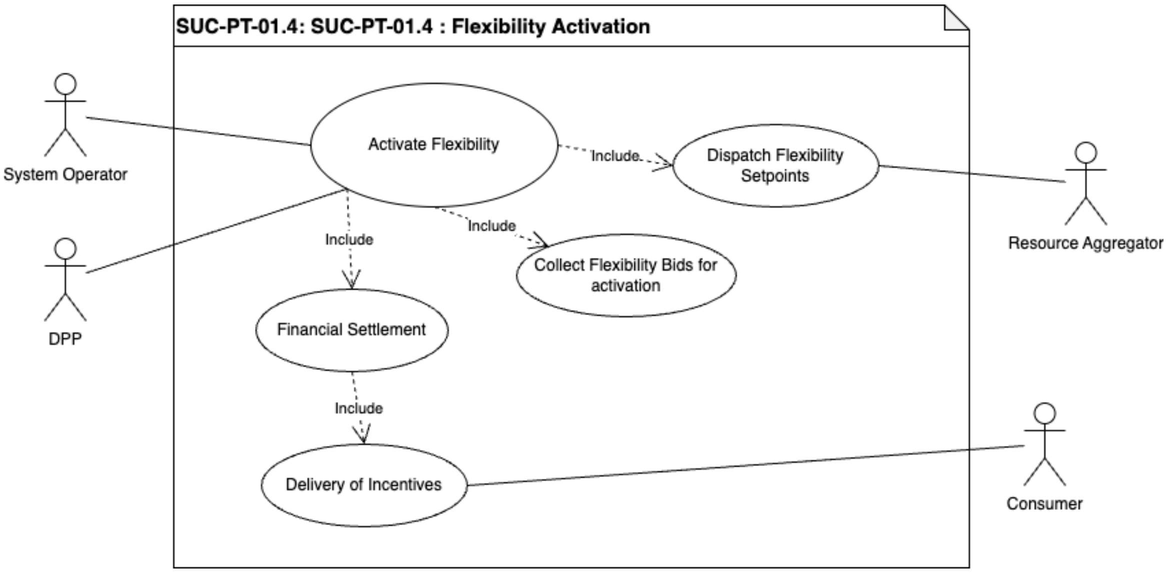


FIGURE 13 – UML USE CASE DIAGRAM

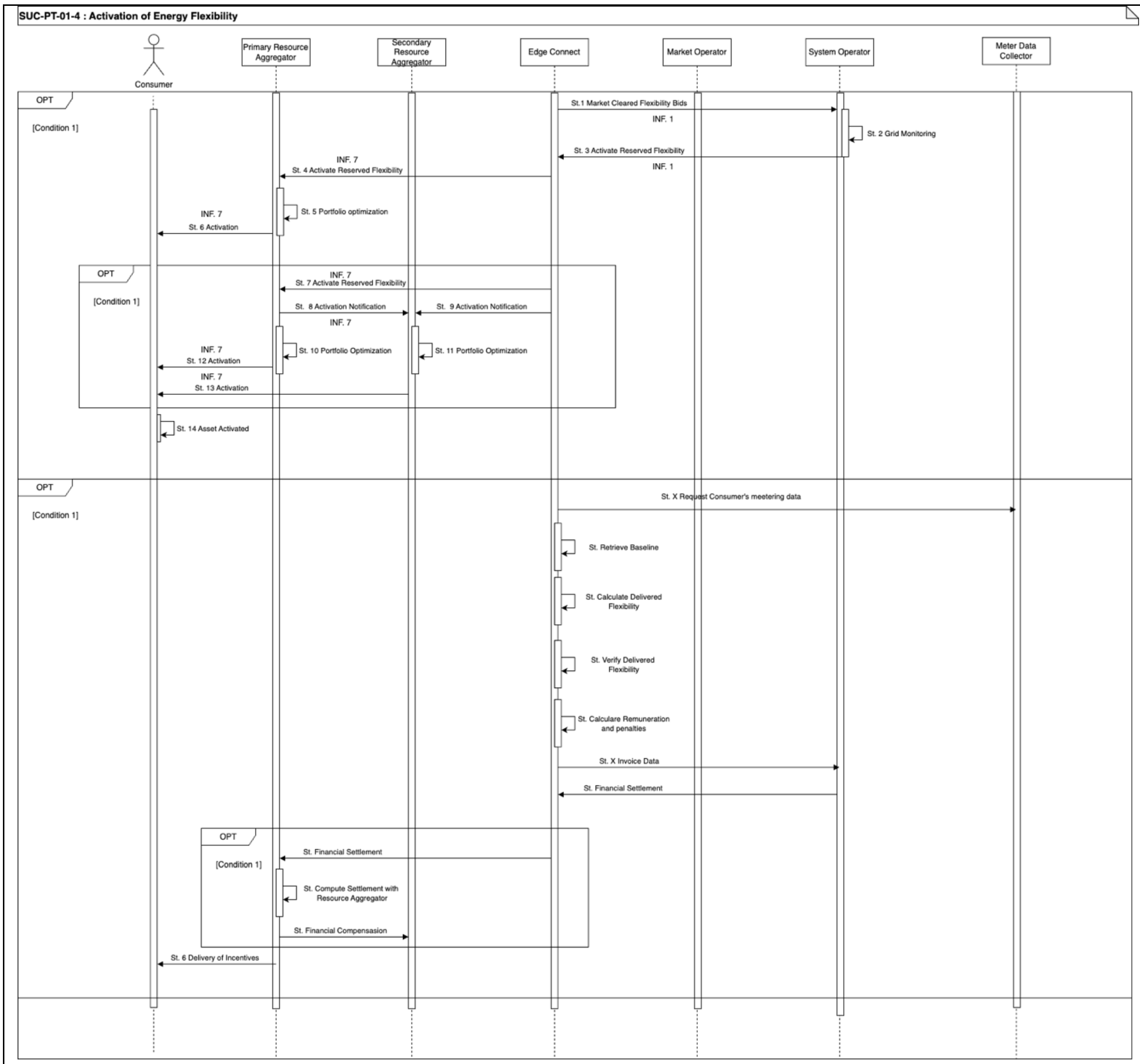


FIGURE 14 – FLEXIBILITY ACTIVATION (REGULAR SCENARIO) AND VALIDATION AND SETTLEMENT.

3 Technical details

3.1 Actors

Actors			
Actor Name	***Actor Type***	***Actor Description***	***Further information specific to this use case***
Consumer	Business actor	A legal representative that has a contractual relationship with a service provider	CEVE
Resource Aggregator	Business actor	A business provider that explores and optimizes the different flexible assets from consumers and optimize their operation.	CEVE, ELERGONE, SONAE
System Operator (SO)	Operator	A system operator is responsible for ensuring the reliable and efficient operation of a power grid. Their primary role involves monitoring, controlling, and optimizing the	REN, RDNESTER

		flow of electricity across the grid to meet demand while maintaining system stability and reliability.	
Market Operator (MO)	Operator	A party that provides a service of collecting offers to sell and bids to buy electricity and matching these offers and bids to determine a market price at the clearing point.	REN, RDNESTER
EdgeConnect (Platform)	Business actor	(The ICT/SW/DP Provider) Supports other entities with ICT, Software (SW) or Digital Platforms (DP).	INESC TEC
Meter Data Collector	Operator	A party responsible for meter reading and quality control of the reading.	CEVE

3.2 References.

References						
No.	***Reference Type***	***Reference***	***Status***	***Impact on use case***	***Originator / organisation***	***Link***
1	Reports	Blueprint of the Common European Energy Data Space	Public	High	Int:Net CSA (INESC TEC as contributor)	https://zenodo.org/records/10964387

4 Step by step analysis of use case

4.1 Overview of scenarios

Scenario conditions						
No.	**Scenario name**	**Scenario description**	**Primary actor**	**Triggering event**	**Pre-condition**	**Post-condition**
Sc. 1	Flexibility Activation, Validation and Settlement	The flexibility bids that win the market clearing process are communicated to the system operator that decides which should be activated. The activation signal is handled by the Edge Connect Digital Platform that forwards the request to the corresponding Resource Aggregators in the flexibility zone.	EdgeConnect (Digital Platform Provider)	Market clearing with cleared Flexibility bids and bid selection by System Operator.	Flexibility bids were issued by Resource Aggregators in reply of a flexibility request by the SO (SUC-PT-03)	The flexibility is activated in consumers in the Resource Aggregator portfolio. The settlement and validation process is engaged for compensation and penalty accrual.

4.2 Steps – Scenarios

Scenario								
Scenario name:		**No. 1 - Flexibility Activation, Validation and Settlement**						
Step No.	**Event**	**Name of process/ activity**	**Description of process/ activity**	**Service**	**Information producer (actor)**	**Information receiver (actor)**	**Information Exchanged (IDs)**	**Requirement, R-IDs**
St. 1	Market clearing	Market cleared flexibility requests	The market clearing results are available and are forwarded to the system operator (SO).	GET	EdgeConnect	SO	Inf.1	O-X, Sec-X, Conf-X
St. 2	Close to real time grid monitoring	Grid Monitoring	The SO assess the distribution grids condition close to real time and decide that the flexibility previously reserved should be activated.	EXECUTE	SO	SO		Sec-X
St. 3	Activate reserved flexibility	Activate reserved flexibility	That information is also sent to the EdgeConnect where contracted flexibility resources are registered (For simplicity, no close to real-time market is considered here, although the SO could use this type of market to look for additional and more cost-effective flexibility).	CREATE	SO	EdgeConnect	Inf.1	O-X, Sec-X, Conf-X, F.1, F.5, D.1
St. 4	Activate reserved flexibility	Activate reserved flexibility	EdgeConnect sends the information to registered Aggregators of the resources to be activated.	CREATE	EdgeConnect	Aggregator	Inf.7	O-X, Sec-X, Conf-X, F.3
St. 5	Optimal Portfolio activation	Portfolio activation	If possible, Aggregators optimize their portfolios prior to sending activation signals to the resources.	EXECUTE	Aggregator	Aggregator		
St. 6	Activation	Activation	The flexibility activation is forwarded from the Aggregators to the Consumers' resources.	CREATE	Aggregator	Consumer	Inf.7	O-X, Sec-X, Conf-X, F.4, D.1
OPT – Bilateral Agreement between resource aggregators								
St. 7	Activate reserved flexibility	Activate reserved flexibility	EdgeConnect sends the information to registered Aggregators of the resources to be activated.	CREATE	EdgeConnect	(Primary) Aggregator	Inf.7	O-X, Sec-X, Conf-X, D.2, F.3

St. 8	Activate reserved flexibility	Activate reserved flexibility	The flexibility activation is also sent to the resource aggregator that has established a bilateral agreement with a primary resource aggregator.	CREATE	EdgeConnect	(Secondary) Aggregator	Inf.7	O-X, Sec-X, Conf-X, D.2, F.3
St. 9	Resource Aggregator notifies flexibility aggregation	Activation Notification	The primary resource aggregator may verify / forward the activation notification that was received from the EdgeConnect considering the bilateral agreement in place.	CREATE	(Primary) Aggregator	(Secondary) Aggregator		O-X, Sec-X, Conf-X, D.2
St. 10	Optimal Portfolio activation	Portfolio optimization	If possible, Aggregators optimize their portfolios prior to sending activation signals to the resources.	EXECUTE	(Primary) Aggregator	(Primary) Aggregator		
St. 11	Portfolio activation	Portfolio optimization	If possible, Aggregators optimize their portfolios prior to sending activation signals to the resources.	EXECUTE	(Secondary) Aggregator	(Secondary) Aggregator		
St. 12	Activation	Activation	The flexibility activation is forwarded from the Aggregators to the Consumers' resources.	CREATE	(Primary) Aggregator	Consumer	Inf.7	O-X, Sec-X, Conf-X, F.4, D.1
St. 13	Activation	Activation	The flexibility activation is forwarded from the Aggregators to the Consumers' resources.	CREATE	(Secondary) Aggregator	Consumer	Inf.7	O-X, Sec-X, Conf-X, F.4, D.1
END OF OPT – Bilateral Agreement between resource aggregators								
St. 14	Asset Activated	Asset Activated	The flexible assets are activated.	EXECUTE	Consumer	Consumer		
St. 15	Consumers metering data.	Consumers metering data.	Consumers' metering data is sent from the Meter Data Collector to the EdgeConnect (in some cases the Meter Data Collector might be the SO).	GET	Meter Data Collector	EdgeConnect	Inf.2	O-X, Sec-X, Conf-X, F.2, F.4, D.2
St. 16	Retrieve Baseline	Retrieve Baseline	The EdgeConnect retrieves the baselines of each Aggregator.	GET	EdgeConnect	EdgeConnect	InF.2	
St. 17	Calculate delivered flexibility	Calculate delivered flexibility	The EdgeConnect computes the deviation between the baselines and the actual delivery. For those cases where flexibility was reserved and activated close to real time, this flexibility needs to be aggregated to the last aggregator baseline before comparing to the actual energy	EXECUTE	EdgeConnect	EdgeConnect		

			delivery.					
St. 18	Verify delivered flexibility	Verify delivered flexibility	The EdgeConnect validates if deliverable flexibility is in line with requested activation.	EXECUTE	EdgeConnect	EdgeConnect		
St. 19	Calculate remuneration and penalties	Calculate remuneration and penalties	The EdgeConnect computes the flexibility remuneration (reserved, delivered and deviation penalties) according to SO predefined flexibility remuneration rules.	EXECUTE	EdgeConnect	EdgeConnect		
St. 20	Invoice Data	Invoice Data	The EdgeConnect generates the data needed for invoicing and communicates it to the SO.	CREATE	EdgeConnect	SO	Inf.3	O-X, Sec-X, Conf-X, D.2
St. 21	Financial Settlement	Financial Settlement	The SO communicates the financial settlements to the EdgeConnect platform.	CREATE	SO	EdgeConnect	InF.3	O-X, Sec-X, Conf-X, F.6, D.2
St. 22	Financial Settlement	Financial Settlement	The EdgeConnect forwards financial settlements to the Aggregators.	CREATE	EdgeConnect	Aggregator	InF.3	O-X, Sec-X, Conf-X, F.6, D.1, D.2
OPT – Bilateral Agreement between resource aggregators								
St. 23	Financial Settlement	Financial Settlement	The EdgeConnect forwards financial settlements to the Aggregators.	CREATE	EdgeConnect	Aggregator	InF.3	O-X, Sec-X, Conf-X, F.6, D.1, D.2
St. 24	Settle with contracted Resource Aggregator	Compute Settlement with Resource Aggregator in agreement	The (primary) resource aggregator considering the bilateral agreement conducts its own settlement with the (secondary) resource aggregator.	EXECUTE	(Primary) Aggregator	(Primary) Aggregator		
St. 25	Financial compensation and penalties.	Financial compensation	Financial compensation with the (secondary) resource aggregator.	CREATE	(Primary) Aggregator	(Secondary) Aggregator	InF.3	O-X, Sec-X, Conf-X, F.6, D.2
END OF OPT – Bilateral Agreement between resource aggregators								
St. 26	Financial Settlement	Financial Settlement	The Aggregators sends the invoices to the respective Consumers completing the flexibility activation and settlement cycle.	CREATE	Aggregator	Consumer	Inf.3	O-X, Sec-X, Conf-X, D.1

5 Information exchanged

Information exchanged			
Information exchanged (ID)	**Name of information**	**Description of information exchanged**	**Requirement, R-IDs**

Inf. 1	Flexibility needs	{
		id
		requesterId
		productId
		contractDuration
		gridNodeId
		flexibilityZoneId
		longflexContractId
		responseType
		periodFrom
		periodTo
		volume
		maxActivationPrice
		maxReservationPrice
		gateCloseTimestamp
		status
		}
			O-X

Inf. 2	Consumers metering data.	{
		id
		status
		portfolioId
		periodFrom
		periodTo
		quantity
		quantityType
		}
			O-X

Inf. 3	Invoice Data	{
		id
		issuerId
		recipientId
		ammount
		currency
		description
		status
		}
			O-X

Inf. 4	Baseline	{
		id
		providerId
		calendarDay (timestamp-extractDay)
		IntervalSettlementPeriod
		data: [
		{
		consumerId
		meterId
		IntervalSettlementData: [
		{
		periodNumber
		power
		}
		]
		}
		]
		}
			O-X

Inf. 5	Flexibility bid	A flexibility bid for a given time interval. It includes data like volume of energy to move, the activation price and if it is divisible or not.	O-X
Inf. 6	Financial Settlement	The settlement for a given flexibility bid (Inf. 5) disaggregated for each aggregator that participated on the bid.	O-X
Inf. 7	Flexibility Activation Setpoints	Flexibility activation signal sent	O-X

6 Requirements

Quality of Service Requirements		
Categories ID	**Category name for requirements**	**Category description**
QoS	Quality of Service	Generic properties that service/SUC should provide – quality attributes.
Requirement R-ID	**Requirement name**	**Requirement description**
QoS.1	Elapsed time response requirements for exchanging data	1-2 seconds
QoS.2	Logging access	Any access to the data is logged in the database.
QoS.3	Metadata is derived from key data types	Metadata is derived from main types.
QoS-X	All constraints also apply.	All requirements in this category.

Security Requirements		
Categories ID	**Category name for requirements**	**Category description**
Sec	Security	Authentication of user, confidentiality, integrity, prevention of denial of service, non-repudiation or accountability, error management.
Requirement R-ID	**Requirement name**	**Requirement description**
Sec.1	Eavesdropping: Ensuring confidentiality, avoiding illegitimate use of data, and preventing unauthorized reading of data, is:	Crucial
Sec.2	Authentication and Access Control mechanisms for services	Authentication Pair and secondary channel validation,
Sec.3	Network security measures commonly used with this data exchange	Firewall with Access Control Lists Reverse proxy server
Sec.4	Acknowledge timeout	One minute for any M2M communication.
Sec-X	All constraints also apply.	All requirements in this category.

Data Management Requirements		
Categories ID	**Category name for requirements**	**Category description**
D	Data Management	Type of source of data, correctness or validity of data, timeliness or time stamping of data, volume of data, synchronization, or consistency of data

		across systems, timely access to data, validation of data across organizational boundaries, transaction management, data naming, identification, formats across disparate systems, maintenance of data and databases.
Requirement R-ID	**Requirement name**	**Requirement description**
D.1	Data validation from multiple sources	Mapping of data items is required for data from different sources
D.2	Management of data across organizational boundaries	Data exchanges go across organizational boundaries.

Discovery and Configuration Requirements		
Categories ID	**Category name for requirements**	**Category description**
Conf	Configuration	Locations, distances, communication layout, commonly used communication protocol media, network bandwidth, existing protocols, number of devices, systems, volume of data items, expected growth, etc.
Requirement R-ID	**Requirement name**	**Requirement description**
Conf.1	Communication media	Wireless required
Conf.2	Data exchange with EdgeConnect API	Client-server
Conf.3	EdgeConnect API communication Protocol	HTTP/2
Conf-X	All constraints also apply.	All requirements in this category.

Other Requirements		
Categories ID	**Category name for requirements**	**Category description**
O	Regulatory obligation related to privacy	2016/679 GDPR (General Data Protection Regulation)
F	Functional	Essential functionalities that build the core concept of the service/SUC.
Requirement R-ID	**Requirement name**	**Requirement description**
O.1	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.
O.2	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.
O.3	Data retention policy	Personal data may not be transferred to a third-party if the data subject did not agree and the third party provide appropriate safeguard.
O.4	Data processing consent	Personal data may not be processed unless there is at least one legal basis to do so.
O-X	All constraints also apply.	All requirements in this category.

F.1	Login in the DPP	Stakeholder is successfully logged into the DPP.
F.2	Consumer/prosumer energy consumption data	Mandatory, measured in 15 min intervals
F.2-1	Consumer/prosumer PV production data	Optional
F.2-2	Consumer/prosumer geographical coordinates for the energy consumed	Mandatory
F.3	Digital service available on the DPP platform	One Targets the specified consumer
F.4	Service provider controls assets of subscribed consumers/prosumers	Mandatory for all assets
F.5	Digital services available on the DPP platform	At least one
F.6	Service contract between stakeholders on the DPP platform	Mandatory

7 Common Terms and Definitions

Common Terms and Definitions	
Term	**Definition**
DPP	Digital Platform Provider
O&M	Operations and Maintenance
QoS	Quality-of-Service
SO	System Operator

5 SUC-PT-02.1 BIDDING & SELECTION

1 Description of the use case

1.1 Name of the use case

ID	Area / Domain(s) / Zones(s)	Name of Use Case
SUC-PT-02.1	Ancillary services market	Bidding & Selection

1.2 Version management

Version Management			
Version No.	Date	Name of Author(s)	Changes
0.1	27.05.2024	Inoussa Laouali (RDN), Raquel Segurado Silva (RDN), Mateo Toro-Cárdenas (RDN), Ricardo Pastor (RDN)	First draft
0.2	29.07.2024	Inoussa Laouali (RDN), Raquel Segurado Silva (RDN), Mateo Toro-Cárdenas (RDN),	Complete draft
0.3	23.08.2024	Inoussa Laouali (RDN), Raquel Segurado Silva (RDN)	Revised Draft with Reviewers' Comments Addressed
1	04.09.2024	Inoussa Laouali (RDN), Mateo Toro-Cárdenas (RDN)	Final draft

1.3 Scope and objectives of use case

Scope and Objectives of Use Case	
Scope	The scope of this use case encompasses the processes involved in soliciting bids from reserve capacity providers and selecting the most appropriate bid to maintain network stability and frequency regulation. This includes the initiation of the bidding process, the submission of bids by the reserve capacity providers, the review of the bids and the selection by the system operator.
Objective(s)	1. Streamline the process of soliciting flexibility offers and selecting the most suitable bids to ensure efficient procurement of flexibility services. 2. Select bids that offer the best combination of capacity, response time, and pricing to effectively address grid stability and frequency regulation requirements. 3. Ensure compliance with established market rules and regulations governing the bidding and selection process to maintain market integrity and fairness.
Related business case(s)	BUC-PT-02

1.4 Narrative of use case

Narrative of Use Case
Short description
The "Bidding & Selection" use case outlines the process of soliciting bids from flexibility providers and selecting the most suitable offers to procure flexibility services for automatic frequency restoration reserve (aFRR) and manual frequency restoration reserve (mFRR). Market Operators initiate a call for offers, and flexibility providers submit bids detailing capacity, response time, and pricing. The Market Operator evaluates offers and selects the most cost-effective options to meet system requirements while minimizing costs. The use case aims to ensure efficient grid stability and frequency regulation.
Complete description
In the context of power system management, maintaining frequency stability is critical to the reliable operation of power systems. The Bidding & Selection Use Case outlines the process of procuring flexibility services that are essential for the Automatic Frequency Restoration Reserve (aFRR) and the Manual Frequency Restoration Reserve (mFRR). These services help to balance the grid by adjusting supply or demand in response to frequency deviations. System operators (SOs) rely on ancillary services (AS) to maintain the reliability, security, stability and power quality of the electricity system. These services can be provided by conventional generators, renewable energy sources (RES), network devices and controlled loads. Demand-side flexibility enables these distributed energy resources (DERs) to be used to improve system resilience and support by reallocating their capacity to ancillary services. Alongside improving grid stability, this strategic shift towards the use of DERs for ancillary services also promotes a more responsive and dynamic energy ecosystem. In this scenario, Energy Communities (ECs) are essential for pooling small-scale resources and offering collective market flexibility through a single agent, which facilitates their participation in ancillary services. The process begins with a call for bids issued by the market operator, who solicits proposals from flexibility providers to supply the necessary aFRR and mFRR services. A variety of entities, such as power plants, battery storage operators, industrial facilities, residential energy communities and other energy resource managers, respond by submitting bids. Each bid includes details of the amount of capacity they can provide, how quickly they can respond to a frequency deviation (response time) and the cost associated with their service. Once all bids are submitted, the System Operator evaluates them based on several criteria, including cost-effectiveness, response time, reliability, and the overall ability to meet system requirements. The goal is to select the most cost-effective solutions that ensure grid stability, choosing bids that provide the necessary services at the lowest possible cost while maintaining the required performance standards. After a thorough evaluation, the System Operator selects the bids that best meet the criteria, and the selected providers are then contracted to deliver the flexibility services as per the agreed terms. With contracts in place, flexibility providers are ready to provide the necessary services. The market operator monitors performance to ensure that services are provided in accordance with the contract. In the event of a frequency deviation, contracted providers activate their resources to restore balance, which may involve increasing or decreasing electricity production or adjusting consumption patterns. This process is essential for network stability, profitability, transparency and the promotion of competition in the market for flexibility services. The inclusion of industrial and residential energy communities in the provision of these ancillary services further enhances the diversity and reliability of the grid's flexibility resources.

1.5 Key performance indicators (KPI)

ID	Name	Description	Reference to mentioned use case objectives
OB1	Different types of IoT/edge devices to be exploited in Demo Areas	The IoT/edge devices to be used within this SUC	1
OB4	Users involved in the piloting	Number of users part of the Portuguese Demo, based on the installation of edge/IoT devices	1

KPI9	Flexibility unlocked and transacted in markets	Amount of flexibility that is accepted by consumers due to market signals	2
KPI17	Increased flexibility incorporation enabled by IoT/Edge technologies for grid security	Capacity of assets available for DR to limit grid disturbances	3

1.6 Use case conditions

Use case conditions
Assumptions
• The resource aggregator (RA) collects a variety of customer loads or locally generated electricity in the energy community (EC), facilitating their bidding on the electricity market. • The ancillary services market is open to demand-side bids from aggregators. • Internal processes within the aggregated physical unit are regarded as inputs for the simulation and are consequently outside the scope of the use case (UC).
Prerequisites
• Prequalification. It is a form of Registration. Providers must follow these criteria to be allowed to enter and contract as a reserve provider. At the time of registration, the requirements shall be determined based on the local requirements by the relevant SO. The BSP and Reserve Providing Units (or Groups) must meet all the requirements represented by the electrical and system control capabilities and availability to qualify. • The demand scheduler, flexibility availability, baseline schedule, and bidding strategy of the aggregated and storage physical units, along with any relevant local market outcomes. • Quantification of the available flexibility in the EC by the BSP. • Automated execution of energy asset actions for aFRR. • Historical Portuguese market data for aFRR and mFRR, e.g. bids, activated power, clearing price.

1.7 Further Information to the use case for classification / mapping

Classification Information
Relation to other use cases
BUC-PT-02-Participation of industrial and residential energy communities in ancillary services market for the TSO SUC-PT-02.2- aFRR/mFRR Activation SUC-PT-02.3- aFRR / mFRR Settlement
Level of depth
General
Prioritisation
Generic, regional or national relation
National
Nature of the use case
System Use Case
Further keywords for classification
Ancillary Services, Electricity Markets, Energy Communities, Reserve Flexibility Services

1.8 General Remarks

General Remarks

2 Diagrams of use case

Diagram(s) of use case

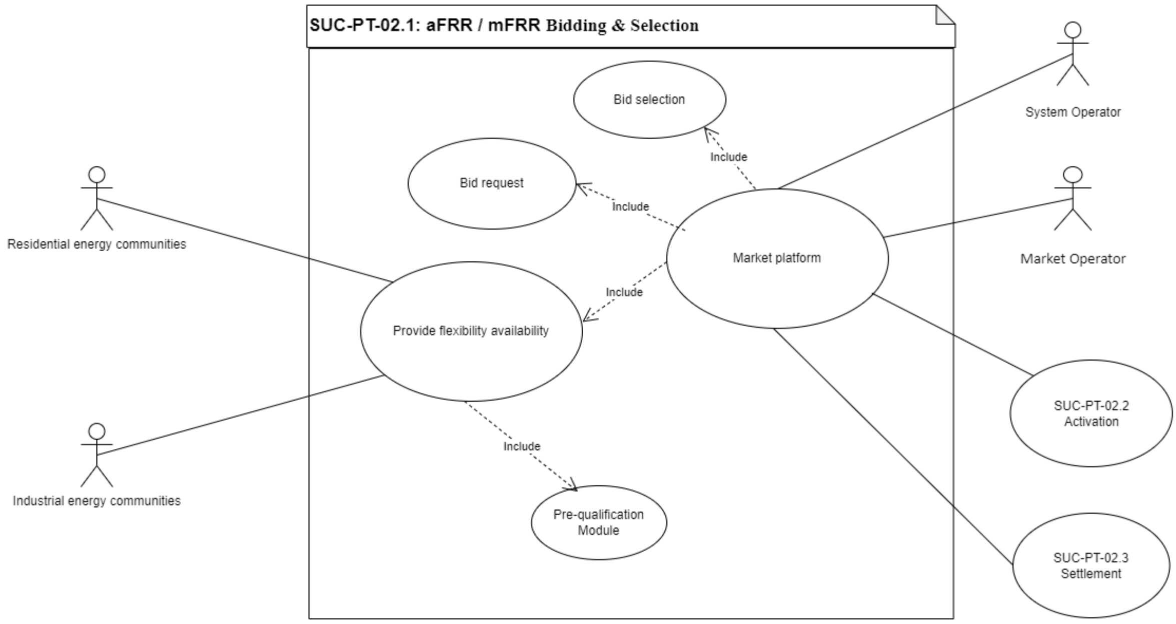


FIGURE 15: AFRR / MFRR BIDDING AND SELECTION USE CASE DIAGRAM

Diagram(s) of use case

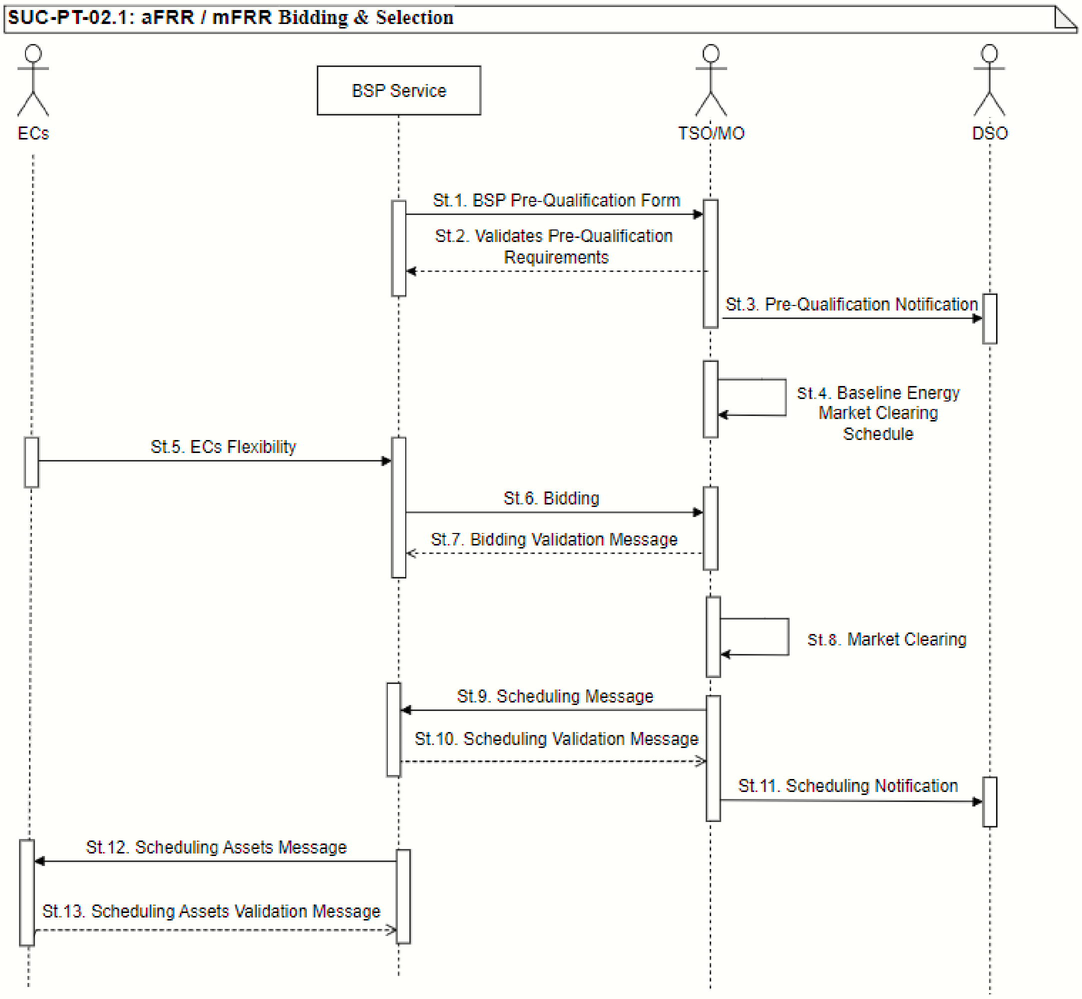


FIGURE 16: AFRR / MFRR BIDDING AND SELECTION SEQUENCE DIAGRAM

3 Technical details

3.1 Actors

Actors			
Actor Name	***Actor Type***	***Actor Description***	***Further information specific to this use case***
Energy Community (EC)	Business Actor	Entity involved in power generation, consumption or both (producers, consumers and prosumers), distribution and use, whose goal is to provide the local community with environmental, economic and social benefits.	In this SUC, EC includes both residential (CEVE's costumers) and industrial (SONAE) energy communities.
System Operator (SO)	Operator	Entity responsible to compute and deliver the markets results.	In this SUC, SO incorporates both TSO (REN) and DSO(CEVE).
Market Operator (MO)	Operator	A party that provides a service of collecting offers to sell and bids to buy electricity and matching these offers and bids to determine a market price at the clearing	In this SUC, the TSO (REN) will perform the actions of the Market Operator.

		point. This activity can be conducted in the forward, days-ahead and/or intraday timeframes, and can be combined with transmission capacity allocation in the context of market coupling. Organization in charge of calculating and delivering ancillary services' market results, as well as giving the Flexibility Platform instructions on service delivery and specifications.	

3.2 References

References						
No.	***Reference Type***	***Reference***	***Status***	***Impact on use case***	***Originator / organisation***	***Link***
1	Regulation	Establishing a guideline on electricity balancing	Public	Require ments	EU	https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A02017R2195-20220619#PP2Contents

4 Step by step analysis of use case

4.1 Overview of scenarios

Scenario conditions						
No.	**Scenario name**	**Scenario description**	**Primary actor**	**Triggering event**	**Pre-condition**	**Post-condition**
Sc.1.	aFRR	The market platform simulation will emulate the aFRR market of Portugal. HIL simulation for technical KPI evaluation. Simulation of the whole system for technical performance evaluation.	ECs	Bid submission	Pre-qualification (success)	Saved results of the simulation regarding: - Bidding history -Scheduling
Sc.2	mFRR	The market platform simulation will emulate the mFRR market of Portugal. HIL simulation for technical KPI evaluation. Simulation of the whole system for technical performance evaluation.	ECs	Bid submission	Pre-qualification (success)	Saved results of the simulation regarding: - Bidding history -Scheduling

4.2 Steps – Scenarios.

Scenario								
Scenario name:	aFRR / mFRR							
Step No.	***Event***	***Name of process/ activity***	***Description of process/ activity***	***Service***	***Information producer (actor)***	***Information receiver (actor)***	***Information Exchanged (IDs)***	***Requirement, R-IDs***
St.1	Pre-Qualification form submission	BSP Pre-Qualification Form	The BSP submits the pre-qualification form to the TSO/MO	GET	BSP	TSO/MO	Inf.1	CONF.1, QOS.3, QOS.4, CONF.4, CONF.5, SEC.1, D.X, O.X
St.2	Validation of Pre-Qualification Requirements	Validates Pre-Qualification Requirements	The TSO/MO validates the pre-qualification requirements of the BSP	GET	TSO/MO	BSP	Inf.1	CONF.1, QOS.3, QOS.4, CONF.4, CONF.5, SEC.1, D.X, O.X
St.3	Pre-Qualification Notification	Pre-Qualification Notification	The TSO/MO notifies the DSO on the pre-qualification process result of the BSP located in its network.	REPORT	TSO/MO	DSO	Inf.2	CONF.1, QOS.3, QOS.4, CONF.4, CONF.5, SEC.1, D.X, O.X
St.4	Energy Market Clearing Schedule	Baseline Energy Market Clearing Schedule	The energy market clearing schedule for the current market hour, set as a power baseline upon which the bids for FRR from the ECs are applied.	EXECUTE	TSO/MO Locally saved historical data.	TSO/MO	Inf.3	CONF.X, QOS.X, SEC.1, D.X, O.X
St.5	ECs send reserve availability	ECs Flexibility	The ECs communicate the available flexibility for FRR to the BSP.	CREATE	EC	BSP	Inf.4	CONF.X, QOS.X, SEC.1, D.X, O.X
St.6	BSP submits FRR bids	Bidding	The BSP submits the FRR bids to the TSO/MO (according to the internal procedures defined by the EC).	GET	BSP	TSO/MO	Inf.5	CONF.X, QOS.X, SEC.1, D.X, O.X

St.7	TSO/MO bid validation	Bidding Validation Message	Message accepting or rejecting FRR bids.	REPORT	TSO/MO	BSP	Inf.5	CONF.X, QOS.X, SEC.1, D.X, O.X
St.8	TSO/MO computes market clearing	Market Clearing	The TSO/MO computes market clearing.	EXECUTE	TSO/MO	TSO/MO	Inf.6	CONF.X, QOS.X, SEC.1, D.X, O.X
St.9	TSO/MO sends scheduling signal	Scheduling Message	The TSO/MO sends scheduling Message to BSP.	REPORT	TSO/MO	BSP	Inf.7	CONF.X, QOS.X, SEC.1, D.X, O.X
St.10	Scheduling Validation Message	Scheduling Validation Message	The BSP confirms reception of scheduling signal to TSO/MO.	REPORT	BSP	TSO/MO	Inf.7	CONF.X, QOS.X, SEC.1, D.X, O.X
St.11	DSO Scheduling Notification	Scheduling Notification	The TSO/MO notifies the DSO on the scheduling of the BSP located in its network.	REPORT	TSO/MO	DSO	Inf.7	CONF.1, QOS.X, SEC.1, D.X, O.X
St.12	BSP assets scheduling	Scheduling Assets Message	BSP schedules assets from EC members.	REPORT	BSP	EC	Inf.8	CONF.X, QOS.X, SEC.1, D.X, O.X
St.13	EC scheduling confirmation	Scheduling Assets Validation Message	The EC confirms and validates scheduling with message to BSP, if there are assets.	REPORT	EC	BSP	Inf.8	CONF.X, QOS.X, SEC.1, D.X, O.X

5 Information exchanged

Information exchanged			
Information exchanged (ID)	***Name of information***	***Description of information exchanged***	***Requirement, R-IDs***
Inf.1	Pre-Qualification Form	Information about the assets, their capabilities and their communication system (e.g., SCADA).	CONF.1, QOS.3, QOS.4, CONF.4, CONF.5, SEC.1, D.X, O.X
Inf.2	Pre-Qualification Notification	The TSO/MO notifies the DSO about the pre-qualification results of the BSP sending a message to the DSO.	CONF.1, QOS.3, QOS.4, CONF.4, CONF.5, SEC.1, D.X, O.X
Inf.3	Baseline Energy Market Clearing Schedule	Energy market clearing schedule for the current market hour, set as a power baseline upon which the bids for FRR from the EC are applied. The market clearing schedule is shared between the MO and the TSO (internal information).	CONF.X, QOS.X, SEC.1, D.X, O.X
Inf.4	EC Flexibility	Members of the energy community (EC) provide a forecast of available flexibility based on estimation and/or agreed flexibility settings (contracts).	CONF.X, QOS.X, SEC.1, D.X, O.X
Inf.5	Bids submission from BSP to TSO/MO	Following the reserve bid market model (using an XML file).	CONF.X, QOS.X, SEC.1, D.X, O.X
Inf.6	Market Clearing Results	The market clearing results are shared between the MO and the TSO (internal information).	CONF.X, QOS.X, SEC.1, D.X, O.X
Inf.7	Scheduling Message	Following the reserve bid market model (using an XML file).	CONF.X, QOS.X, SEC.1, D.X, O.X
Inf.8	Scheduling Assets Message	The schedule message for each asset includes an ID, an activation time, a period, and a setpoint. This schedule is sent prior to the activation time.	CONF.X, QOS.X, SEC.1, D.X, O.X

6 Requirements

Quality of Service Requirements		
Categories ID	**Category name for requirements**	**Category description**
QoS	Quality of Service	Generic properties that service/SUC should provide – quality attributes.
Requirement R-ID	**Requirement name**	**Requirement description**
QoS.1	aFRR product quality requirements	The starting of the provision of secondary regulation (aFRR) should not take more than 30 seconds and its activation should be concluded, in the case of loss of one important generation installation, pumping or storage, no later than 5 minutes[1]. The physical units that can provide this service

		must have a total regulation capacity (up or down) equal or higher than 1 MW and have the corresponding qualification from the GGS (procedure 11 of MPGGS[1]).
QoS.2	mFRR product quality requirements	Refer to Conf.3 for description of activation times, delivery period restrictions, ramping, etc.
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.
QoS.4	Elapsed time of data exchange	Elapsed time response requirements for exchanging data from 1-2 seconds.
QoS.X	All constraints also apply.	All requirements in this category.

Security Requirements		
Categories ID	**Category name for requirements**	**Category description**
Sec	Security	Authentication of user, confidentiality, integrity, prevention of denial of service, non-repudiation or accountability, error management.
Requirement R-ID	**Requirement name**	**Requirement description**
Sec.1	MPGGS security requirements	Security requirements according to MPGGS.

Data Management Requirements		
Categories ID	**Category name for requirements**	**Category description**
D	Data Management	Type of source of data, correctness or validity of data, timeliness or time stamping of data, volume of data, synchronization, or consistency of data across systems, timely access to data, validation of data across organizational boundaries, transaction management, data naming, identification, formats across disparate systems, maintenance of data and databases.
Requirement R-ID	**Requirement name**	**Requirement description**
D.1	Up-to-date management	Received data must be up-to-date within seconds of source data changing.
D.2	Validation of data exchanges	All data must be validated on each data exchange.
D.3	Management of data across organizational boundaries	Data exchanges go across organizational boundaries.
D.X	All constraints also apply	All requirements in this category.

Discovery and Configuration Requirements		
Categories ID	**Category name for requirements**	**Category description**
Conf	Configuration	Locations, distances, communication layout, commonly used communication protocol media, network bandwidth, existing protocols, number of devices, systems, volume of data items, expected growth, etc.

Requirement R-ID	Requirement name	Requirement description
Conf.1	Pre-qualification requirements.	It describes the Pre-qualification requirements for the provision of ancillary services in the Portuguese Ancillary Services Market. Any market agent willing to participate in the ancillary services market, as a Balancing Service Provider (BSP) must comply with the following requirements (MPGGS[1]): a) Ensure the continuous compliance with the technical and operational requirements necessary to participate in the market; b) Acquire, install and maintain in proper working conditions the equipment with the characteristics indicated by GGS and needed infrastructure for the participation in the ancillary services market; c) Bear the costs associated with the acquisition, conservation and maintenance of the equipment and infrastructure indicated in the previous point; d) Report to the GGS any irregularities that could jeopardize their participation in ancillary services market; e) Be technically capable of complying with the power instructions issued by the GGS; f) Comply with dispatch instructions and power limitation instructions issued by the GGS; g) Pay the penalties owed to the GGS when applicable; h) Pay the obligations resulting from the ancillary services contracted within this market; i) Be able to exchange operational communications, namely, the submission of bids and the reception of the results of its participation in the market; j) Install and maintain in good operation conditions the equipment and communication channels that ensure observability and controllability by the GGS and compliance with the network code related to emergency and restoration states in electricity networks, where applicable; k) Be able to exchange communications with the IT system of the settlement department, for the communication of information needed for carrying out the settlement processes of the market and receiving the associated results.
Conf.2	aFRR product configuration requirements.	The market agents that want to qualify a physical unit, should ask the GGS, with at least five working days in advance, the carrying out of tests to assess the technical and operational capacity. These tests assess the following aspects: a) The communication capacity with the central regulator; b) Real generation or consumption in fixed load regime; c) Variation gradient of the generation or consumption and the conservation of this value; d) Response to requests for random variation in generation or consumption, including reversing the direction of the request.

[1] ERSE, Manual de Procedimentos de Gestão de Sistema, 2023. Available on: https://www.erse.pt/media/3bqhdcjq/diretiva-19_2023-mpggs.pdf

		The response of the generator in the test is always assessed according to the type of group in question, considering the experience with groups with the same type of response. The power-generating modules must comply with the requirements on the basis of the voltage level of their connection point and their maximum capacity according to their category. For the sake ensuring the feasibility of this use case with the existing demand-side assets, the following requirements were relaxed: • Minimum bid size: 0.1MW • Bid granularity: 0.01MW
Conf.3	mFRR product configuration requirements.	In Portugal, BSP can participate in the mFRR market, remunerated in terms of activated energy, and the mFRR band market, remunerated in terms of capacity. Additionally, in the mFRR market, BSPs can provide a standard product or a specific product of rapid mFRR[2]. The characteristics of the standard mFRR service are stated in the following table (procedure 12 of MPGGS[1]), and include the following requirements: a) Activation mode: manual b) Time unit of the mFRR market: 15 min c) Activation moment: i. Direct activation: Between the publishing of the results of the scheduled activation and the beginning of the next process ii. Scheduled activation: 12.5 min before the delivery period d) Full activation time: 12.5 min e) Minimum bid: 1 MW f) Maximum bid: 9999 MW g) Bid granularity: 1MW h) Minimum duration of delivery period: 5 min i) Price of the bid: €/MWh, with resolution of 0.01 €/MWh j) Preparation period: 2.5 min (included in the full activation time) k) Ramping period: 10 min (included in the full activation time) l) Deactivation period: up to 10 min m) Aggregation level of the bids: Bidding area n) Delivery period: i. Direct Activation: between 6 and 19 min, according to the activation point ii. Scheduled activation: 5 min To be able to provide mFRR services, the physical units should get the qualification with the GGS, by demonstrating that they fulfil the technical and operational requirements, namely the ones referred above. The enabled physical units should have an offer capacity over 1 MW[1]. The participation of aggregated physical units with a bidding capacity below 1 MW is allowed, as long as the aggregated capacity exceeds 1 MW, they are aggregated in the same bidding area and are associated with the programming units of a single Balancing Responsible Party (BRP)[1].

		To qualify a physical unit, the respective BSP should ask the GGS to carry out tests to assess the unit's technical and operational capacity. The following requirements must be checked (procedure 12 of MPGGS [1]): a) The connection of the physical unit to the remote metering system; b) The correct operation of real time communications between the physical unit and the SCADA of the GGS; c) The correct operation of voice communications between the dispatch and the command rooms of the physical unit; d) The quality of the real time measurements of the physical unit; e) The correct operation of the equipment to receive the instructions from the dispatch centre and limitations to production or consumption; f) The capacity to receive and reply to instructions of the dispatch from the command room of the physical unit; g) The capacity of the command room of the physical unit to communicate changes to its available power; h) The existence of means for the compliance of the instructions of the dispatch in case of total failure in the command room of the physical unit, including the test of the contingency plans established. The specific product of rapid mFRR is used when the available balancing products do not permit to solve a given constraint that is threatening the stability of the electric system. The characteristics of this product demands for a faster response time in comparison with the standard product. The additional requirements of this product are stated below: a) Activation mode: Manual b) Full activation time: From 1 to 10 min c) Bid granularity: 1 MW d) Minimum duration of delivery period: 1 min e) Maximum duration of delivery period: 12.5 min f) Direction: a. Positive (upwards regulation) or b. Negative (downwards regulation) According to procedure 15 of MPGGS [1], mFRR band is defined as the power variation margin in which the bidding area can be mobilized to go up, through scheduled activation, in less than 12.5 minutes, starting from its current operation point. The entities or installations that want to deliver band mFRR services must fulfil the following requirements (procedure 15 of MPGGS [1]): a) Be connected to Extra-High Voltage (EHV), High Voltage (HV) or Medium Voltage (MV) and be: i. A physical unit associated to a power consumption installation; or ii. A physical unit associated to a power generation installation that is not obliged to participate in the mFRR market; iii. A physical unit associated to a storage installation; b) Be a market agent qualified to provide mFRR service;

		c) If the consuming installation is a cogeneration plant, it needs to prove it has the capacity to reduce consumption without loss of generation; d) If it is a production unit for self-consumption (does not use the public power grid), the measurement of the provision of the service will use as reference the net value between consumption and production in interconnection point with the grid e) Each physical unit should have an eligible power equal or higher than 1 MW; f) Install the real-time measurement devices, according to the requirements published by GGS; g) Ensure the correct operation of the real-time communications between the physical units and the SCADA from GGS; h) Do not have any unsettled overdue debt with the GGS; i) Provision of guarantees to the Integrated Guarantee Manager (GIG, "*Gestor Integrado de Garantias*", in Portuguese), under the risk and guarantee management regime in the national electricity system, whenever applicable; j) Comply with the requirements to participate in the mFRR market (stated above). For the sake ensuring the feasibility of this use case with the existing demand-side assets, the following requirements were relaxed: • Minimum bid size: 0.1MW • Bid granularity: 0.01MW
Conf.4	Data exchange methods	Master-slave
Conf.5	Commonly used communication protocol	IEC 60870-5-104 standard[2].
Conf.X	All constraints also apply.	All requirements in this category.

Other Requirements		
Categories ID	**Category name for requirements**	**Category description**
O	Regulatory obligation related to privacy	2016/679 GDPR (General Data Protection Regulation)
Requirement R-ID	**Requirement name**	**Requirement description**
O.1	GDPR requirements.	Compliance with the EU Genral Data Protection Regulation (GDPR).
O.2	All constraints also apply.	Personal data may not be processed unless there is at least one legal basis to do so.
O.3	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.
O.4	Data transfer consent	The data subject shall have the right to obtain from the controller without undue delay the

[2] NGS, D3.1 – Definition of TSO and DSO market requirements for balancing and ancillary services, 2024.

		access/rectification/erasure/restriction of inaccurate personal data concerning him or her.
O.5	Data retention policy	Personal data may not be transferred to a third-party if the data subject does not agree and the third party provides appropriate safeguard.
O.X	All constraints also apply.	All requirements in this category.

7 Common Terms and Definitions

Common Terms and Definitions	
Term	**Definition**
aFRR	Automatic Frequency Restauration Reserve
BRP	Balancing Responsible Party
BSP	Balancing Service Provider
DER	Distributed Energy Resources
DSO	Distribution System Operator
GGS	Global System Management (from the System Operator)
GIG	Integrated Guarantees Manager
HIL	Hardware-In-the-Loop
HVAC	Heating, Ventilation, and Air Conditioning
mFRR	Manual Frequency Restauration Reserve
MO	Market Operator
MPGGS	Portuguese Global System Management Procedures Manual for the electricity sector
MSP	Market Simulation Platform
NPV	Net Present Value
RA	Resource Aggregator
RR	Reserve Resource
RTU	Remote Terminal Unit
SCADA	Supervisory Control and Data Acquisition
SO	System Operator
TSO	Transmission System Operator

6 SUC-PT-02.2 AFRR/MFRR ACTIVATION

1 Description of the use case

1.1 Name of the use case

ID	*Area / Domain(s) / Zones(s)*	*Name of Use Case*
SUC-PT-02.2	Ancillary Services markets	aFRR/mFRR Activation

1.2 Version management

Version Management			
Version No.	*Date*	*Name of Author(s)*	*Changes*
0.1	22.05.2024	Mateo Toro-Cárdenas, RDN Inoussa Laouali, RDN	First draft of the Use case and sequence diagrams
0.2	16.07.2024	Mateo Toro-Cárdenas, RDN Raquel Segurado Silva, RDN	Revision of the Use case and sequence diagrams. First draft of remaining sections.
0.3	09.08.2024	Raquel Segurado Silva, RDN	Completion of the remaining sections.
0.4	22.08.2024	Raquel Segurado Silva, RDN Mateo Toro-Cárdenas, RDN	Implementation of ED's feedback
1	05.09.2024	Mateo Toro-Cárdenas, RDN	Final draft

1.3 Scope and objectives of use case

Scope and Objectives of Use Case	
Scope	The scope of this system use case involves the activation of the automatic Frequency Restoration Reserves (aFRR) and manual Frequency Restoration Reserves (mFRR) services provided by industrial and residential energy communities (ECs).
Objective(s)	1. Identify, at the systems' functionality level, what is necessary to activate aFRR and mFRR. 2. Develop a coordinated mechanism among the actors for the issuing of activation signals. 3. Communicate and confirm reception of activation signals to the corresponding actors.
Related business case(s)	BUC-PT-02

1.4 Narrative of use case

Narrative of Use Case
Short description
The "aFRR/mFRR Activation" system use case outlines the process of the activation of the aFRR/mFRR services. Once selected, the service suppliers are responsible for delivering the agreed quantity of aFRR/mFRR within a specific timeframe, in accordance with the network operator's instructions. This involves constantly monitoring the network frequency and reacting quickly to deviations by adjusting

the production of their resources or activating reserve capacity if necessary. Suppliers must remain ready to respond to dispatching instructions throughout the delivery phase to support network stability.
Complete description
This system use case is one of the stages of the aFRR/mFRR service provision. If the offer of the BSP is accepted (SUC-PT-02.1), the SO will instruct the BSP to provide the service. The ECs will instruct the BSP flexibility platform to perform the actions on the backed-up energy assets (turning on/off the specific energy assets as agreed). The BSP flexibility platform performs the reprogramming and sets the new setpoints for the energy assets. The main steps of this system use case are: • The TSO activates the BSP service and the BSP confirms and validates this activation. • The TSO notifies the DSO on the scheduling of the BSP, since the BSP is located in the DSO's network. • Finally, the BSP activates the assets of the ECs members to provide the service defined previously (SUC-PT-02.1), and the ECs validates this activation. This system use case has two scenarios, one is the activation of the aFRR service and the other is the activation of the mFRR service. There are differences between the activation of the aFRR and mFRR services. In the activation of the aFRR service, the BSP and TSO are connected through the SCADA, that sends setpoints every 4 seconds.

1.5 Key performance indicators (KPI)

ID	Name	Description	Reference to mentioned use case objectives
OB1	Different types of IoT/edge devices to be exploited in Demo Areas	The IoT/edge devices to be used within this SUC	1
OB4	Users involved in the piloting	Number of users part of the Portuguese Demo, based on the installation of edge/IoT devices	1
KPI12	Faster application response time		2 and 3

1.6 Use case conditions

Use case conditions
Assumptions
• The cloud-based service, which encompasses the market simulator and manages communication among the involved actors, will operate automatically and in real-time throughout the duration of the simulation for the use case.
Prerequisites
• Metering capability of the power delivery from EC (consumption or generation), either real or synthetized and communication between BSP and TSO/MO.

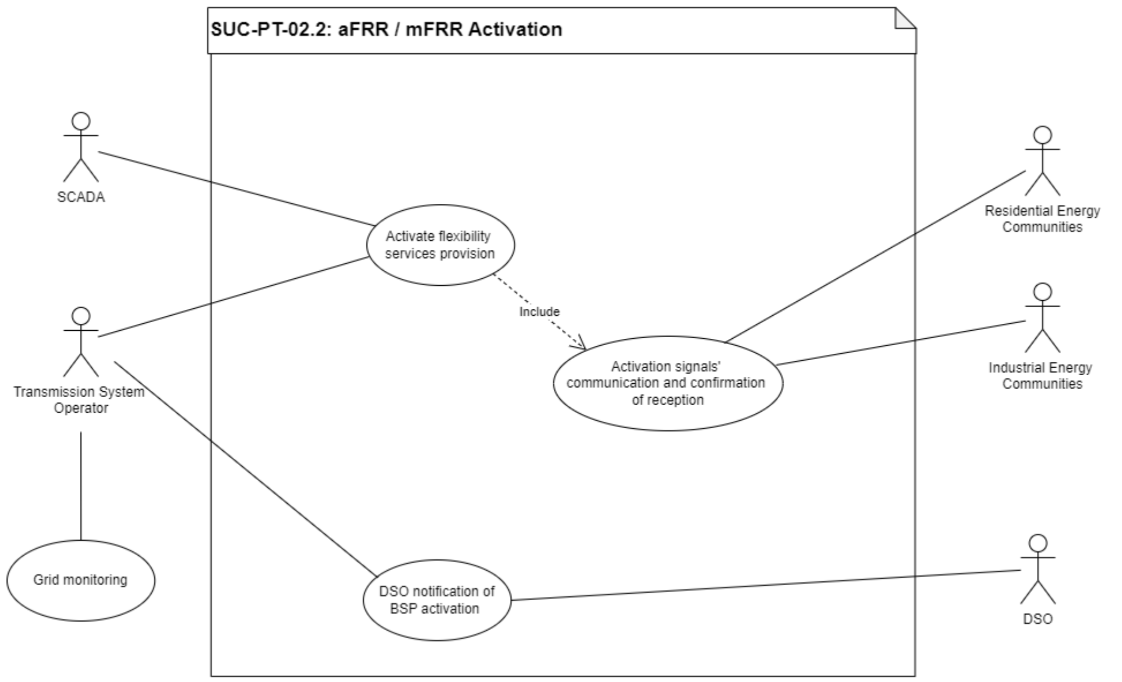
1.7 Further Information to the use case for classification / mapping

Classification Information
Relation to other use cases
BUC-PT-02 – Participation of industrial and residential energy communities in ancillary services market for the TSO SUC-PT-02.1 – Bidding and Selection SUC-PT-01.4 – Activation of Energy Flexibility
Level of depth
General
Prioritisation
Generic, regional or national relation
National
Nature of the use case
System use case
Further keywords for classification
Ancillary services, Electricity markets, Energy Communities, Reserve Flexibility Services.

1.8 General Remarks

General Remarks

2 Diagrams of use case

Diagram(s) of use case
 FIGURE 17 – UML USE CASE DIAGRAM

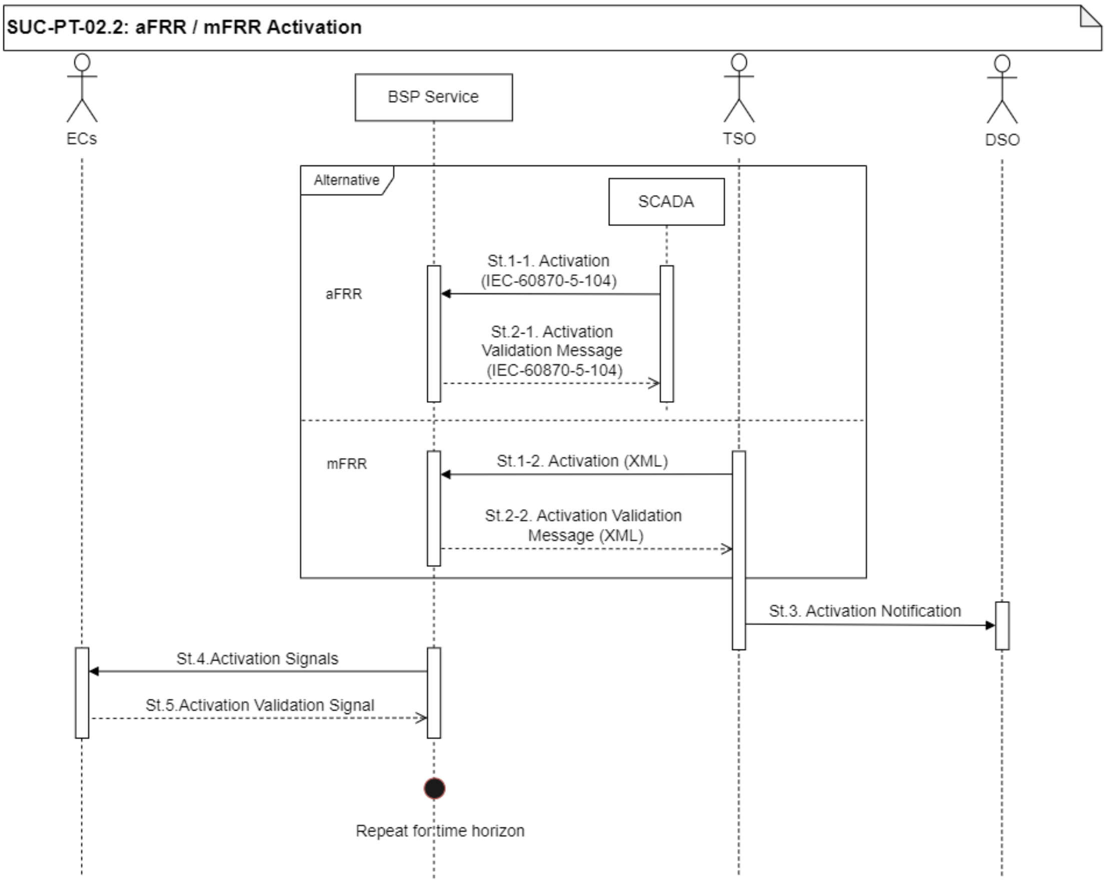


FIGURE 18 – UML SEQUENCE DIAGRAM

3 Technical details

3.1 Actors

Actors			
Actor Name	***Actor Type***	***Actor Description***	***Further information specific to this use case***
Energy community (EC)	Flexibility provider	Entity involved in power generation, consumption or both (producers, consumers and prosumers), distribution and use, whose goal is to provide the local community with environmental, economic and social benefits.	In this SUC, EC includes both residential (CEVE's costumers) and industrial (SONAE) energy communities.
Systems Operator (SO)	Operator	A system operator is responsible for ensuring the reliable and efficient operation of a power grid. Their primary role involves monitoring, controlling, and optimizing the flow of electricity across the grid to meet demand while maintaining system stability and reliability.	This SUC incorporates both TSO (REN) and DSO (CEVE).
Market Operator (MO)	Operator	A party that provides a service of collecting offers to sell and bids to buy electricity and	In this SUC, the TSO acts also as a MO (REN).

		matching these offers and bids in order to determine a market price at the clearing point. This activity can be conducted in the forward, days-ahead and/or intraday timeframes, and can be combined with transmission capacity allocation in the context of market coupling. Organization in charge of calculating and delivering ancillary services' market results, as well as giving the Flexibility Platform instructions on service delivery and specifications.	
Balancing Service Provider (BSP)	Business Actor	A party providing energy-balancing services to the energy market.	CEVE with their residential energy Community and SONAE with the Industrial Energy Community together will act as a BSP

3.2 References

References						
No.	***Reference Type***	***Reference***	***Status***	***Impact on use case***	***Originator / organisation***	***Link***
1	Directive	MPGGS_Directive19/2023 from ERSE	Active	Rules for aFRR/mFRR services	Portuguese TSO / ERSE	https://diariodarepublica.pt/dr/detalhe/diretiva/19-2023-835663384

4 Step by step analysis of use case

4.1 Overview of scenarios

Scenario conditions						
No.	**Scenario name**	**Scenario description**	**Primary actor**	**Triggering event**	**Pre-condition**	**Post-condition**
Sc. 1	aFRR	Activation of the aFRR service	TSO/MO	Activation	Bidding and selection	Settlement
Sc. 2	mFRR	Activation of the mFRR service	TSO/MO	Activation	Bidding and selection	Settlement

4.2 Steps – Scenarios

Scenario								
Scenario name:		aFRR/mFRR						
Step No.	***Event***	***Name of process/ activity***	***Description of process/ activity***	***Service***	***Information producer (actor)***	***Information receiver (actor)***	***Information Exchanged (IDs)***	***Requirement, R-IDs***
St. 1-1	BSP activation	Activation	The TSO/MO activates aFRR from BSP.	EXECUTE	TSO/MO	BSP	Inf. 1	QoS.X, Conf.X, Sec.1, D.X, O.X
St. 2-1	BSP activation confirmation	Activation validation message	BSP confirms and validates activation message.	REPORT	BSP	TSO/MO	Inf. 1	QoS.X, Conf.X, Sec.1, D.X, O.X
St.1-2	BSP activation	Activation	The TSO/MO activates mFRR from BSP	EXECUTE	TSO/MO	BSP	Inf. 2	QoS.X, Conf.X, Sec.1, D.X, O.X
St.2-2	BSP activation confirmation	Activation validation message	BSP confirms and validates activation message.	REPORT	BSP	TSO/MO	Inf. 2	QoS.X, Conf.X, Sec.1, D.X, O.X
St.3	DSO Activation Notification	Activation Notification	The TSO/MO notifies the DSO on the scheduling of the BSP located in its network.	REPORT	TSO/MO	DSO	Inf.3	QoS.X, Conf.X, Sec.1, D.X, O.X
St.4	BSP activates ECs assets	Activation Signals	The BSP activates the assets from ECs members.	EXECUTE	BSP	ECs	Inf.4	QoS.X, Conf.X, Sec.1, D.X, O.X
St. 5	ECs activation confirmation	Activation Validation Message	The ECs validates the activation to the BSP.	REPORT	ECs	BSP	Inf.4	QoS.X, Conf.X, Sec.1, D.X, O.X

5 Information exchanged

Information exchanged			
Information exchanged (ID)	***Name of information***	***Description of information exchanged***	***Requirement, R-IDs***
Inf. 1	aFRR Activation message	Following the reserve bid market model (using IEC 60870-5-104).	QoS.X, Conf.X, Sec.1, D.X, O.X
Inf. 2	mFRR Activation message	Following the reserve bid market model (using an XML file).	QoS.X, Conf.X, Sec.1, D.X, O.X
Inf. 3	Activation Notification	The TSO/MO notifies the DSO about the activation of the BSP by sending a message to the DSO.	QoS.3, QoS.4, Conf.3, Conf.4, Sec.1, D.X, O.X
Inf. 4	Activation signals	The activation signal for each asset includes an id, an activation time, a period, and a setpoint.	QoS.X, Conf.X, Sec.1, D.X, O.X

6 Requirements

Quality of Service Requirements		
Categories ID	**Category name for requirements**	**Category description**
QoS	Quality of Service	Generic properties that service/SUC should provide – quality attributes.
Requirement R-ID	**Requirement name**	**Requirement description**
QoS.1	aFRR product quality requirements	The starting of the provision of secondary regulation (aFRR) should not take more than 30 seconds and its activation should be concluded, in the case of loss of one important generation installation, pumping or storage, no later than 5 minutes[1]. The physical units that can provide this service must have a total regulation capacity (up or down) equal or higher than 1 MW and have the corresponding qualification from the GGS (procedure 11 of MPGGS[1]). .
QoS.2	mFRR product quality requirements	Refer to Conf.2 for description of activation times, delivery period restrictions, ramping, etc.
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.
QoS.4	Elapsed time of data exchange	Elapsed time response requirements for exchanging data from 1-2 seconds
QoS.X	All constraints also apply.	All requirements in this category.

Security Requirements		
Categories ID	**Category name for requirements**	**Category description**
Sec	Security	Authentication of user, confidentiality, integrity, prevention of denial of service, non-repudiation or accountability, error management.
Requirement R-ID	**Requirement name**	**Requirement description**
Sec.1	MPGGS security requirements	Security requirements according to MPGGS.

Data Management Requirements		
Categories ID	**Category name for requirements**	**Category description**
D	Data Management	Type of source of data, correctness or validity of data, timeliness or time stamping of data, volume of data, synchronization, or consistency of data across systems, timely access to data, validation of data across organizational boundaries, transaction management, data naming, identification, formats across disparate systems, maintenance of data and databases.
Requirement R-ID	**Requirement name**	**Requirement description**
D.1	Up-to-date management	Received data must be up-to-date within seconds of source data changing.
D.2	Validation of data exchanges	All data must be validated on each data exchange.
D.3	Management of data across organizational boundaries	Data exchanges go across organizational boundaries.
D.X	All constraints also apply.	All requirements in this category.

Discovery and Configuration Requirements		
Categories ID	**Category name for requirements**	**Category description**
Conf	Configuration	Locations, distances, communication layout, commonly used communication protocol media, network bandwidth, existing protocols, number of devices, systems, volume of data items, expected growth, etc.
Requirement R-ID	**Requirement name**	**Requirement description**
Conf.1	aFRR product configuration requirements.	The market agents that want to qualify a physical unit, should ask the GGS, with at least five working days in advance, the carrying out of tests to assess the technical and operational capacity. These tests assess the following aspects: e) The communication capacity with the central regulator; f) Real generation or consumption in fixed load regime; g) Variation gradient of the generation or consumption and the conservation of this value; h) Response to requests for random variation in generation or consumption, including reversing the direction of the request.

		The response of the generator in the test is always assessed according to the type of group in question, considering the experience with groups with the same type of response. The power-generating modules must comply with the requirements on the basis of the voltage level of their connection point and their maximum capacity according to their category. For the sake ensuring the feasibility of this use case with the existing demand-side assets, the following requirements were relaxed: • Minimum bid size: 0.1MW • Bid granularity: 0.01MW
Conf.2	mFRR product configuration requirements.	In Portugal, BSP can participate in the mFRR market, remunerated in terms of activated energy, and the mFRR band market, remunerated in terms of capacity. Additionally, in the mFRR market, BSPs can provide a standard product or a specific product of rapid mFRR[2]. The characteristics of the standard mFRR service are stated in the following table (procedure 12 of MPGGS[1]), and include the following requirements: o) Activation mode: manual p) Time unit of the mFRR market: 15 min q) Activation moment: i. Direct activation: Between the publishing of the results of the scheduled activation and the beginning of the next process ii. Scheduled activation: 12.5 min before the delivery period r) Full activation time: 12.5 min s) Minimum bid: 1 MW t) Maximum bid: 9999 MW u) Bid granularity: 1MW v) Minimum duration of delivery period: 5 min w) Price of the bid: €/MWh, with resolution of 0.01 €/MWh x) Preparation period: 2.5 min (included in the full activation time) y) Ramping period: 10 min (included in the full activation time) z) Deactivation period: up to 10 min aa) Aggregation level of the bids: Bidding area bb) Delivery period: i. Direct Activation: between 6 and 19 min, according to the activation point ii. Scheduled activation: 5 min To be able to provide mFRR services, the physical units should get the qualification with the GGS, by demonstrating that they fulfil the technical and operational requirements, namely the ones referred above. The enabled physical units should have an offer capacity over 1 MW[1]. The participation of aggregated physical units with a bidding capacity below 1 MW is allowed, as long as the aggregated capacity exceeds 1 MW, they are aggregated in the same bidding area and are associated with the

		programming units of a single Balancing Responsible Party (BRP)[1]. To qualify a physical unit, the respective BSP should ask the GGS to carry out tests to assess the unit's technical and operational capacity. The following requirements must be checked (procedure 12 of MPGGS [1]): i) The connection of the physical unit to the remote metering system; j) The correct operation of real time communications between the physical unit and the SCADA of the GGS; k) The correct operation of voice communications between the dispatch and the command rooms of the physical unit; l) The quality of the real time measurements of the physical unit; m) The correct operation of the equipment to receive the instructions from the dispatch centre and limitations to production or consumption; n) The capacity to receive and reply to instructions of the dispatch from the command room of the physical unit; o) The capacity of the command room of the physical unit to communicate changes to its available power; p) The existence of means for the compliance of the instructions of the dispatch in case of total failure in the command room of the physical unit, including the test of the contingency plans established. The specific product of rapid mFRR is used when the available balancing products do not permit to solve a given constraint that is threatening the stability of the electric system. The characteristics of this product demands for a faster response time in comparison with the standard product. The additional requirements of this product are stated below: g) Activation mode: Manual h) Full activation time: From 1 to 10 min i) Bid granularity: 1 MW j) Minimum duration of delivery period: 1 min k) Maximum duration of delivery period: 12.5 min l) Direction: a. Positive (upwards regulation) or b. Negative (downwards regulation) According to procedure 15 of MPGGS [1], mFRR band is defined as the power variation margin in which the bidding area can be mobilized to go up, through scheduled activation, in less than 12.5 minutes, starting from its current operation point. The entities or installations that want to deliver band mFRR services must fulfil the following requirements (procedure 15 of MPGGS [1]): k) Be connected to Extra-High Voltage (EHV), High Voltage (HV) or Medium Voltage (MV) and be: i. A physical unit associated to a power consumption installation; or

		ii. A physical unit associated to a power generation installation that is not obliged to participate in the mFRR market; iii. A physical unit associated to a storage installation; l) Be a market agent qualified to provide mFRR service; m) If the consuming installation is a cogeneration plant, it needs to prove it has the capacity to reduce consumption without loss of generation; n) If it is a production unit for self-consumption (does not use the public power grid), the measurement of the provision of the service will use as reference the net value between consumption and production in interconnection point with the grid o) Each physical unit should have an eligible power equal or higher than 1 MW; p) Install the real-time measurement devices, according to the requirements published by GGS; q) Ensure the correct operation of the real-time communications between the physical units and the SCADA from GGS; r) Do not have any unsettled overdue debt with the GGS; s) Provision of guarantees to the Integrated Guarantee Manager (GIG, "*Gestor Integrado de Garantias*", in Portuguese), under the risk and guarantee management regime in the national electricity system, whenever applicable; t) Comply with the requirements to participate in the mFRR market (stated above). For the sake ensuring the feasibility of this use case with the existing demand-side assets, the following requirements were relaxed: • Minimum bid size: 0.1MW • Bid granularity: 0.01MW
Conf.3	Data exchange methods	Master-slave
Conf.4	Commonly used communication protocol	IEC 60870-5-104 standard[3].
Conf.X	All constraints also apply.	All requirements in this category.

Other Requirements		
Categories ID	**Category name for requirements**	**Category description**
O	Regulatory obligation related to privacy	2016/679 GDPR (General Data Protection Regulation)
Requirement R-ID	**Requirement name**	**Requirement description**
O.1	GDPR requirements.	Compliance with the EU General Data Protection Regulation (GDPR).
O.2	All constraints also apply.	Personal data may not be processed unless there is at least one legal basis to do so.
O.3	Right to access, rectify, erasure, restriction	Data retention policy outlines the specific sensitive time period data can be retained,

[3] NGS, D3.1 – Definition of TSO and DSO market requirements for balancing and ancillary services, 2024.

		plus how it will be disposed of when the time to do so comes.
O.4	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.
O.5	Data retention policy	Personal data may not be transferred to a third-party if the data subject did not agree and the third party provide appropriate safeguard.
O.X	All constraints also apply.	All requirements in this category.

7 Common Terms and Definitions

Common Terms and Definitions	
Term	**Definition**
aFRR	Automatic Frequency Restauration Reserve
BRP	Balancing Responsible Party
BSP	Balancing Service Provider
DSO	Distribution System Operator
GGS	Global System Management (from the System Operator)
GIG	Integrated Guarantees Manager
mFRR	Manual Frequency Restauration Reserve
MO	Market Operator
MPGGS	Portuguese Global System Management Procedures Manual for the electricity sector
RTU	Remote Terminal Unit
SCADA	Supervisory Control and Data Acquisition
SO	System Operator
TSO	Transmission System Operator

7 SUC-PT-02.3 AFRR / MFRR SETTLEMENT

1 Description of the use case

1.1 Name of the use case

ID	Area / Domain(s) / Zones(s)	Name of Use Case
SUC-PT-02.3	Ancillary Services markets	aFRR / mFRR Settlement

1.2 Version management

Version Management			
Version No.	Date	Name of Author(s)	Changes
0.1	03.06.2024	Ricardo Pastor – RDN Kamalanathan Ganesan, RDN	First Draft
0.2	24.07.2024	Kamalanathan Ganesan, RDN Yang Cao, RDN	First Draft Revision - Completion of Section 1, Revision of UML and Sequence Diagrams
0.3	27.08.2024	Kamalanathan Ganesan, RDN	Second Draft - Address ED's comments and completion of Section 4.2, 5, 6 and 7
1	04.09.2024	Kamalanathan Ganesan, RDN	Final Draft

1.3 Scope and objectives of use case

Scope and Objectives of Use Case	
Scope	Verification and Settlement of the automatic frequency restoration reserve (aFRR)/ manual frequency restoration reserve (mFRR) flexibilities actually delivered by Balancing Service Providers (BSPs)
Objective(s)	1. Calculate actually delivered flexibility as response to activation requests. 2. Verify that flexibility delivered matches with flexibility requested. 3. Calculate the payments and penalty if flexibility delivered is less than flexibility requested.
Related business case(s)	BUC-PT-02 – Ancillary services to TSO

1.4 Narrative of use case

Narrative of Use Case
Short description
Actual flexibility delivered is calculated as the difference between baseline and metered consumption/generation of that BSPs. The verification takes place by comparing the actually

delivered flexibility and flexibility requested by the System Operator. BSP receives a penalty if actually delivered flexibility is less than requested flexibility.
Complete description
In this final phase, after the service window ends, the market operator handles settlement. Using metering data, the market operator compares the flexibility provided by each BSP with the agreed baseline. Flexibility provided by each BSP (RR/RA) is calculated using pre-agreed baselines, leading to payments or penalties to be settled. The TSO (also the MO in this case) calculates the reconciliation values and communicates them to the BSP, who is responsible for allocating the payments/penalties accordingly. Validation and settlement are based on minute-by-minute metering data. Penalties are imposed when discrepancies between the offered and delivered flexibility are identified. In case of partial delivery by the BSP, the market operator applies a correction factor to the final payment. To verify if the requested aFRR/mFRR was fulfilled, a verification task is performed according to a pre-agreed baseline (calculated by a baseline methodology or communicated by the BSP) and by monitoring the performance of the BSP (RA/RR) or the capability of the flexible assets under their control to provide the committed flexibility. The settlement process includes the following steps: • The delivered flexibility is calculated as the difference between the baseline and meter data provided by the BSP (or Distribution System Operator (DSO)). • Verify that the delivered flexibility matches the requested flexibility by comparing the actual delivered flexibility and the requested flexibility by the TSO. • Calculate reconciliation values for the BSP. After the settlement is completed between the flexibility procurers (TSOs) and the BSP, the BSPs must settle with the energy communities (ECs) in their registered portfolios to ensure that the added value for the provision of flexibility is shared with the Community Consumers.

1.5 Key performance indicators (KPI)

ID	***Name***	***Description***	***Reference to mentioned use case objectives***
PT2.3-KPI1	*Flexibility delivery accuracy*	The percentage of actual delivered flexibility compared to the requested flexibility to measure how accurately BSPs respond to activation requests.	Obj 1
PT2.3-KPI2	*Discrepancy rate*	Identifies how often and by how much BSPs fail to meet the requested flexibility.	Obj 2 and 3
PT2.3-KPI3	*Correction Factor/Penalty rate*	The rate at which penalties are imposed for under-delivery of flexibility which holds BSPs accountable for failing to meet requested flexibility.	Obj 2 and 3

1.6 Use case conditions

Use case conditions
Assumptions
• Market participant baselines have been previously collected or defined. • Activation volumes requested by System Operator. • Metering data of the RR/RA either from the DSO or BSP. • Definition of payments and penalties.
Prerequisites
• Meter data and baselines are available. • The BSP is compliant with market rules. • For verification and penalties calculation, the collected values (meter data, baselines, activation) must be accurate and reliable.

1.7 Further Information to the use case for classification / mapping

Classification Information
Relation to other use cases
BUC-PT-02 – Ancillary services to TSO, SUC-PT-02.1 – Bidding and Selection, and SUC-PT-02.2 – Activation
Level of depth
System use case (SUC) use case which describes in detail the functionality/technological solutions of (a part of) a business process BUC-PT-02.
Prioritisation
High
Generic, regional or national relation
Generic
Nature of the use case
System use case for verifying and settling the flexibility delivered by the BSPs
Further keywords for classification
Validation, Payments, Penalty

1.8 General Remarks

General Remarks

2 Diagrams of use case

Diagram(s) of use case

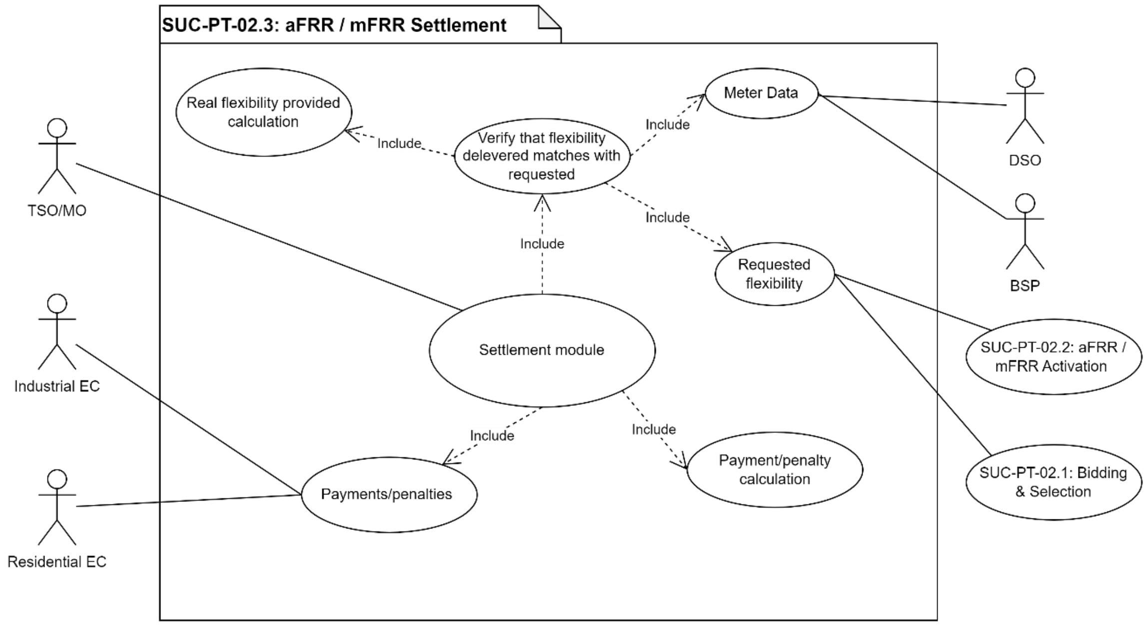


FIGURE 19: AFRR/MFRR SETTLEMENT USE CASE DIAGRAM

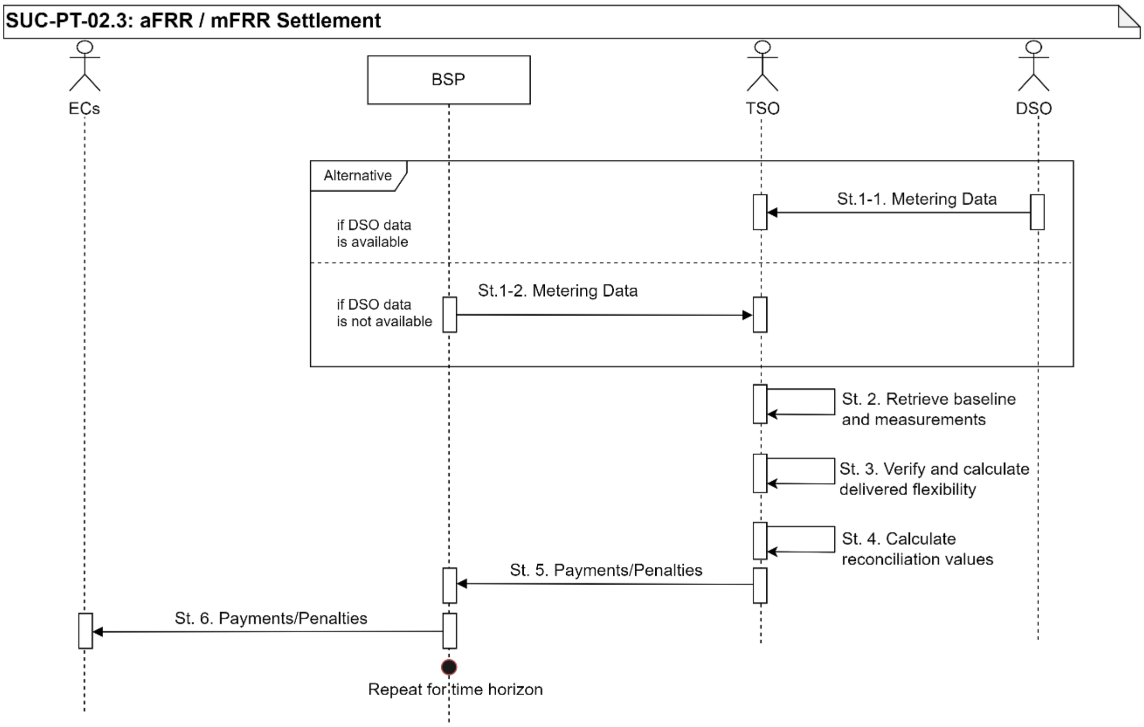


FIGURE 20: AFRR/MFRR SETTLEMENT SEQUENCE DIAGRAM

3 Technical details

3.1 Actors

Actors			
Actor Name	***Actor Type***	***Actor Description***	***Further information specific to this use case***
Market Operator (MO)	Operator	A party that provides a service of collecting offers to sell and bids to buy electricity and matching these offers and bids to determine a market price at the clearing point. This activity can be conducted in the forward, days-ahead and/or intraday timeframes, and can be combined with transmission capacity allocation in the context of market coupling. Organization in charge of calculating and delivering ancillary services' market results, as well as giving the Flexibility Platform instructions on service delivery and specifications.	In this SUC, the TSO (REN) will perform the actions of the Market Operator.
Energy Community (EC)	Flexibility provider	Industrial or residential entity involved in power generation, consumption or both (producers, consumers and prosumers), distribution and use, whose goals provide the local community with environmental, economic and social benefits.	In this SUC, Energy Communities includes both residential (CEVE's costumers) and industrial (SONAE) energy communities.
Distribution System Operator (DSO)	Operator	A party that provides the metering data in case the BSPs fails to do so.	CEVE will be the distribution system operator for this use case.
Balancing Service Provider (BSP)	Role	A party responsible or the provision of metering data to the TSO/MO.	CEVE with their residential energy Community and SONAE with the Industrial Energy Community together will act as a BSP.

3.2 References

References						
No.	***Reference Type***	***Reference***	***Status***	***Impact on use case***	***Originator / organisation***	***Link***
1	Directive	MPGGS_Directive19/2023 from ERSE	Active	Rules for aFRR/mFRR services	Portuguese TSO / ERSE	https://diariodarepublica.pt/dr/detalhe/diretiva/19-2023-835663384

4 Step by step analysis of use case

4.1 Overview of scenarios

Scenario conditions						
No.	**Scenario name**	**Scenario description**	**Primary actor**	**Triggering event**	**Pre-condition**	**Post-condition**
Sc.1	BSP meter data	Initial scenario is to collect meter data from DSO. To verify and evaluate the settlement for BSPs, meter data is collected by the TSO for the BSPs providing aFRR/mFRR services.	DSO TSO	Flexibility Delivery	Metering Data	Recover baseline and validate delivered flexibility
Sc. 2	BSP meter data	Secondary scenario is to collect meter data from BSPs. To verify and evaluate the settlement for BSPs, meter data is collected by the TSO for the BSPs providing aFRR/mFRR services.	BSP TSO	Flexibility Delivery	Metering Data	Recover baseline and validate delivered flexibility

4.2 Steps – Scenarios

Scenario								
Scenario name:		BSP Meter Data						
Step No.	***Event***	***Name of process/ activity***	***Description of process/ activity***	***Service***	***Information producer (actor)***	***Information receiver (actor)***	***Information Exchanged (IDs)***	***Requirement, R-IDs***
St. 1.1	On Request – Metering Data	Metering Data	Acquire consumption data of BSP energy meters corresponding to aFRR/mFRR collected from DSO.	GET	DSO	TSO	Inf.1	QoS.3, QoS.4, Conf.3, Conf.4, Sec.1, D.X, (QoS.1, Conf.1) or (QoS.2, Conf.2), O.X
St. 1.2	On Request – BSPs Metering Data	Metering Data	Acquire consumption data from BSP energy meters corresponding to aFRR/mFRR.	GET	BSP	TSO	Inf.1	QoS.3, QoS.4, Conf.3, Conf.4, Sec.1, D.X, (QoS.1, Conf.1) or (QoS.2, Conf.2), O.X
St. 2	TSO initiates after delivery period	Retrieve baseline and measurements	Recover baselines of the participating BSPs along with meter data.	GET	TSO	TSO	Inf.2	QoS.3, QoS.4, Conf.3, Conf.4, Sec.1, D.X, (QoS.1, Conf.1) or (QoS.2, Conf.2)
St. 3	TSO initiates after delivery period	Verify and calculate delivered flexibility	Validate and compare meter data and baseline to estimate delivered flexibility.	EXECUTE	TSO	TSO	Inf.3	QoS.3, QoS.4, Conf.3, Conf.4, Sec.1, D.X, (QoS.1, Conf.1) or (QoS.2, Conf.2)
St. 4	TSO initiates after delivery period	Calculate reconciliation values	Evaluate the remunerations and penalties applicable to the BSPs based on results from step 3.	CREATE	TSO	TSO	Inf.3 and Inf.4	QoS.3, QoS.4, Conf.3, Conf.4, Sec.1, D.X, (QoS.1, Conf.1) or (QoS.2, Conf.2)
St. 5	TSO initiates after settlement estimation	Payments/Penalties	TSO communicates settlements (payments or penalties) to the BSPs.	REPORT	TSO	BSP	Inf.4	QoS.3, QoS.4, Conf.3, Conf.4, Sec.1, D.X, (QoS.1, Conf.1) or (QoS.2, Conf.2), O.X
St. 6	BSP sends settlement information	Payments/Penalties	BSPs communicate settlements (payments or penalties) to their respective ECs.	REPORT	BSP	EC	Inf.4	QoS.3, QoS.4, Conf.3, Conf.4, Sec.1, D.X, (QoS.1, Conf.1) or (QoS.2, Conf.2), O.X

5 Information exchanged

Information exchanged			
Information exchanged (ID)	***Name of information***	***Description of information exchanged***	***Requirement, R-IDs***
Inf.1	Metering Data	Metering data of the BSPs providing aFRR/mFRR.	QoS.3, QoS.4, Conf.3, Conf.4, Sec.1, D.X, (QoS.1, Conf.1) or (QoS.2, Conf.2), O.X
Inf.2	Baseline	Baseline of the BSPs.	QoS.3, QoS.4, Conf.3, Conf.4, Sec.1, D.X, (QoS.1, Conf.1) or (QoS.2, Conf.2)
Inf.3	Delivered Flexibility	Amount of flexibility delivered by each BSP.	QoS.3, QoS.4, Conf.3, Conf.4, Sec.1, D.X, (QoS.1, Conf.1) or (QoS.2, Conf.2)
Inf.4	Payments and Penalties	Remuneration and penalties applicable for each BSP during the settlement period.	QoS.3, QoS.4, Conf.3, Conf.4, Sec.1, D.X, (QoS.1, Conf.1) or (QoS.2, Conf.2), O.X

6 Requirements

Quality of Service Requirements		
Categories ID	**Category name for requirements**	**Category description**
QoS	Quality of Service	Generic properties that service/SUC should provide – quality attributes.
Requirement R-ID	**Requirement name**	**Requirement description**
QoS.1	aFRR product quality requirements	The starting of the provision of secondary regulation (aFRR) should not take more than 30 seconds and its activation should be concluded, in the case of loss of one important generation installation, pumping or storage, no later than 5 minutes[1]. The physical units that can provide this service must have a total regulation capacity (up or down) equal or higher than 1 MW and have the corresponding qualification from the GGS (procedure 11 of MPGGS[1]). .
QoS.2	mFRR product quality requirements	Refer to Conf.2 for description of activation times, delivery period restrictions, ramping, etc.
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.
QoS.4	Elapsed time of data exchange	Elapsed time response requirements for exchanging data from 1-2 seconds
QoS.X	All constraints also apply.	All requirements in this category.

Security Requirements		
Categories ID	**Category name for requirements**	**Category description**
Sec	Security	Authentication of user, confidentiality, integrity, prevention of denial of service, non-repudiation or accountability, error management.

Requirement R-ID	Requirement name	Requirement description
Sec.1	MPGGS security requirements	Security requirements according to MPGGS.

	Data Management Requirements	
Categories ID	**Category name for requirements**	**Category description**
D	Data Management	Type of source of data, correctness or validity of data, timeliness or time stamping of data, volume of data, synchronization, or consistency of data across systems, timely access to data, validation of data across organizational boundaries, transaction management, data naming, identification, formats across disparate systems, maintenance of data and databases.
Requirement R-ID	**Requirement name**	**Requirement description**
D.1	Up-to-date management	Received data must be up-to-date within seconds of source data changing.
D.2	Validation of data exchanges	All data must be validated on each data exchange.
D.3	Management of data across organizational boundaries	Data exchanges go across organizational boundaries.
D.X	All constraints also apply.	All requirements in this category.

Discovery and Configuration Requirements		
Categories ID	**Category name for requirements**	**Category description**
Conf	Configuration	Locations, distances, communication layout, commonly used communication protocol media, network bandwidth, existing protocols, number of devices, systems, volume of data items, expected growth, etc.
Requirement R-ID	**Requirement name**	**Requirement description**
Conf.1	aFRR product configuration requirements.	The market agents that want to qualify a physical unit, should ask the GGS, with at least five working days in advance, the carrying out of tests to assess the technical and operational capacity. These tests assess the following aspects: i) The communication capacity with the central regulator; j) Real generation or consumption in fixed load regime; k) Variation gradient of the generation or consumption and the conservation of this value; l) Response to requests for random variation in generation or consumption, including reversing the direction of the request. The response of the generator in the test is always assessed according to the type of group in question, considering the experience with groups with the same type of response. The power-generating modules must comply with the requirements on the basis of the voltage level of their connection point and their maximum capacity according to their category.

		For the sake ensuring the feasibility of this use case with the existing demand-side assets, the following requirements were relaxed: • Minimum bid size: 0.1MW • Bid granularity: 0.01MW
Conf.2	mFRR product configuration requirements.	In Portugal, BSP can participate in the mFRR market, remunerated in terms of activated energy, and the mFRR band market, remunerated in terms of capacity. Additionally, in the mFRR market, BSPs can provide a standard product or a specific product of rapid mFRR[2]. The characteristics of the standard mFRR service are stated in the following table (procedure 12 of MPGGS[1]), and include the following requirements: cc) Activation mode: manual dd) Time unit of the mFRR market: 15 min ee) Activation moment: i. Direct activation: Between the publishing of the results of the scheduled activation and the beginning of the next process ii. Scheduled activation: 12.5 min before the delivery period ff) Full activation time: 12.5 min gg) Minimum bid: 1 MW hh) Maximum bid: 9999 MW ii) Bid granularity: 1MW jj) Minimum duration of delivery period: 5 min kk) Price of the bid: €/MWh, with resolution of 0.01 €/MWh ll) Preparation period: 2.5 min (included in the full activation time) mm) Ramping period: 10 min (included in the full activation time) nn) Deactivation period: up to 10 min oo) Aggregation level of the bids: Bidding area pp) Delivery period: i. Direct Activation: between 6 and 19 min, according to the activation point ii. Scheduled activation: 5 min To be able to provide mFRR services, the physical units should get the qualification with the GGS, by demonstrating that they fulfil the technical and operational requirements, namely the ones referred above. The enabled physical units should have an offer capacity over 1 MW[1]. The participation of aggregated physical units with a bidding capacity below 1 MW is allowed, as long as the aggregated capacity exceeds 1 MW, they are aggregated in the same bidding area and are associated with the programming units of a single Balancing Responsible Party (BRP)[1]. To qualify a physical unit, the respective BSP should ask the GGS to carry out tests to assess the unit's technical and operational capacity. The following requirements must be checked (procedure 12 of MPGGS [1]): q) The connection of the physical unit to the remote metering system; r) The correct operation of real time communications between the physical unit and the SCADA of the GGS;

		s) The correct operation of voice communications between the dispatch and the command rooms of the physical unit; t) The quality of the real time measurements of the physical unit; u) The correct operation of the equipment to receive the instructions from the dispatch centre and limitations to production or consumption; v) The capacity to receive and reply to instructions of the dispatch from the command room of the physical unit; w) The capacity of the command room of the physical unit to communicate changes to its available power; x) The existence of means for the compliance of the instructions of the dispatch in case of total failure in the command room of the physical unit, including the test of the contingency plans established. The specific product of rapid mFRR is used when the available balancing products do not permit to solve a given constraint that is threatening the stability of the electric system. The characteristics of this product demands for a faster response time in comparison with the standard product. The additional requirements of this product are stated below: m) Activation mode: Manual n) Full activation time: From 1 to 10 min o) Bid granularity: 1 MW p) Minimum duration of delivery period: 1 min q) Maximum duration of delivery period: 12.5 min r) Direction: a. Positive (upwards regulation) or b. Negative (downwards regulation) According to procedure 15 of MPGGS [1], mFRR band is defined as the power variation margin in which the bidding area can be mobilized to go up, through scheduled activation, in less than 12.5 minutes, starting from its current operation point. The entities or installations that want to deliver band mFRR services must fulfil the following requirements (procedure 15 of MPGGS [1]): u) Be connected to Extra-High Voltage (EHV), High Voltage (HV) or Medium Voltage (MV) and be: i. A physical unit associated to a power consumption installation; or ii. A physical unit associated to a power generation installation that is not obliged to participate in the mFRR market; iii. A physical unit associated to a storage installation; v) Be a market agent qualified to provide mFRR service; w) If the consuming installation is a cogeneration plant, it needs to prove it has the capacity to reduce consumption without loss of generation; x) If it is a production unit for self-consumption (does not use the public power grid), the measurement of the provision of the service will use as reference the net value between consumption and production in interconnection point with the grid y) Each physical unit should have an eligible power equal or higher than 1 MW;

		z) Install the real-time measurement devices, according to the requirements published by GGS; aa) Ensure the correct operation of the real-time communications between the physical units and the SCADA from GGS; bb) Do not have any unsettled overdue debt with the GGS; cc) Provision of guarantees to the Integrated Guarantee Manager (GIG, "*Gestor Integrado de Garantias*", in Portuguese), under the risk and guarantee management regime in the national electricity system, whenever applicable; dd) Comply with the requirements to participate in the mFRR market (stated above). For the sake ensuring the feasibility of this use case with the existing demand-side assets, the following requirements were relaxed: • Minimum bid size: 0.1MW • Bid granularity: 0.01MW
Conf.3	Data exchange methods	Master-slave
Conf.4	Commonly used communication protocol	IEC 60870-5-104 standard[4].
Conf.X	All constraints also apply.	All requirements in this category.

Other Requirements		
Categories ID	**Category name for requirements**	**Category description**
O	Regulatory obligation related to privacy	2016/679 GDPR (General Data Protection Regulation)
Requirement R-ID	**Requirement name**	**Requirement description**
O.1	GDPR requirements.	Compliance with the EU Genral Data Protection Regulation (GDPR).
O.2	All constraints also apply.	Personal data may not be processed unless there is at least one legal basis to do so.
O.3	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.
O.4	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.
O.5	Data retention policy	Personal data may not be transferred to a third-party if the data subject does not agree and the third party provides appropriate safeguard.
O.X	All constraints also apply.	All requirements in this category.

[4] NGS, D3.1 – Definition of TSO and DSO market requirements for balancing and ancillary services, 2024.

7 Common Terms and Definitions

Common Terms and Definitions	
Term	**Definition**
aFRR	Automatic Frequency Restauration Reserve
BRP	Balancing Responsible Party
BSP	Balancing Service Provider
DSO	Distribution System Operator
GGS	Global System Management (from the System Operator)
GIG	Integrated Guarantees Manager
mFRR	Manual Frequency Restauration Reserve
MO	Market Operator
MPGGS	Portuguese Global System Management Procedures Manual for the electricity sector
RTU	Remote Terminal Unit
SCADA	Supervisory Control and Data Acquisition
SO	System Operator
TSO	Transmission System Operator

8 SUC-PT-03.1 INTEGRATE FLEXIBLE ASSETS FROM COMMERCIAL BUILDINGS

1 Description of the use case

1.1 Name of the use case

ID	Area / Domain(s)	Name of Use Case
SUC-PT-03.1	Energy Flexibility	Integrate flexible assets from commercial buildings

1.2 Version management

Version Management			
Version No.	Date	Name of Author(s)	Changes
0.1	29.07.2024	Amândio Ferreira (Elergone Energia) João Azevedo (Elergone Energia)	First complete draft.
0.2	19.09.2024	Amândio Ferreira (Elergone Energia) João Azevedo (Elergone Energia)	Final revision of the SUC.
0.3	01.10.2024	Amândio Ferreira (Elergone Energia) João Azevedo (Elergone Energia) Marta Faria (Elergone Energia)	Final version of the SUC.
0.4	01.10.2024	Amândio Ferreira (Elergone Energia) João Azevedo (Elergone Energia) Marta Faria (Elergone Energia)	Final version of the SUC.

1.3 Scope and objectives of use case

Scope and Objectives of Use Case	
Scope	Flexibility aggregation for commercial applications
Objective(s)	Objective 1: Integrate selected Reserve Resources in the Energybox Objective 2: Control selected Reserve Resources through Energybox Objective 3: Enrolment of Reserve Resources in Platform Provider
Related business case(s)	SUC-PT-02 - Default valorisation scenario based on price hedging SUC-PT-03 - Flexibility aggregation at tertiary buildings BUC-PT-03 – Flexibility aggregation for commercial applications

1.4 Narrative of use case

Narrative of Use Case
Short description
The current SUC details the architecture and data flows at building level and cloud level that allows integration of flexible assets data. It comprises the actual flexible assets, asset controllers, the aggregator gateway (that acts as BEMS – Building Energy Management System) and the cloud layer that collects all data and provides interaction with digital platforms / algorithms.
Complete description

The main steps of your SUC:

- Stablish VLAN where both reserve resource and energy box can communicate between each other
- Guarantee that Energybox is connect and integrated with in Reserve Resource
- Guarantee collection and analysis of data collected from Energybox to cloud
- Guarantee reception of commands and distribute that to reserve resources
- Guarantee enrolment of reserve resources in DPP Digital Platform Provider

The SUC comprises the following components:

- **Reserve Resource** or Flexible Assets
  - HVAC – Heating Ventilation and Air Conditioning – building thermal inertia
    - HVAC controller – BMS (Building Management System) – main functions of building air renovation and temperature control. For the purpose of the project, three power modes are available, BOOST / ECO / NORMAL
  - Cooling system – responsible for fresh and frozen goods – cooling cabinets thermal inertia
    - Cooling system controller – main functions of defrosting, demist and temperature control. For the purpose of the project, three power modes are available, BOOST / ECO / NORMAL
  - Batteries – Lithium-Ion battery storage - storage capacity of the batteries
    - Battery controller – BattMS (Battery Management System) + BattEMS (Battery Energy Management System) main functions of charge and discharge control, temperature control, cells equalization, etc… For the purpose of the project, different modes are available.
- **Energybox** acts as aggregator gateway
  - The aggregator has its own gateway that acts and BEMS (Building Energy Management System) as it locally integrates with flexible asset controllers enabling data monitoring and control.
- **Resource Aggregator**: The data of various buildings is aggregated and available in the cloud, where it can be accessed/shared with digital services and algorithms.
- **Digital Platform Provider**: digital platform that assures the interaction between flexibility service provider and flexibility market operator.

This SUC has only one scenario: Asset integration.

1.5 Key performance indicators (KPI)

ID	Name	Description	Reference to mentioned use case objectives
KPI 1	*Number of reserve resources*	Number of assets able to participate in flexibility activation	Obj 1
KPI 2	*Data availability during pilot*	Number of hours where flexible asset is not able to respond to flexibility activation	Obj 2
KPI 3	*Number of reserve resources enrolled in DPP*	Number of assets that were accepted in DPP	Obj 3

1.6 Use case conditions

Use case conditions
Assumptions
The reserve resources predicted to be integrated are: HVAC's, cooling systems and batteries. All reserve resources should be tested to validate their integration with Energybox.
Prerequisites
All resource resources and Energybox should be connected to the same VLAN.

1.7 Further Information to the use case for classification / mapping

Classification Information
Relation to other use cases
BUC-PT-03 – Flexibility aggregation at tertiary buildings.
Level of depth
System use case (SUC) which describes in detail the functionality/technological solutions of (a part of) a business process.
Prioritisation
High Level of Priority – To be demonstrated in Portugal.
Generic, regional or national relation
Generic (Regional scope for demonstration)
Nature of the use case
Flexibility Services
Further keywords for classification
Flexibility value-chain, energy services

1.8 General Remarks

General Remarks
–

2 Diagrams of use case

Diagram(s) of use case

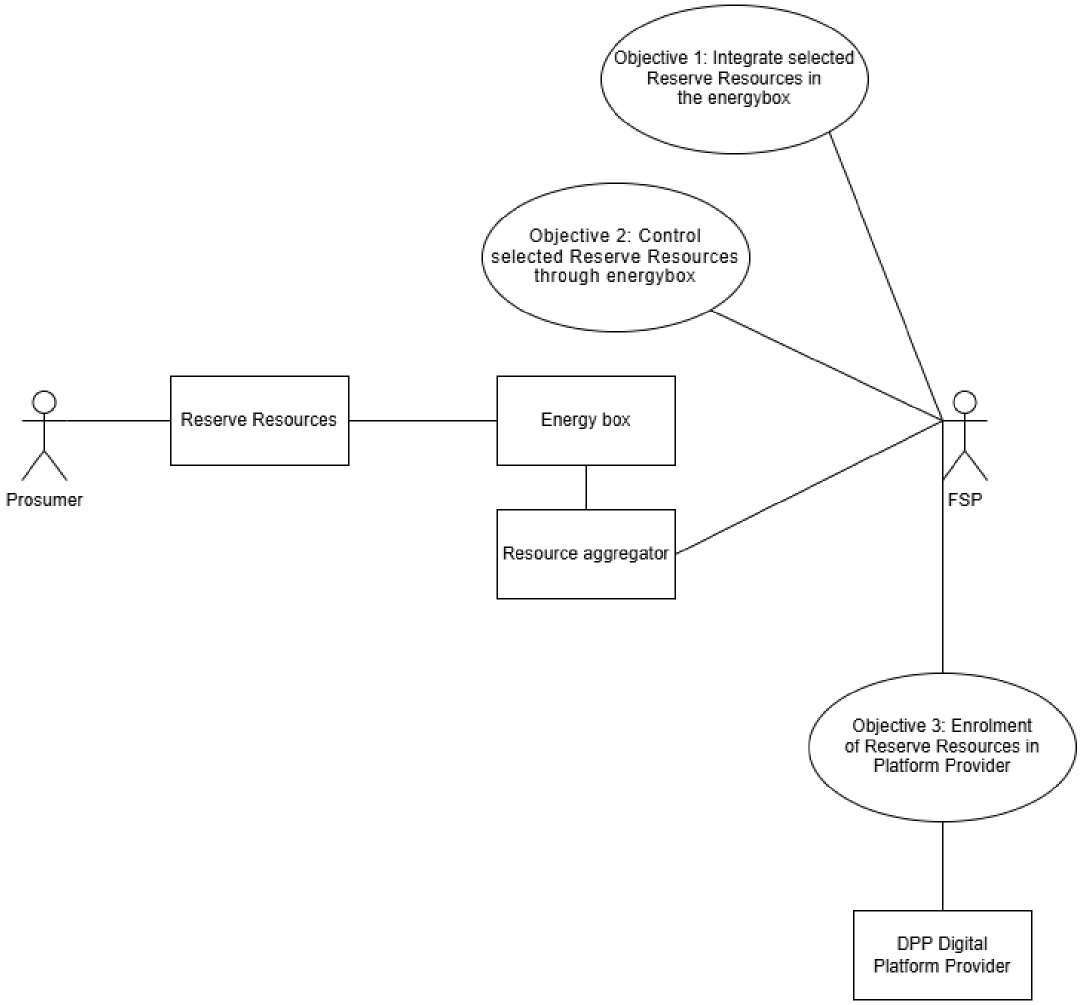


FIGURE 21 – UML USE CASE DIAGRAM

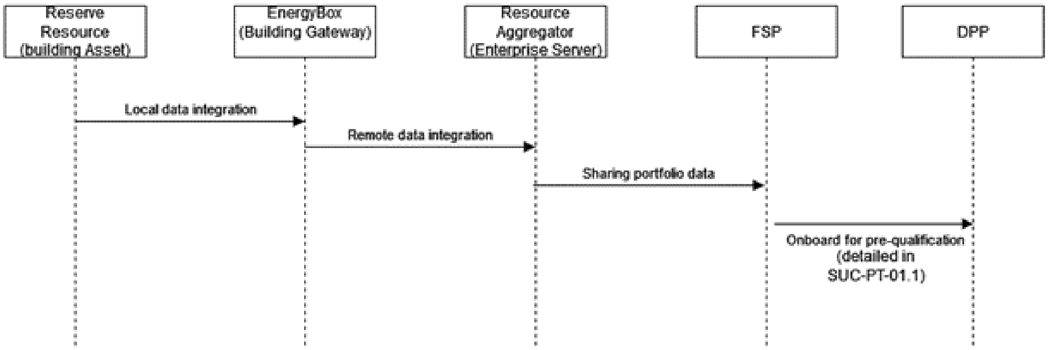


FIGURE 22 – UML SEQUENCE DIAGRAM

3 Technical details

3.1 Actors

Actors			
Actor Name	***Actor Type***	***Actor Description***	***Further Information***
Prosumer	Operator	Consumer/prosumer that has contracted energy services.	Sonae MC
Reserve Resource (RR)	Logical	A resource technically pre-qualified using a uniform set of standards to supply reserve capabilities to a System Operator and is associated with one or more tele-measuring devices.	Building asset (HVAC's, Cooling systems and batteries)
Energybox	Logical	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.	Building gateway (Schneider AS-P)
Resource Aggregator (RA)	Logical	A cloud solution that oversees all "Building Gateways" aggregating information of the whole portfolio of buildings and assets.	Enterprise Server
Flexibility Service Provider (FSP)	Business	A party providing energy balancing services to the energy market. Also designated as Balancing Responsible Party (BSP).	Elergone Energia
DPP Platform (DPP)	Logical	The ICT/SW/DP Provider supports other entities with ICT (Information and Communications Technology), Software (SW) or Digital Platforms (DP).	INESC-TEC

3.2 References

References						
No.	***References Type***	***Reference***	***Status***	***Impact on use case***	***Originator / organisation***	***Link***
-	-	-	-	-	-	-

4 Step by step analysis of use case

4.1 Overview of scenarios

Scenario conditions						
No.	**Scenario name**	**Scenario description**	**Primary actor**	**Triggering event**	**Pre-condition**	**Post-condition**
1	Assets integration	Integration of data at different levels, from specific assets, building and portfolio.	Resource Aggregator / Service Provider	Continuous	-	-

4.2 Steps – Scenarios

Scenario								
Scenario name:		***No. 1.1 – Assets integration***						
Step No.	***Event***	***Name of process/ activity***	***Description of process/ activity***	***Service***	***Information producer (actor)***	***Information receiver (actor)***	***Information Exchanged (IDs)***	***Requirement, R-IDs***
St. 1	Local data integration	Local data integration	Integration of assets data at local building controller Energybox.	POST	Reserve Resource	Energybox (Building Gateway)	Inf.1	CONN-1 CONN-2
St. 2	Remote data integration	Remote data integration	Integration of building data at cloud Resource Aggregator (Entreprise Server).	POST	Energybox (Building Gateway)	Resource Aggregator (Entreprise Server)	Inf.2	CONN-3 CONN-4 GPDR-1
St. 3	Sharing portfolio data	Sharing portfolio data	Access portfolio data to the Resource Aggregator / Service Provider.	POST	Resource Aggregator (Entreprise Server)	FSP	Inf.2	CONN-3 CONN-4 GPDR-1
St. 4	Onboard for pre-qualification	Onboard for pre-qualification	Send portfolio control signals to the Building Aggregator (Entreprise Server).	POST	FSP	DPP	Inf.3	CONN-4 GPDR-1

5 Information exchanged

Information exchanged			
Information exchanged (ID)	***Name of information***	***Description of information exchanged***	***Requirement, R-IDs***
Inf.1	Local data integration	Building ID, asset ID, Energy metering, temperature setpoints, building temperature, battery status, battery SOC, charging power…	CONN-1 CONN-2
Inf.2	Remote data integration	All buildings ID, asset ID, Energy metering, temperature setpoints, building temperature, battery status, battery SOC, charging power…	CONN-3 CONN-4 GPDR-1
Inf.3	Onboard for pre-qualification	Platform registration, assets types and characteristics, store info, location, grid connection identifier, nominal power…	CONN-4 GPDR-1

6 Requirements

Security Requirements		
Category ID	**Category name for requirements**	**Category description**
CONN	Connectivity	Connectivity, network and infrastructure requirements
GPDR	Data protection	Data protection and privacy
Requirement R-ID	**Requirement name**	**Requirement description**
CONN-1	VLAN	All assets connected to the same VLAN within the building.
CONN-2	Variable binding	Variables mapped and binded into the Energybox.
CONN-3	Buildings mapping	Buildings data must be mapped as well as its assets.
CONN-4	Internet connection	Assets shall have secure and stable connection to the internet.
GPDR-1	Data protection and privacy	Applicable data protection and privacy rules must be fulfilled.

7 Common Terms and Definition

Common Terms and Definitions	
Term	**Definition**
RA	Resource Aggregator
RR	Reserve Resource
FSP	Flexibility Service Provider
DPP	Digital Platform Provider
VLAN	Virtual Local Area Network
TSO	Transmission System Operator

9 SUC-PT-03.2 DEFAULT VALORIZATION SCENARIO BASED ON PRICE HEDGING

1 Description of the use case

1.1 Name of the use case

ID	Area / Domain(s)	Name of Use Case
SUC-PT-03.2	Energy Flexibility	**Default valorisation scenario based on price hedging**

1.2 Version management

Version Management			
Version No.	**Date**	**Name of Author(s)**	**Changes**
0.1	01.08.2024	Amândio Ferreira (Elergone Energia) João Azevedo (Elergone Energia)	First draft.
0.2	19.09.2024	Amândio Ferreira (Elergone Energia) João Azevedo (Elergone Energia)	Final revision of the SUC.
0.3	01.10.2024	Amândio Ferreira (Elergone Energia) João Azevedo (Elergone Energia) Marta Faria (Elergone Energia)	Final version of the SUC.

1.3 Scope and objectives of use case

Scope and Objectives of Use Case	
Scope	Flexibility aggregation for commercial applications
Objective(s)	Objective 1: optimize default scenario based on cost savings through forecast tools Objective 2: upload schedule, based on default scenarios, for each reserve resources
Related business case(s)	BUC-PT-03 – Flexibility aggregation for commercial applications SUC-PT-01.1 - Connect flexibility providers across the DPP flexibility value chain SUC-PT-03.1 - Integrate flexible assets from commercial buildings

1.4 Narrative of use case

Narrative of Use Case
Short description
The current SUC details the creation of a default valorization scenario based on price hedging and targeting cost savings. It comprises main data flows and the interaction between forecasting tools, reserve resources and the default valorization scenario algorithm.
Complete description
Reserve resources owners seek the best possible monetization of their resources. With the use of forecasting tools and algorithms, it is possible to predict the energy needs for the next day, but also understand when load can be shifted so that less energy is requested from the provider but in a seamless way. This SUC encompasses the following steps:

#1 load historical data (energy consumption, operational data and energy generation) #2 feed forecasting models to get day ahead forecasts #3 load energy contracts data #4 load technical restrictions #5 build "optimal" schedule #6 upload "optimal" schedule to assets

1.5 Key performance indicators (KPI)

ID	*Name*	*Description*	*Reference to mentioned use case objectives*
KPI 1	Monetary impact	Monetary impact of the default valorization scenario	Obj 1
KPI 2	Variation in energy consumption	% increase in energy consumption due to activation of default valorisation scenario (default valorization scenario vs baseline)	Obj 2
KPI 3	Valorisation scenarios generated	Number of default valorisation scenario generated	Obj 1
KPI 4	Valorisation scenario activated	% of default valorisation scenario activated	Obj 2
KPI 5	Schedule deviation	Deviation between default valorisation scenario and actual building schedule	Obj 2

1.6 Use case conditions

Use case conditions
Assumptions
The forecasting tools have historical data to be loaded. The algorithms will have access to ERP data (Energy provider contractual data). The main goal of algorithm will be cost savings based on price hedging.
Prerequisites
The implementation of SUC -PT-03.1 occurs with success.

1.7 Further Information to the use case for classification / mapping

Classification Information
Relation to other use cases
BUC-PT-03 – Flexibility aggregation at tertiary buildings.
Level of depth
System use case (SUC) which describes in detail the functionality/technological solutions of (a part of) a business process.
Prioritisation
High Level of Priority – To be demonstrated in Portugal.
Generic, regional or national relation
Generic (Regional scope for demonstration)
Nature of the use case

Flexibility Services
Further keywords for classification
Flexibility value-chain, energy services

1.8 General Remarks

General Remarks

2 Diagrams of use case

Diagram(s) of use case

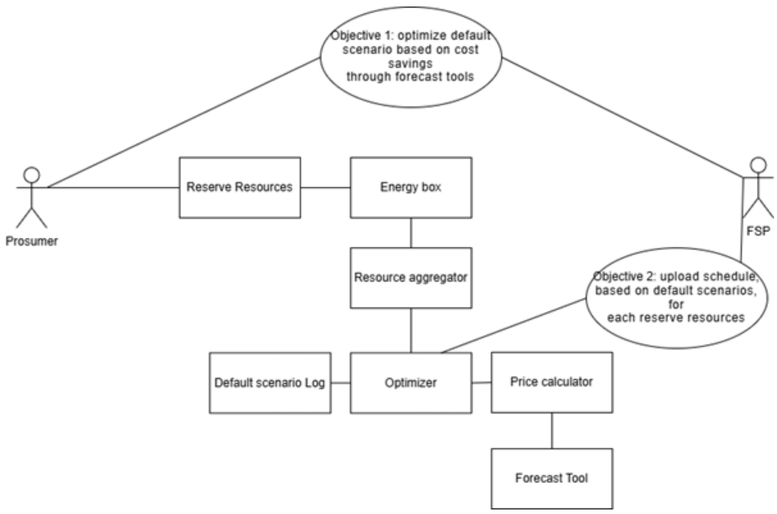


FIGURE 23 – UML USE CASE DIAGRAM FOR DEFAULT SCENARIO CREATION

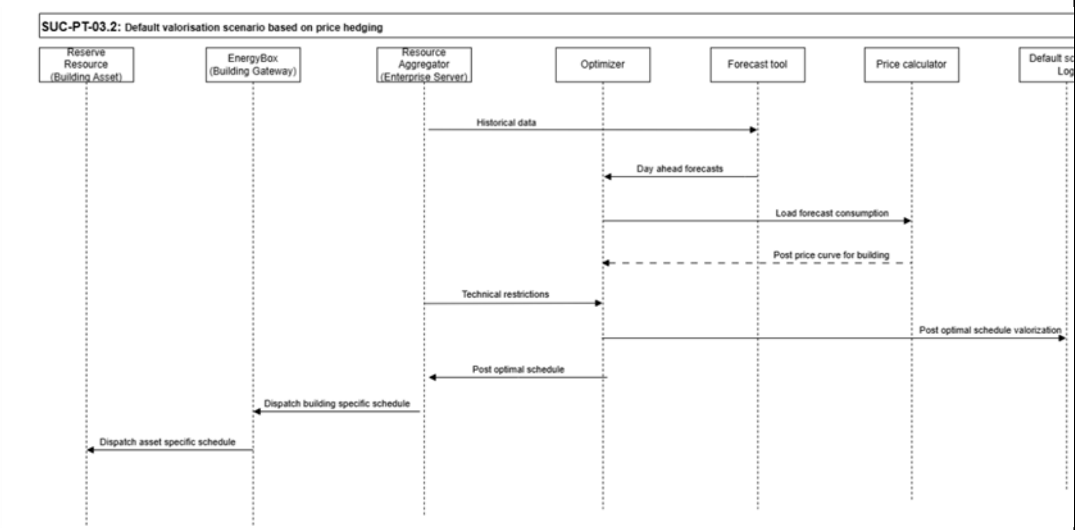


FIGURE 24 – UML SEQUENCE DIAGRAM

3 Technical details

3.1 Actors

Actors			
Actor Name	***Actor Type***	***Actor Description***	***Further Information***
Forecast Tool	Logical	Set of forecasting tools able to predict day-ahead scenarios.	Elergone and INESC-TEC
Optimizer	Logical	Application that builds the optimal schedule for each resource according to the cost variation along the day.	Elergone
Default scenario Log	Logical	Component responsible for storing Default Scenarios for later comparison with TSO-based requests.	Elergone
Price calculator	Logical	Tool that according to the contractual data of the building generates the cost variation along the day.	Elergone
Prosumer	Operator	Consumer /prosumer that has contracted energy services.	Sonae MC
Reserve Resource (RR)	Logical	A resource technically pre-qualified using a uniform set of standards to supply reserve capabilities to a System Operator and is associated with one or more tele-measuring devices.	Building assets (HVAC's, Cooling systems and batteries)
Energybox	Logical	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.	Building gateway (Schneider AS-P)
Resource Aggregator (RA)	Logical	A cloud solution that oversees all "Building Gateways" aggregating information of the whole portfolio of buildings and assets.	Enterprise Server
Flexibility Service Provider (FSP)	Business	A party providing energy balancing services to the energy market. Also designated as Balancing Responsible Party (BSP).	Elergone

3.2 References

References						
No.	***References Type***	***Reference***	***Status***	***Impact on use case***	***Originator / organisation***	***Link***
-	-	-	-	-	-	-

4 Step by step analysis of use case

4.1 Overview of scenarios

Scenario conditions						
No.	**Scenario name**	**Scenario description**	**Primary actor**	**Triggering event**	**Pre-condition**	**Post-condition**
Sc. 1	Default valorisation	Default creation of valorisation scenario	Default Scenario Creator	Automatic - daily recurrence		

4.2 Steps – Scenarios

Scenario								
Scenario name:		**No. 1.1 – Default valorisation**						
Step No.	**Event**	**Name of process/ activity**	**Description of process/ activity**	**Service**	**Information producer (actor)**	**Information receiver (actor)**	**Information Exchanged (IDs)**	**Requirement, R-IDs**
St. 1	Historical data	Historical data	Continuously update historical data to feed the forecasting models.	POST	Resource Aggregator	Forecast tool	Inf.1	CONN-4 GPDR-1
St. 2	Day ahead forecasts	Day ahead forecasts	Get output of forecasting models.	POST	Forecast tool	Optimizer	Inf.2	CONN-4 GPDR-1
St. 3	Load forecast consumption	Load forecast consumption	Load forecast consumption to the price calculator.	POST	Optimizer	Price calculator	Inf.3	CONN-4 GPDR-1
St. 4	Post price curve for building	Post price curve for building	Post price curve for building assets.	POST	Price calculator	Optimizer	Inf.4	CONN-4 GPDR-1
St. 5	Import technical restrictions	Import technical constraints	Get information regarding technical constraints for the optimization problem.	GET	Resource Aggregator	Optimizer	Inf.5	CONN-4 GPDR-1
St. 6	Run default scenario	Create default scenario	With all information create the default valorisation scenario.	EXE	-	-	-	CONN-4 GPDR-1
St.7	Post optimal schedule	Post optimal schedule	Post optimal schedule for each asset.	POST	Optimizer	Resource Aggregator	Inf.6	CONN-4 GPDR-1
St.8	Dispatch building specific schedule	Dispatch building specific schedule	Dispatch building specific schedule with all assets schedule included.	POST	Resource Aggregator	Energybox	Inf.7	CONN-4 GPDR-1
St.9	Post optimal schedule valorisation	Post optimal schedule valorisation	Add optimal schedule valorisation to the scenario log.	POST	Optimizer	Default Scenario Log	Inf.8	CONN-4 GPDR-1
St.10	Dispatch asset-specific schedule	Dispatch asset-specific schedule	Dispatch asset specific schedule to each asset.	POST	Energybox	Reserve Resource	Inf.9	CONN-4 GPDR-1

5 Information exchanged

Information exchanged			
Information exchanged (ID)	***Name of information***	***Description of information exchanged***	***Requirement, R-IDs***
Inf.1	Historical data	Data regarding energy consumption, generation, operational data of assets to run forecasts.	CONN-4 GPDR-1
Inf.2	Day ahead forecasts	Day ahead forecast for each building and associated assets.	CONN-4 GPDR-1
Inf.3	Load forecast consumption	Building ID, forecast for each building and associated assets, time interval.	CONN-4 GPDR-1
Inf.4	Post price curve for building	Building ID, price curve for submitted time interval.	CONN-4 GPDR-1
Inf.5	Import technical restrictions	Technical restrictions and operational range for each asset.	CONN-4 GPDR-1
Inf.6	Post optimal schedule	Building ID, Asset ID, schedule, operation modes to be activated.	CONN-4 GPDR-1
Inf.7	Dispatch building-specific schedule	For each building defines: Asset ID, schedule, operation modes to be activated.	CONN-4 GPDR-1
Inf.8	Post optimal schedule valorisation	Building ID, Assets ID, valorisation, time period, amount of power mobilized, amount of energy mobilized.	CONN-4 GPDR-1
Inf.9	Dispatch asset-specific schedule	For each asset defines: schedule, operation modes to be activated.	CONN-4 GPDR-1

6 Requirements

Security Requirements		
Category ID	**Category name for requirements**	**Category description**
CONN	Connectivity	Connectivity, network and infrastructure requirements.
GPDR	Data protection	Data protection and privacy.
Requirement R-ID	**Requirement name**	**Requirement description**
CONN-1	VLAN	All assets connected to the same VLAN within the building.
CONN-2	Variable binding	Variables mapped and linked into the Energybox.
CONN-3	Buildings mapping	Buildings data must be mapped as well as its assets.
CONN-4	Internet connection	Assets shall have secure and stable connection to the internet.
GPDR-1	Data protection and privacy	Applicable data protection and privacy rules must be fulfilled.

7 Common Terms and Definition

Common Terms and Definitions	
Term	**Definition**
RA	Resource Aggregator
RR	Reserve Resource

FSP	Flexibility Service Provider
DPP	Digital Platform Provider
VLAN	Virtual Local Area Network
TSO	Transmission System Operator

10 SUC-PT-03.3 TSO VALORIZATION SCENARIO

1 Description of the use case

1.1 Name of the use case

ID	Area / Domain(s)	Name of Use Case
SUC-PT-03.3	Energy Flexibility	TSO valorisation scenario

1.2 Version management

Version Management			
Version No.	Date	Name of Author(s)	Changes
0.1	01.08.2024	Amândio Ferreira (Elergone Energia) João Azevedo (Elergone Energia)	First draft.
0.2	13.09.2024	Amândio Ferreira (Elergone Energia) João Azevedo (Elergone Energia)	First complete version.
0.3	19.09.2024	Amândio Ferreira (Elergone Energia) João Azevedo (Elergone Energia)	Final revision of the SUC.
0.4	01.10.2024	Amândio Ferreira (Elergone Energia) João Azevedo (Elergone Energia) Marta Faria (Elergone Energia)	Final version of the SUC.

1.3 Scope and objectives of use case

Scope and Objectives of Use Case	
Scope	Flexibility aggregation for commercial applications
Objective(s)	Objective 1: Compare default and market-based scenarios Objective 2: Creation and submission of bids to the flexibility market Objective 3: Upload schedule, based on TSO request, for each reserve resources
Related business case(s)	BUC-PT-03 SUC-PT-03.2 SUC-PT-01.3 SUC-PT-01.4

1.4 Narrative of use case

Narrative of Use Case
Short description
The current SUC regards the participation of tertiary building in the flexibility market.
Complete description
The participation of prosumers (domestic or commercial/industrial) in flexibility markets for provision of flexibility to grid operators will only become a reality if prosumers/assets owners get the right incentives to do so. Such incentives will necessarily be compared to other possibilities, namely through price edging scenarios which can be considered a default valorization. For commercial buildings, 3 types of assets will be considered in the pilot demonstrations (cooling/HVAC and storage). Creation of

this default valorization scenario requires the simulation and optimization of flexibility activation schedule for each asset within the building based on price hedging. In this SUC, the scenario of providing flexibility to the grid operator is created. Flexibility aggregator of commercial buildings can also integrate additional assets in its offer to the grid operator. These assets can be integrated in the aggregator offer via bilateral agreement with other aggregators [linked to BUC-PT-01]. **Main steps:** **#1** Receive flexibility requests from TSO **#2** Bid creation and submission **#3** Upload schedule, based on TSO request, for each reserve resources

1.5 Key performance indicators (KPI)

ID	*Name*	*Description*	*Reference to mentioned use case objectives*
KPI 1	TSO requests	Number of requests by the TSO	Obj 1
KPI 2	% of activations of TSO requests	% activation of TSO requests	Obj 3
KPI 3	TSO requests valorisation	Valorisation associated to TSO requests	Obj 2

1.6 Use case conditions

Use case conditions
Assumptions
There is a default valorisation scenario already created, for comparing purposes. When the bid is submitted, the prosumer is already committed to provide the flexibility service.
Prerequisites
Guarantee the enrolment of reserve resources.

1.7 Further Information to the use case for classification / mapping

Classification Information
Relation to other use cases
BUC-PT-03 – Flexibility aggregation at tertiary buildings.
Level of depth
System use case (SUC) which describes in detail the functionality/technological solutions of (a part of) a business process.
Prioritisation
High Level of Priority – To be demonstrated in Portugal.
Generic, regional or national relation
Generic (Regional scope for demonstration)
Nature of the use case
Flexibility Services
Further keywords for classification
Flexibility value-chain, energy services

1.8 General Remarks

General Remarks
–

2 Diagrams of use case

Diagram(s) of use case

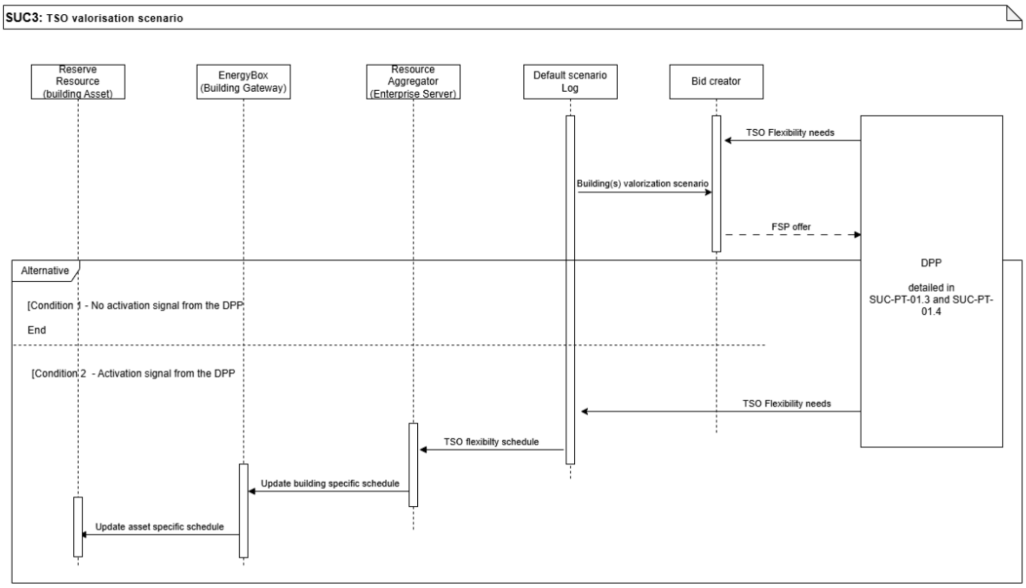


FIGURE 25 – UML USE CASE DIAGRAM

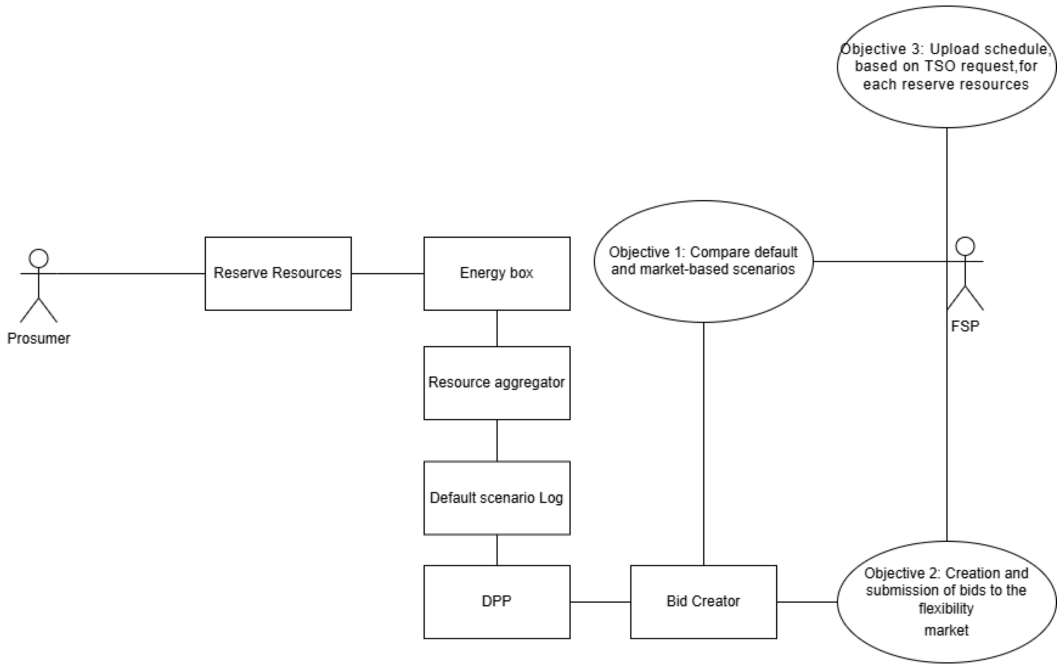


FIGURE 26 – UML SEQUENCE DIAGRAM

3 Technical details

3.1 Actors

Actors			
Actor Name	***Actor Type***	***Actor Description***	
Bid Creator	Technical Actor	Application that gets the TSO request and, according to the default valorisation scenario, generates a bid for market participation.	Elergone
Default scenario Log	Logical	Component responsible for storing Default Scenarios for later comparison with TSO-based requests.	Elergone
Prosumer	Operator	Consumer/prosumer that has contracted energy services.	Sonae MC
Reserve Resource (RR)	Logical	A resource technically pre-qualified using a uniform set of standards to supply reserve capabilities to a System Operator and is associated with one or more tele-measuring devices.	Building asset (HVAC's, Cooling systems and batteries)
Energybox	Logical	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.	Building gateway (Schneider AS-P)
Resource Aggregator (RA)	Logical	A cloud solution that oversees all "Building Gateways" aggregating information of the whole portfolio of buildings and assets	Enterprise Server
Flexibility Service Provider (FSP)	Business	A party providing energy balancing services to the energy market. Also designated as Balancing Responsible Party (BSP).	Elergone
DPP Platform (DPP)	Logical	The ICT/SW/DP Provider supports other entities with ICT (Information and Communications Technology), Software (SW) or Digital Platforms (DP).	INESC-TEC

3.2 References

References						
No.	***References Type***	***Reference***	***Status***	***Impact on use case***	***Originator / organisation***	***Link***
-	-	-	-	-	-	–

4 Step by step analysis of use case

4.1 Overview of scenarios

Scenario conditions						
No.	**Scenario name**	**Scenario description**	**Primary actor**	**Triggering event**	**Pre-condition**	**Post-condition**
Sc. 1	Get TSO valorisation	Interaction between FSP and DPP platform in order to get the valorisation associated to TSO flexibility activation.	DPP	TSO flexibility request	-	-

4.2 Steps – Scenarios

Scenario								
Scenario name:		**No. 1.1 – Onboard all stakeholders on the DPP (Success) – Consumer View**						
Step No.	**Event**	**Name of process/ activity**	**Description of process/ activity**	**Service**	**Information producer (actor)**	**Information receiver (actor)**	**Information Exchanged (IDs)**	**Requirement, R-IDs**
St. 1	TSO flexibility needs	TSO flexibility needs	TSO flexibility needs provided through the DPP.	POST	DPP	Bid Creator	Inf.1	CONN-4 GPDR-1
St. 2	Building(s) valorisation scenario	Building(s) valorisation scenario	According to St. 1, one or more buildings are included in the TSO flexibility request. Default valorisation of those buildings is loaded to Bid creator for comparison and creation of an offer to the flexibility market.	GET	Default scenario Log	Bid Creator	Inf.2	CONN-4 GPDR-1
St. 3	FSP offer	FSP offer	FSP puts its bid into the DPP.	POST	Bid Creator	DPP	Inf.3	CONN-4 GPDR-1
St. 4	TSO flexibility needs	TSO flexibility needs	TSO accepted bid and requests flexibility activation.	POST	DPP	Default scenario Log	Inf.4	CONN-4 GPDR-1
St. 5	TSO flexibility schedule	TSO flexibility schedule	TSO flexibility schedule is communicated to the RA.	POST	Default scenario Log	RA	Inf.5	CONN-4 GPDR-1
St. 6	Update building-specific schedule	Update building-specific schedule	Update building-specific schedule to answer TSO request.	POST	RA	Energybox	Inf.6	CONN-4 GPDR-1
St. 7	Update asset-specific schedule	Update asset-specific schedule	Update asset-specific schedule to answer TSO request.	POST	Energybox	RR	Inf.7	CONN-1 CONN-2 CONN-3

5 Information exchanged

Information exchanged			
Information exchanged (ID)	*Name of information*	*Description of information exchanged*	*Requirement, R-IDs*
Inf.1	TSO flexibility needs	Grid connection ID(s), amount of flexibility estimated, time period.	CONN-4 GPDR-1
Inf.2	Building(s) valorisation scenario	Grid connection ID(s), default valorisation.	CONN-4 GPDR-1
Inf.3	FSP offer	Grid connection ID(s), amount of flexibility estimated, time period, price	CONN-4 GPDR-1
Inf.4	TSO flexibility needs	Bid ID, status.	CONN-4 GPDR-1
Inf.5	TSO flexibility schedule	Grid connection ID(s) and associated schedules.	CONN-4 GPDR-1
Inf.6	Update building-specific schedule	Building specific schedules.	CONN-4 GPDR-1
Inf.7	Update asset-specific schedule	Asset specific schedules.	CONN-1 CONN-2 CONN-3

6 Requirements

Security Requirements		
Category ID	**Category name for requirements**	**Category description**
CONN	Connectivity	Connectivity, network and infrastructure requirements.
GPDR	Data protection	Data protection and privacy.
Requirement R-ID	**Requirement name**	**Requirement description**
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GPDR-1	Data protection and privacy	Applicable data protection and privacy rules must be fulfilled .

7 Common Terms and Definition

Common Terms and Definitions	
Term	**Definition**
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RR	Reserve Resource
FSP	Flexibility Service Provider
DPP	Digital Platform Provider
VLAN	Virtual Local Area Network
TSO	Transmission System Operator

HEDGE-IoT

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

D2.2

Functional Specifications of the HEDGE-IoT system

|Annex Document 6 - Slovenian Pilot SUCs|

31/10/2024

Co-funded by the European Union

This project has received funding from the European Union's Horizon Europe research and innovation programme under the Grant Agreement number 101136216. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Climate, Infrastructure and Environment Executive Agency. Neither the European Union nor the granting authority can be held responsible for them.

PROJECT INFORMATION

Project Number	101136216		
Project Acronym	HEDGE-IoT		
Project Full title	Holistic Approach towards Empowerment of the Digitalization of the Energy Ecosystem through adoption of IoT solutions		
Project Start Date	01 January 2024		
Project Duration	42 months		
Funding Instrument	Horizon Europe Framework Programme	Type of action	HORIZON-IA HORIZON Innovation Actions
Call	HORIZON-CL5-2023-D3-01-15		
Topic	Supporting the green and digital transformation of the energy ecosystem and enhancing its resilience through the development and piloting of AI-IoT Edge-cloud and platform solutions		
Coordinator	European Dynamics Luxembourg SA		

DELIVERABLE INFORMATION

Deliverable No.	D2.2							
Deliverable Title	Functional Specifications of the HEDGE-IoT system – Annex Document 6 – Slovenian Pilot SUCs							
Work-Package No.	WP2							
Work-Package Title	Stakeholders' Requirements and System Specifications							
Lead Beneficiary	TRIALOG							
Main Author	Lenart Ribnikar (EG) Josipa Stegić (KONC) Leila Luttenberger Marić (KONC) Ivan Krajnović (KONC) Siniša Sekulić (KONC) Urban Bavčar (ELES) Marjan Bogataj (OPR) And Slovenian pilot members							
Other Authors	Léo Cornec (TRIALOG) Lenos Peratitis (ED) Gregor Kosec (JSI)							
Due date	31/10/2024							
Deliverable Type	X	Document, Report (R)		Data management plan (DMP)		Websites, press & media action (DEC)		Other
Dissemination Level	X	Public (PU)		Sensitive (SEN)		Classified		
	PU: Public, fully open SEN: Sensitive, limited under the conditions of the Grant Agreement							

	Classified R-UE/EU-R – EU RESTRICTED under the Commission Decision No2015/444 Classified C-UE/EU-C – EU CONFIDENTIAL under the Commission Decision No2015/444 Classified S-UE/EU-S – EU SECRET under the Commission Decision No2015/444

Document Revision History

Version	Date	Description of change	List of contributor(s)
0.1	09/10/2024	Compilation of all the pilot SUCs	Léo Cornec (TRIALOG)
0.2	23/10/2024	Review by European Dynamics	Lenos Peratitis (ED)
0.3	26/10/2024	Review by Institut Jozefstefan	Gregor Kosec (JSI)
1.0	29/10/2024	Final document version for integration to Deliverable D2.2	Léo Cornec (TRIALOG)

EXECUTIVE SUMMARY

This document is an annex of HEDGE-IoT deliverable D2.2 titled "Functional Specifications of the HEDGE-IoT system" document. It provides specifications for the System Use Cases (SUCs) of the pilot.

Each SUC was defined by pilot members, based on the corresponding Business Use Case (BUC) and the IEC 62559-2 template, with support from the task leader for the methodology.

This document will be updated later in the project based on additional work and feedback. For the HEDGE-IoT project, the following sections and subsections of the IEC 62559-2 template were defined as mandatory to be completed by the pilot demonstrators for the SUCs:

1. Description of the use case
    1.1. Name of the use case
    1.2. Scope and objectives of the use case
    1.3. Narrative of the use case
2. Diagrams of the use case
3. Technical details
    3.1. Actors
4. Step-by-step analysis of use case
    4.1. Overview of scenarios
    4.2. Steps - scenarios
5. Information exchanged
6. Requirements

The following table links the BUCs and the SUCs of the pilot:

BUC ID & BUC name	**SUC ID**	**SUC name**
BUC-SI-01 Maximizing asset capacity for increased lifetime of DSO and TSO equipment	SUC-SI-01.1	Dynamic Thermal Rating (DTR) edge calculation
	SUC-SI-01.2	Dynamic Line Rating (DLR) edge calculation
BUC-SI-02 Enhanced Network Manageability and Observability	SUC-SI-02.1	Semantic model of the substation
	SUC-SI-02.2	ML algorithm for enhanced network management and planning

1 SUC-SI-01.1 – DYNAMIC THERMAL RATING EDGE CALCULATION

1 Description of the use case

1.1 Name of the use case

ID	Area / Domain(s) / Zones(s)	Name of Use Case
SUC-SI-01.1	Smart Grid Technologies, IoT integration, Real-Time Grid Management, Electric Grid Optimization	Dynamic Thermal Rating edge calculation

1.2 Version management

Version Management			
Version No.	Date	Name of Author(s)	Changes
0.1	17.05.2024	Lenart Ribnikar	First draft of SUC
0.2	24.05.2024	Lenart Ribnikar	Fixed comments based on TRIALOG suggestion
0.3	17.06.2024	Lenart Ribnikar	Changed SUC definition based on Aachen workshop and internal communication
0.4	8.07.2024	Lenart Ribnikar	Final changes to SUC based on TRIALOG feedback
0.5	05.09.2024	Lenart Ribnikar	Updated requirements to new version

1.3 Scope and objectives of use case

Scope and Objectives of Use Case	
Scope	The scope of System use case is the edge calculation of Dynamic thermal rating that is taking place on IoT devices located on secondary transformer substations.
Objective(s)	The main objective of this SUC is the edge DTR calculation. The calculation is performed on IoT devices located at secondary transformers substations in the DSO grid. The DTR calculation is redesigned for the edge calculation including all necessary input parameters and additional sensors for the tuning and validation of the DTR.
Related business case(s)	BUC-SI-01

1.4 Narrative of use case

Narrative of Use Case
Short description

This SUC focuses on implementing of Dynamic Thermal Rating (DTR) algorithms on IoT devices to enable real-time data processing and decision-making directly at the network edge. This functionality is crucial for immediate reaction to fluctuating network conditions without having to rely on remote servers or cloud systems.
Complete description
SUC-01.1 focuses on implementing Dynamic Thermal Rating (DTR) algorithms on IoT devices within the Distribution System Operator (DSO) grid infrastructure. This initiative aims to enhance the grid's operational efficiency and responsiveness by enabling real-time data processing and decision-making capabilities directly at the edge. The DTR algorithms are reimplemented for efficient operation on IoT devices with limited computational resources while maintaining target accuracy and high reliability. The IoT devices process real-time ambient and operational data using the DTR algorithms, allowing immediate thermal rating calculations that facilitating prompt decision-making at the grid's edge. Compatibility between IoT devices, their algorithms, DSO's and existing grid infrastructures, including power quality meters and communication protocols, to ensure seamless operation within the grid. Initial tests are being conducted to verify that the IoT devices accurately process the supplied real-time data in DTR calculations and are ready for integration into the operational framework. Transformers are one of the most important assets in the distribution power network. Overloading them significantly deteriorates their service life due to the insulation damage while underloading them means they are not optimally utilized. Recently, the rise of micro power plants, e.g. rooftop solar installations, and increased electricity consumption due to heating and the electrification of the transport have led to higher complexity of grid operation. This has a direct impact on the load of the distribution networks, potentially causing transformer overloads and necessitating investment in new network infrastructure. Currently, transformer load is monitored based on rated power, which is not an accurate indicator of overload. DTR allows the calculation of the optimal load of the transformer based on its temperature, enabling transformers to be overloaded over their rated power in favorable weather conditions without affecting their lifespan. The involved DTR algorithm is a three-mass (core and winding, oil and transformer station) model mathematically described with three coupled partial differential equations and corresponding boundary conditions describing the heat exchange with surroundings. accounted for Weather data will be collected locally using dedicated sensor or alternatively through an API from weather data providers, transformer load will be obtained from power quality meters. By focusing on these functionalities, the SUC ensures that edge IoT devices are effectively equipped to enhance the grid's performance through real-time data processing and autonomous decision-making capabilities.

1.5 Key performance indicators (KPI)

ID	***Name***	***Description***	***Reference to mentioned use case objectives***
KPI 3	*% Of planned usage of Hedge-IoT tools/data services om field demos*	Number of IoT devices for DTR calculation implemented in DSO grid	5-10
KPI 8	*IoT/Edge/Fog sites uptime*	Availability of IoT devices deployed in DSO grid for edge DTR calculation	95%

	and availability		
KPI11	*Increased grid operational performance*	Increased grid operation based on DTR calculation	Increased transformer loads up to 30% over their rated power
OB1	*Different types of IoT/edge devices to be exploited in Demo Areas e.g., Smart Meter, HEMS, Sensors, inverter*	New IoT devices and sensors implemented in DSO grid for DTR calculation needs	20

1.6 Use case conditions

Use case conditions
Assumptions
In this SUC it is assumed that: • DSO has overloaded transformers with sufficient data • DSO is implementing edge DTR for overloaded transformers
Prerequisites
• DSO has secondary transformer stations with PQ meters • Weather data is available on secondary transformer substation location • Transformers are overloaded

1.7 Further Information to the use case for classification / mapping

Classification Information
Relation to other use cases
SUC-SL-01.2 SUC-SL-02.1 Main connection to BUC-SL-01
Level of depth
Prioritisation
To be demonstrated in Slovenia (Pilot 6)
Generic, regional or national relation
Generic/regional
Nature of the use case
System Use case
Further keywords for classification
Dynamic Thermal Rating, Optimal Load

1.8 General Remarks

General Remarks

2 Diagrams of use case

Diagram(s) of use case

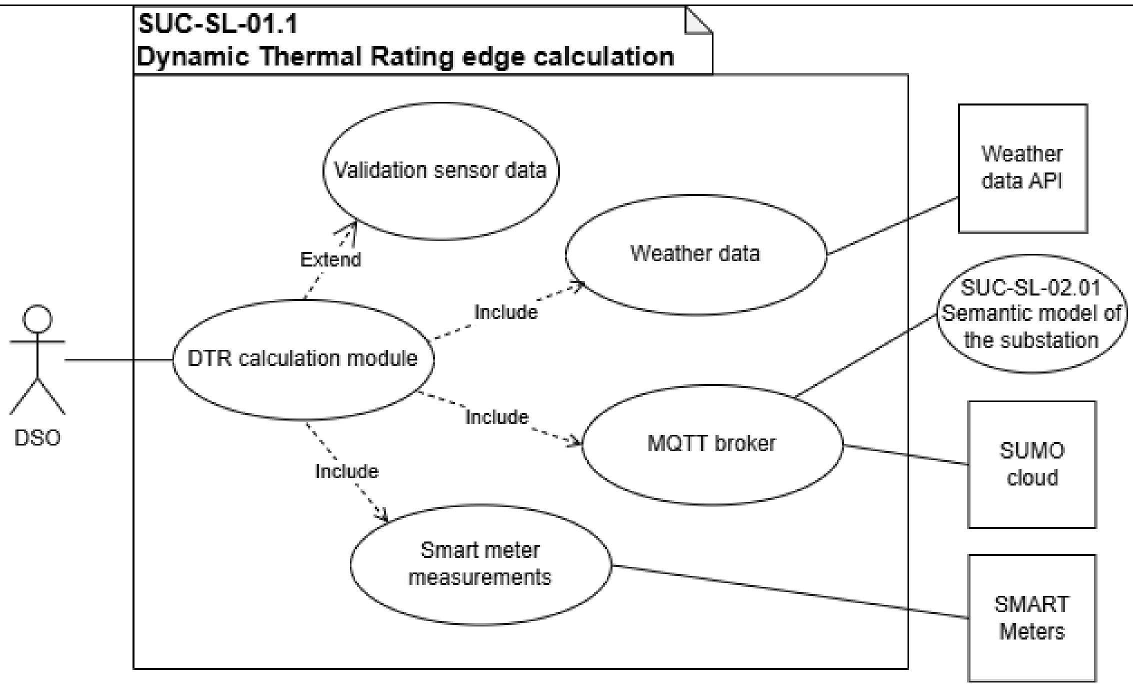

FIGURE 1: UML USE CASE DIAGRAM

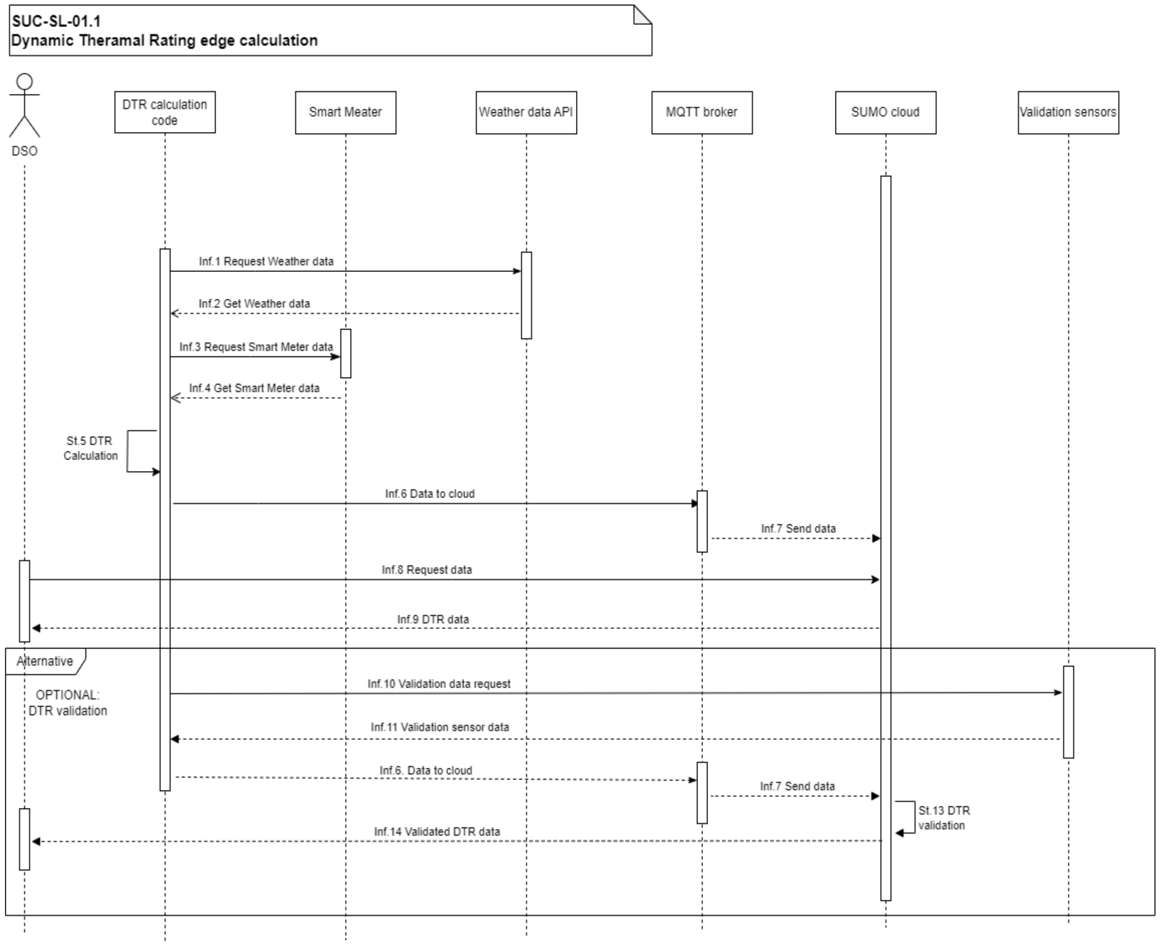

FIGURE 2: UML SEQUENCE DIAGRAM

3 Technical details

3.1 Actors

Actors			
Actor Name	**Actor Type**	**Actor Description**	**Further information specific to this use case**
DSO	Business Actor	DSO gathers the data of DTR of secondary substation transformer	Elektro Gorenjska, d.d.
Smart meters	Logical Actor	Device from which the PQ data is gathered	Elektro Gorenjska, d.d.
SUMO cloud	Logical Actor	Platform where the validation data and calculated DTR from IoT devices is sent for storage and further analysis.	Operato
Weather Data API	Logical Actor	Provides real-time weather data required for DTR and DLR calculations.	/
PowerCIM semantic model	Logical Actor	Semantic Model of secondary transformer substation for better grid observability (SUC-SL-02.1)	KONČAR Digital

3.2 References

References						
No.	**Reference Type**	**Reference**	**Status**	**Impact on use case**	**Originator / organisation**	**Link**

4 Step by step analysis of use case

4.1 Overview of scenarios

Scenario conditions						
No.	**Scenario name**	**Scenario description**	**Primary actor**	**Triggering event**	**Pre-condition**	**Post-condition**
1	Sc.1 Dynamic Thermal Rating edge calculation	Edge DTR calculation on IoT devices	IoT device	BUC-SL-01	Integrated IoT devices on secondary transformer substation in DSO grid	Running on edge DTR calculation

4.2 Steps – Scenarios

Scenario								
Scenario name:		Sc.1 Dynamic Thermal Rating edge calculation						
Step No.	***Event***	***Name of process/ activity***	***Description of process/ activity***	***Service***	***Information producer (actor)***	***Information receiver (actor)***	***Information Exchanged (IDs)***	***Requirement, R-IDs***
1	Request Weather Data.	Requesting Weather data for DTR calculation	IoT device sands weather data request to weather API	CREATE	DTR calculation code	Weather data API	Inf.1	QoS.3, Conf.1, Sec.1, Sec.2
2.	Get Weather data	Gathering weather data	IoT device gathers data from weather API needed for DTR calculation	EXECUTE	Weather API	DTR calculation code	Inf.2	QoS.3, Sec.1, D.2, D.3
3.	Request Smart Meter data	Requesting Smart meter data for DTR calculation	IoT device sands smart meter data request to smart meters	CREATE	DTR calculation code	Smart meter	Inf.3	QoS.3, Sec.1, Conf.1, Sec.2
4.	Get Smart meter data	Gathering smart meter data	IoT device gathers data from smart meters, for DTR calculation	EXECUTE	Smart meter	DTR calculation code	Inf.4	QoS.3, Sec.1, D.2, D.3
5	DTR calculation	DTR calculation	DTR is calculated based on gathered data	EXECUTE	DTR calculation code	DTR calculation code		QoS.X
6	Request to send data via MQTT	Data sending via MQTT	IoT device requests data sending via MQTT to SUMO cloud	CREATE	DTR calculation code	MQTT broker	Inf.6	Sec.3, QoS.3, Conf.2
7.	Send data to CLOUD	Sending data to CLOUD	Sending data to cloud via MQTT broker	EXECUTE	MQTT broker	SUMO cloud	Inf.7	Sec.3, QoS.3, Conf.2, D.4
8.	Request DTR data	Request DTR data from CLOUD	DSO requests DTR data from SUMO cloud	CREATE	DSO	SUMO cloud	Inf.8	Sec.3, QoS.5, Conf.2
9.	DTR data	Data from	DTR data is send from SUMO	EXECTE	SUMO	DSO	Inf.9	QoS.2. QoS.4,

		cloud to DSO	cloud to DSO		cloud			Sec.1, D.3, D.4
10.	Validation data request Optional	Alternative validation data request	DTR edge calculation requests validation sensor data	EXECUTE	DTR calculation code	Validation sensors	Inf.10	QoS.3, Sec.1, Sec.3, D.2, D.3
11.	Validation sensor data Optional	Alternative Validation data to DTR edge calculation	Validation data is sent to DTR on edge calculation	CREATE	Validation sensors	DTR calculation code	Inf.11	QoS.3, Sec.1, Sec.3, D.2, D.3
12.	Request to send data via MQTT Optional	Alternative Validation data send to cloud	Validation sensor data request for MQTT broker	EXECUTE	DTR calculation code	MQTT broker	Inf.6	Sec.3, QoS.3, Conf.2
13.	Validation data to cloud Optional	Validation data sending via MQTT	Validation data is sent via MQTT to cloud	EXECUTE	MQTT broker	SUMO cloud	Inf.7	Sec.3, QoS.3, Conf.2, D.4
13.	DTR validation Optional	DTR validation	DTR values is validated with validation sensor data	EXECUTE	SUMO cloud	SUMO cloud		QoS.1
14.	Transformer DTR information Optional	Alternative DTR validation data send to cloud	DTR validation data is send to DSO from cloud, where the validation is taking place	REPORT	SUMO cloud	DSO	Inf.14	QoS.2, D.4, Sec.2, Sec.3

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5 Information exchanged

Information exchanged			
Information exchanged (ID)	***Name of information***	***Description of information exchanged***	***Requirement, R-IDs***
Inf.1	Weather data request	Weather data request for DTR calculation	QoS.3, Conf.1, Sec.1, Sec.2
Inf.2	Weather data	Weather data for DTR	QoS.3, Sec.1, D.2, D.3
Inf.3	Smart meter data request	P, Q, W, U, I data for DTR calculation request	QoS.3, Sec.1, Conf.1, Sec.2
Inf.4	P, Q, W, U, I value	P, Q, W, U, I data from smart meters	QoS.3, Sec.1, D.2, D.3
Inf.6	MQTT request	Request to sand values via MQTT	Sec.3, QoS.3, Conf.2
Inf.7	DTR data to cloud	Data is sent to cloud via MQTT	Sec.3, QoS.3, Conf.2, D.4
Inf.8	Request DTR data	DTR data request from cloud	Sec.3, QoS.5, Conf.2
Inf.9	DTR data	DTR data from cloud to DSO	QoS.2. QoS.4, Sec.1, D.3, D.4
Inf.10	Validation data request	Request of validation sensor data	QoS.3, Sec.1, Sec.3, D.2, D.3
Inf.11	Validation data	Validation sensor data	QoS.3, Sec.1, Sec.3, D.2, D.3
Inf.14	Validated DTR data	Validated DTR data	QoS.2, D.4, Sec.2, Sec.3

6 Requirements

Quality of Service Requirements		
Categories ID	**Category name for requirements**	**Category description**
QoS	Quality of Service	Generic properties that service/SUC should provide – quality attributes.
Requirement R-ID	**Requirement name**	**Requirement description**
QoS.1	IoT device uptime.	Maintain a minimum uptime of 99.5% for IoT devices to ensure continuous data collection and processing
QoS.2	DTR accuracy	DTR calculation must have a mean absolute error of less then +/- 2°C
QoS.3	Real-time data collection	The IoT device must be able to collect data in real time from smart meters and weather providers
QoS.4	Elapsed time response requirements	The system must support responses times below 1 s second for general operations
QoS.5	Frequency of data exchanges	Data exchanges must occur upon event request

Security Requirements		
Categories ID	**Category name for requirements**	**Category description**
Sec	Security	Authentication of user, confidentiality, integrity, prevention of denial of service, non-repudiation or accountability, error management.
Requirement R-ID	**Requirement name**	**Requirement description**

Sec.1	Ensuring confidentiality	Quite important
Sec.2	Information integrity violation prevention	Quite important
Sec.3	Authentication and Access Control	Public key encryption (e.g. SSL/TLS)

	Data Management Requirements	
Categories ID	**Category name for requirements**	**Category description**
D	Data Management	Type of source of data, correctness or validity of data, timeliness or time stamping of data, volume of data, synchronization, or consistency of data across systems, timely access to data, validation of data across organizational boundaries, transaction management, data naming, identification, formats across disparate systems, maintenance of data and databases.
Requirement R-ID	**Requirement name**	**Requirement description**
D.1	Correctness of source data	Source data is usually correct
D.2	Up-to-date management	Received data must be up to date within seconds of source data changing
D.3	Data consistency and synchronization management across systems	Second-by-second synchronization
D.4	IoT Device Specification	IoT devices must meet technological specifications, including processor capabilities, memory, sensor type and connectivity options for efficient edge computing

	Discovery and Configuration Requirements	
Categories ID	**Category name for requirements**	**Category description**
Conf	Configuration	Locations, distances, communication layout, commonly used communication protocol media, network bandwidth, existing protocols, number of devices, systems, volume of data items, expected growth, etc.
Requirement R-ID	**Requirement name**	**Requirement description**

Conf.1	System Integration	IoT devices must be compatible and seamlessly integrated with existing DSO grid infrastructure
Conf.2	Communication media	Both wired and wireless communication media must be supported, depending on infrastructure availability

Other Requirements		
Categories ID	**Category name for requirements**	**Category description**
O	Regulatory obligation related to privacy	2016/679 GDPR (General Data Protection Regulation)
Requirement R-ID	**Requirement name**	**Requirement description**
O.1	Compliance with standards	Devices and processes must comply with European standards, including GDPR.

7 Common Terms and Definitions

Common Terms and Definitions	
Term	**Definition**
DTR	Dynamic Thermal Rating
DSO	Distribution System Operator
BUC	Business use case
SUC	System Use Case
PQ	Power quality
SO	System operator
I	Current
U	Voltage
P	Active Power
Q	Reactive Power
MQTT	Standard for IoT messaging

2 SUC-SI-01.2 – DYNAMIC LINE RATING CALCULATION

1 Description of the use case

1.1 Name of the use case

ID	Area / Domain(s) / Zones(s)	Name of Use Case
SUC-SI-01.2	Integration of IoT devices, optimization of the electrical grid	Dynamic Line Rating calculation

1.2 Version management

Version Management			
Version No.	**Date**	**Name of Author(s)**	**Changes**
0.1	17.5.2024	Urban Bavčar	First draft
0.2	22.05.2024	Marjan Bogataj	Additional content added to 1.4 and 3.1
0.3	20.06.2024	Urban Bavčar	Updated definition and diagram
0.4	12.07.2024	Urban Bavčar	Additional changes based on feedback meeting
0.5	13.9.2024	Urban Bavčar	Updated requirements

1.3 Scope and objectives of use case

Scope and Objectives of Use Case	
Scope	Calculation of the Dynamic Line Rating calculation on a transformer substation and power line
Objective(s)	The objective of DLR edge calculation is to evaluate the SUMO cloud-edge solution's integration with security measures and to determine its suitability for use in a transmission network
Related business case(s)	BUC-SI-01, BUC-SI-02

1.4 Narrative of use case

Narrative of Use Case
Short description
The aim is to set up a test environment for the SUMO cloud-edge solution with real protective devices and actual data from the substation, and to test or validate the solution in a working environment (transmission network). The aim of DLR edge calculation is to evaluate the integration of SUMO cloud-edge with security measures and to determine its suitability for use in a transmission network.
Complete description
The TSO use case (Fast SUMO Edge DLR) includes the SUMO DLR algorithm, which is fed with observations from a local weather station and running in a substation on an embedded system. The DLR results are used to trigger a relay protection device that disconnects a line at when

loading exceeds the limit defined by the relay protection (related to the static limit). Real-time (calculated on a second-by-second basis) DLR and short-term forecasts are calculated locally.

The short-term local weather forecast is calculated based on weather station measurements. The DLR result (ampacity) is conveyed to the protection relay using a standardized protocol, e.g., IEC 61850 (details TBD with ELES' relay protection engineers). The results are also integrated into the SUMO cloud.

In the DSO use case (TrafoFlex Edge DTR), the "Trafoflex" SUMO DTR algorithm runs locally on an embedded system in a secondary substation and calculates the DTR. It can inform the SUMO cloud and other DSO systems (e.g., ADMS) of the transformer's momentary Thermal Capacity or Time to overheat, based on weather conditions, loading, and the historical data (represented by the current top-oil temperature). Real-time (calculated on a minute-by-minute basis) DTR and short-term forecasts are calculated locally.

Both TSO and DSO use cases enhance the operational efficiency, flexibility, and resilience of the system using real-time data collection, processing, and analysis. IoT devices will be deployed at various levels of the system to dynamically monitor and manage grid operations, including energy distribution optimization, maintenance predictions and rapid response to grid disturbances.

1.5 Key performance indicators (KPI)

ID	Name	Description	Reference to mentioned use case objectives
KPI 3	% Of planned usage of HEDGE-IoT tools/data services (e.g., transactions, periodicity) in field demos	Increase DLR edge devices in a TSO grid	1-5
KPI 4	% Of real-time data sharing among stakeholders	Continuously increased real time data	5-15%
KPI 8	IoT/Edge/Fog sites uptime and availability	Maximum uptime in of the deployed devices in the TSO grid	99%
KPI11	Increased grid operational performance	Maximized grid operation based on implemented edge calculation	10%
KPI12	Faster application response times	Rapid DLR calculations	5-15% improvement

1.6 Use case conditions

Use case conditions
Assumptions
- Deploying DLR algorithm on the edge
Prerequisites
- Accurate weather data

1.7 Further Information to the use case for classification / mapping

Classification Information
Relation to other use cases
SUC-SL-01.1 SUC-SL-02.1
Level of depth
Prioritisation
Demo pilot in Slovenia
Generic, regional or national relation
Generic
Nature of the use case
System use case
Further keywords for classification
Dynamic Line Rating

1.8 General Remarks

General Remarks
/

2 Diagrams of use case

Diagram(s) of use case

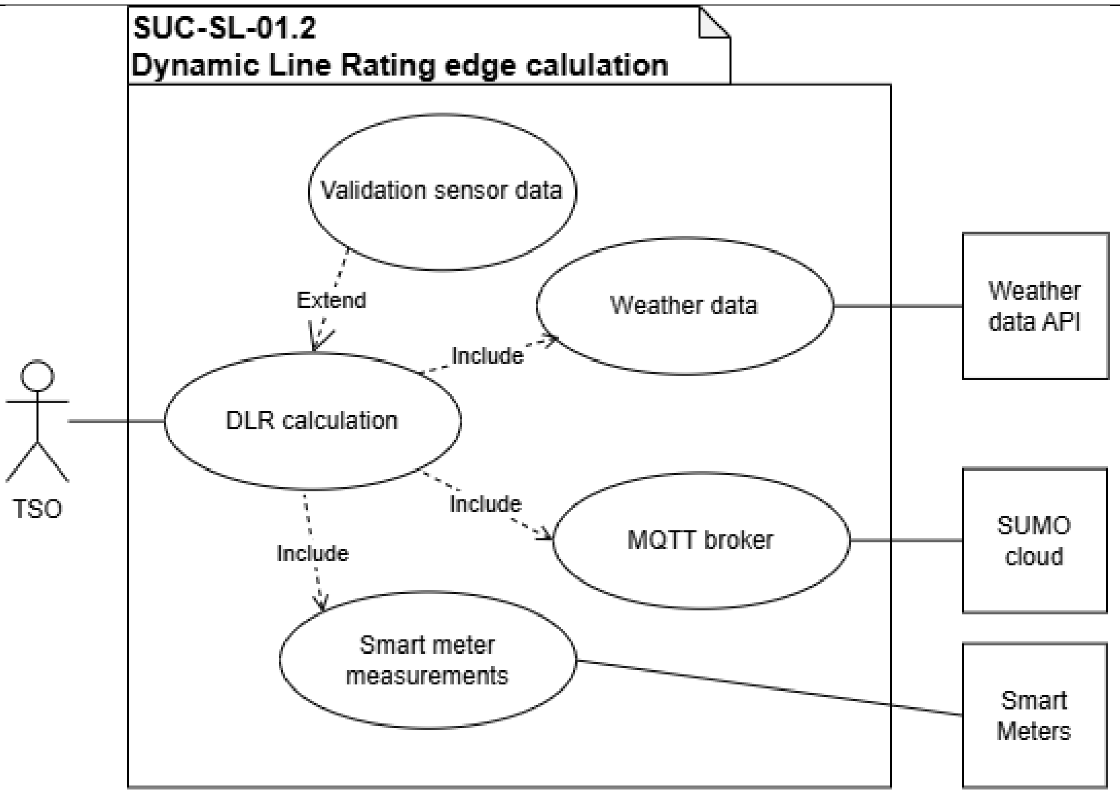

FIGURE 3: UML USE CASE DIAGRAM

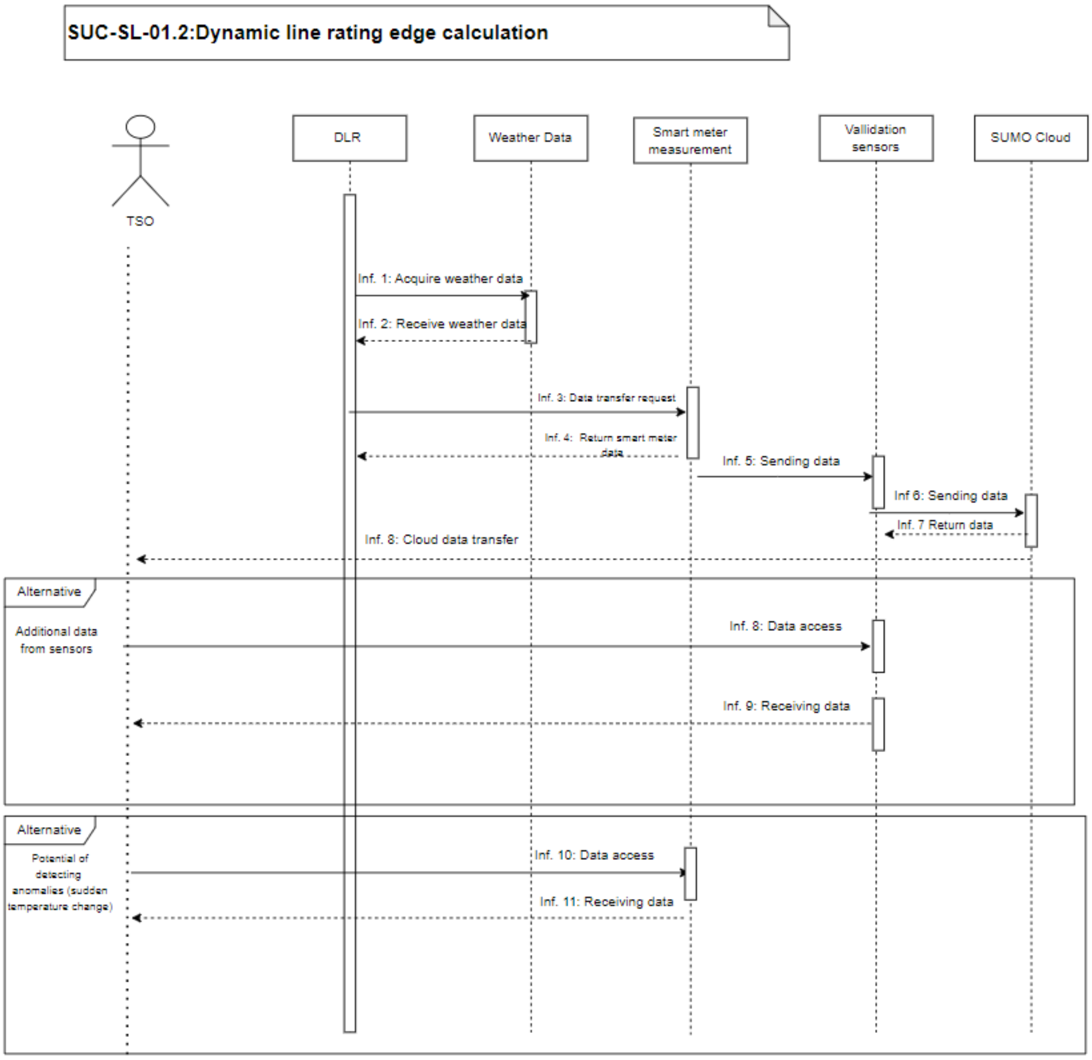

FIGURE 4: UML SEQUENCE DIAGRAM

3 Technical details

3.1 Actors

Actors			
Actor Name	***Actor Type***	***Actor Description***	***Further information specific to this use case***
TSO	Business actor	TSO gathers DLR information from its substations	ELES d.o.o.
SUMO Cloud	Logical actor	Device used for gathering and calculating data	Operato d.o.o.
Weather data API	Logical actor	Provider of weather data to include in the weather calculations	/
Smart meters	Logical actor	Devices used for data gathering	Eles d.o.o.

3.2 References.

References						
No.	*Reference Type*	*Reference*	*Status*	*Impact on use case*	*Originator / organisation*	*Link*

4 Step by step analysis of use case

4.1 Overview of scenarios

Scenario conditions						
No.	**Scenario name**	**Scenario description**	**Primary actor**	**Triggering event**	**Pre-condition**	**Post-condition**
1	Dynamic Line Rating calculation	Edge DLR calculation	SUMO Cloud	Real time environmental changes (wind, temperature) affecting the thermal capacity	DLR Device integration on the TSO grid.	DLR calculations on the edge

4.2 Steps – Scenarios

Scenario								
Scenario name:		Dynamic line rating calculation						
Step No.	***Event***	***Name of process/ activity***	***Description of process/ activity***	***Service***	***Information producer (actor)***	***Information receiver (actor)***	***Information Exchanged (IDs)***	***Requirement, R-IDs***
1	Request weather data	Request data for DLR calculation	IoT device collect Weather data, is sent for DLR calculation	CREATE	DLR	Weather data	Inf.1	QoS.2, Sec.1, D.2
2	Get weather data	Gather weather data	Data is gathered for the calculation	EXECUTE	Weather data API	DLR	Inf. 2	QoS.2, Sec.2, D.3
3	Request data transfer from smart meter	Request data from smart meters	IoT device sands smart meter data request to smart meters	CREATE	DLR	Smart meter	Inf. 3	QoS.3, Conf.3, D.1
4	Get smart meter data	Gathering smart meter data	IoT device gathers data from smart meters, for DTR calculation	EXECUTE	Smart meters	DLR	Inf. 4	D.2, QoS.4
5	Report data to validation sensors	Smart meters send data to Validation sensors	Smart meters send data to Validation sensors	CREATE	DLR	Validation sensors	Inf. 5	D.2, D.3, Sec.1, QoS.3
6.	Request data from validation sensors	Smart meters send data to Validation sensors	Validation sensors gather data	CREATE	Validation sensors	SUMO	Inf. 6	D.2, D.3, Conf.4
7	Get data from validation sensors	SUMO receives data	SUMO receives data from validation sensors	EXECUTE	SUMO Cloud	Validation sensors	Inf. 7	QoS.1, Sec.2, Conf.2
8	Request data from validation sensors	Validation sensors send data	TSO requests data from the validation sensors	CREATE	Validation sensors	TSO	Inf. 8	Conf.4, Sec.1, D.3
9	Get data from sensors	TSO receives data from sensors	Validation sensors data is sent to TSO	EXECTUE	TSO	Validation sensors	Inf. 9	QoS.3, Sec.2, D.3
10	Get data from smart meter measurement	Smart meters send data to TSO	Smart meters send data to TSO	CREATE	Smart meter	TSO	Inf. 10	Conf.3, Sec.1, D.1, QoS.4
11	Smart Meter data	TSO validates the sent data	TSO validates the sent data	EXECUTE	TSO	Smart meter	Inf. 11	D.3, Conf.4, Sec.1

5 Information exchanged

Information exchanged			
Information exchanged (ID)	***Name of information***	***Description of information exchanged***	***Requirement, R-IDs***
Inf. 1	Weather data request	Weather data request for DLR	QoS.2, Sec.1, D.2
Inf. 2	Weather data	Weather data for DLR	QoS.2, Sec.2, D.3
Inf. 3	Smart meter data request	Smart meter data request	QoS.3, Conf.3, D.1
Inf. 4	Smart meter data	Smart meter data for DLR	D.2, QoS.4
Inf. 5	Validation sensors request data	Request data from smart meteres	D.2, D.3, Sec.1, QoS.3
Inf. 6	Get data from validation sensors	Get data from validation sensors	D.2, D.3, Conf.4
Inf. 7	Data from validation sensors	SUMO receives validation sensors data	QoS.1, Sec.2, Conf.2
Inf. 8	Request validation sensor data	TSO request validation sensors data	Conf.4, Sec.1, D.3
Inf. 9	Validation sensor data	TSO receives validator sensors data	QoS.3, Sec.2, D.3
Inf. 10	TSO request smart meter measurements	TSO request smart meter measurements	Conf.3, Sec.1, D.1, QoS.4
Inf. 11	Smart meter measurements	TSO receives smart meter measurements	D.3, Conf.4, Sec.1

6 Requirements

Quality of Service Requirements		
Categories ID	**Category name for requirements**	**Category description**
QoS	Quality of Service	Quality of the attributes
Requirement R-ID	**Requirement name**	**Requirement description**
QoS.1	Device uptime	95% minimum uptime
QoS.2	Real time data collection	Collecting real-time weather data from meters
QoS.3	Response time	Below 1s for general and critical operations
QoS.4	DLR accuracy	Mean skin temperature error +/- 5°C.

Security Requirements		
Categories ID	**Category name for requirements**	**Category description**
Sec	Security	Confidentiality and proper authentication
Requirement R-ID	**Requirement name**	**Requirement description**
Sec.1	Ensuring confidentiality	Very Important
Sec.2	Information integrity violation prevention	Quite important
	Data Management Requirements	

Categories ID	Category name for requirements	Category description
D	Data Management	Source, volume and validity of data, consistency, synchronization, real-time access
Requirement R-ID	**Requirement name**	**Requirement description**
D.1	Validity of source data	Data source must be correct
D.2	Real-time access	Data available within seconds of change
D.3	Data consistency	Instant synchronization

Discovery and Configuration Requirements		
Categories ID	**Category name for requirements**	**Category description**
Conf	Configuration	Distance and location to the substation/powerline, number of devices and its specifications
Requirement R-ID	**Requirement name**	**Requirement description**
Conf.1	Distance and location to the substation/powerline	The device must be in close vicinity to the provided powerline and substation
Conf.2	Number of devices	Up to 5 devices
Conf.3	Integration	Seamless integration to the infrastructure
Conf.4	Communication media	Wired and wireless communication

Other Requirements		
Categories ID	**Category name for requirements**	**Category description**
O	Regulatory obligation related to privacy	2016/679 GDPR (General Data Protection Regulation)
Requirement R-ID	**Requirement name**	**Requirement description**
O.1	Compliance with standards	Devices are in compliance with European standards

3 SUC.SL.02.1 – SEMANTIC MODEL OF THE SUBSTATION

1 Description of the use case

1.1 Name of the use case

ID	*Area / Domain(s) / Zones(s)*	*Name of Use Case*
SUC.SL.02.1	Distribution system, Network management, IEC CIM	Semantic model of the substation

1.2 Version management

Version Management			
Version No.	*Date*	*Name of Author(s)*	*Changes*
1.0	30.04.2024	Josipa Stegić, Leila Luttenberger Marić, Ivan Krajnović, Siniša Sekulić	Document initiation
2.0	14.05.2024.	Josipa Stegić, Leila Luttenberger Marić, Ivan Krajnović, Siniša Sekulić	First version of SUC definition.
3.0	24.05.2024.	Josipa Stegić, Leila Luttenberger Marić, Ivan Krajnović, Siniša Sekulić	Second version of SUC definition.
4.0	18.06.2024.	Josipa Stegić, Leila Luttenberger Marić, Ivan Krajnović, Siniša Sekulić	Third version of SUC definition.
5.0	18.07.2024.	Josipa Stegić, Leila Luttenberger Marić, Ivan Krajnović, Siniša Sekulić	Fourth version of SUC definition.
6.0	13.08.2024.	Josipa Stegić, Leila Luttenberger Marić, Ivan Krajnović, Siniša Sekulić	Document update.
7.0	06.09.2024.	Josipa Stegić	Document update.

1.3 Scope and objectives of use case

Scope and Objectives of Use Case	
Scope	A semantically unified model for power grid stakeholders
Objective(s)	1. Collecting and merging models from separate systems. 2. Providing a standardized model to different system stakeholders.

Related business case(s)	BUC-SL-02

1.4 Narrative of use case

Narrative of Use Case
Short description
This use case requires data from subsystems owned by the System Operator (DSO), e.g. IoT devices, measurement and environment models, Geographic Information System (GIS), etc. Output data related to the Dynamic Thermal Rating/Dynamic Line Rating (DTR/DLR) edge calculation, performed in SUC.SL.01.1 and SUC.SL.01.2, will be used to design the unified model. The PowerCIM platform will serve as a semantic model of the substation, incorporating weather data, and providing a reference point for further analyses conducted by the DSO or Data analysts for network analysis, planning, and various operational tasks related to managing of the distribution network. The solution allows different stakeholders to access data without needing to use the individual subsystems that serve as data sources. This function ensures interoperability, consistency, and standardized data usage across the platform.
Complete description
This UC facilitates the integration of models from different systems within the distribution network, including GIS, measurement and environmental models. The subsystems utilized by the DSO are typically isolated and do not communicate with one another. The implementation of this use case addresses the challenges of achieving interoperability and data standardization, identifying redundancy, and eliminating discrepancies across different data sources. The function involves retrieving models and data from various sources such as GIS, DTR/DLR calculation and metering and environmental models to provide a comprehensive semantic model of the substation. This unified model allows DSOs and data analysts to access a consolidated model to perform various calculations and analyses essential for the management and planning of the distribution network. Modifications are made directly in the original data source systems, ensuring that the primary data remains up-to-date and accurate. In PowerCIM, the collected data is searched, validated, and identifiers are assigned to individual components, ensuring consistency and reliability across the system. This approach improves data integrity and provides a solid basis for informed decision-making in network operations and planning. • This use case includes several steps: Data Collection from separate systems • Model integration and data verification • Design of the semantic model • Create a semantic model of the substation • Serving unified and verified data to different stakeholders

1.5 Key performance indicators (KPI)

ID	Name	Description	Reference to mentioned use case objectives
1	*Number of systems integrated in unified semantic model*	Integration of various sources from Demo 6, such as GIS, DTR edge, DLR edge, Environmental model etc., into unified and standardized semantic model.	Demonstrates the ability of the solution to integrate different data sources into standardized and verified semantic model. Enabling scalability and interoperability of various system within the electric grid.

1.6 Use case conditions

Use case conditions
Assumptions
• Separate systems with different functions within a distribution network. • Data and model storage in various formats. • The systems do not exchange data with each other. • Request for system interoperability.
Prerequisites
• Installed systems with models ready for further implementation.

1.7 Further Information to the use case for classification / mapping

Classification Information
Relation to other use cases
Linked to SUC.SL.01.1: • The results of the DTR calculation are being used as input for developing the Semantic model of the substation. Linked to SUC.SL.02.1: • The results of the DLR calculation are being used as input for developing the Semantic model of the substation. Linked to SUC.SL.02.2: • The semantic model of the substation is used for the development of ML algorithms. Semantic data are utilized, as well as a reference for understanding the obtained data related to the substation.
Level of depth
Prioritisation
To be demonstrated in Slovenian pilot.
Generic, regional or national relation
Generic
Nature of the use case
System use case
Further keywords for classification
IEC CIM, interoperability, standardization

1.8 General Remarks

General Remarks

2 Diagrams of use case

Diagram(s) of use case

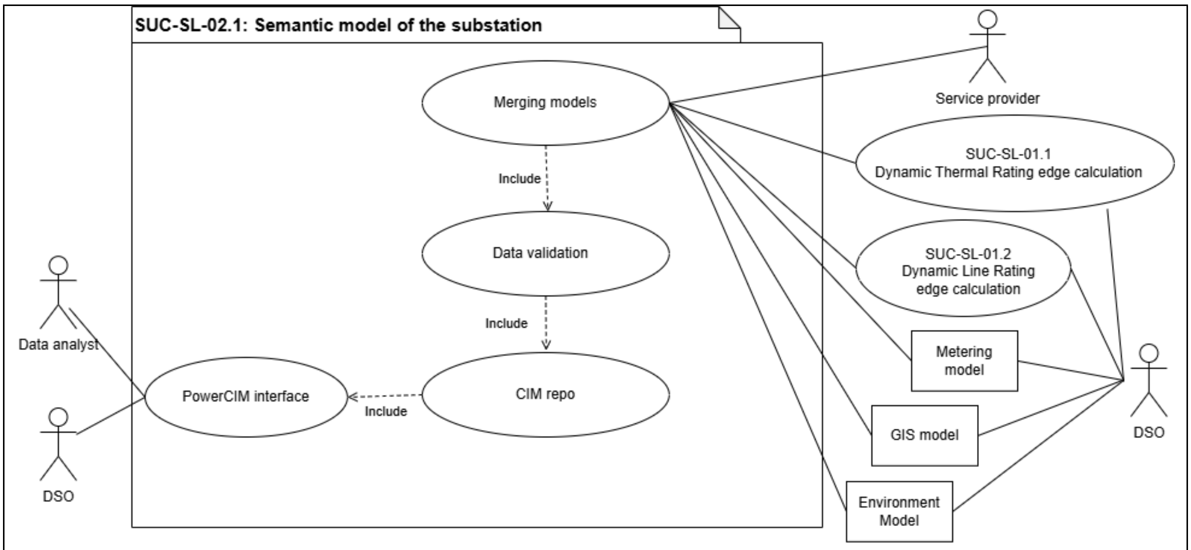

FIGURE 5 UML USE CASE DIAGRAM

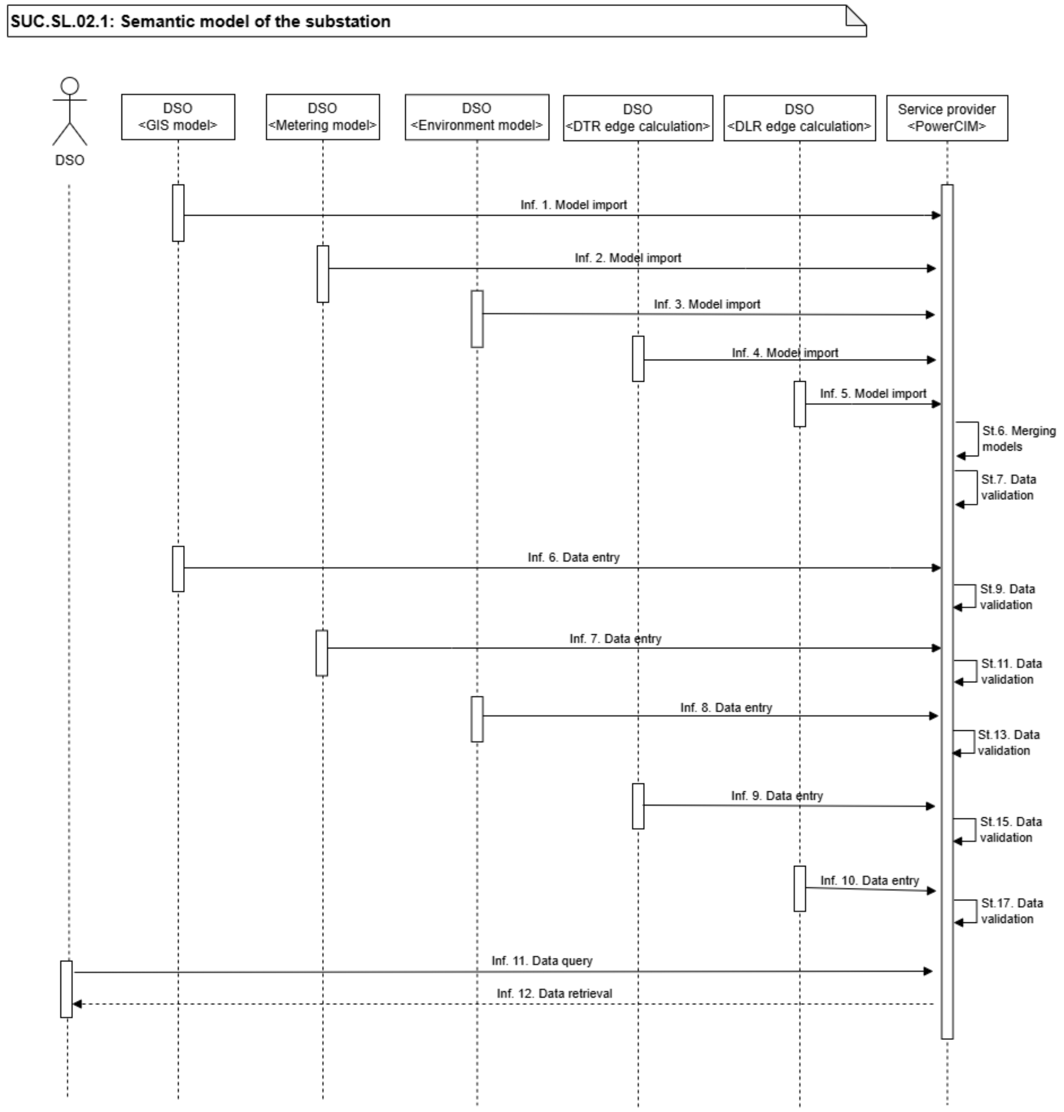

FIGURE 6 UML SEQUENCE DIAGRAM

3 Technical details

3.1 Actors

Actors			
Actor Name	***Actor Type***	***Actor Description***	***Further information specific to this use case***
DSO	Business Actor	A party responsible for operating, ensuring the maintenance of and, if necessary, developing the system in a given area and, where applicable, its interconnections with other systems, and for ensuring the long-term ability of the system to meet reasonable demands for the distribution or transmission of energy.	Elektro Gorenjska
GIS model	Logical Actor	GIS contains spatial data related to the distribution network, i.e. it shows the configuration of the network.	Elektro Gorenjska
Environment model	Logical Actor	Weather data related to a specific substation and used to create a semantic model of the substation.	
Metering model	Logical Actor	Data related to smart meters and sensors that will be used for design of the Semantic model of the substation.	Elektro Gorenjska
DTR edge calculation	Logical Actor	Calculated DTR values used to create the substation semantic model. (SUC-SL-01.1)	Elektro Gorenjska
DLR edge calculation	Logical Actor	Calculated DLR values used to create the substation semantic model. (SUC-SL-01.2)	Elektro-Slovenija
Data analyst	Business Actor	The business actor utilizes the CIM model for semantic identification of components and as a tool in analysing data obtained from various non-aligned systems.	Faculty of electrical engineering and computing, Zagreb
Service provider	Business Actor	The service provider performs the service of extending the semantic model and upgrading existing modules.	Končar Digital

3.2 References

References						
No.	***Reference Type***	***Reference***	***Status***	***Impact on use case***	***Originator / organisation***	***Link***

4 Step by step analysis of use case

4.1 Overview of scenarios

Scenario conditions						
No.	**Scenario name**	**Scenario description**	**Primary actor**	**Triggering event**	**Pre-condition**	**Post-condition**
Sc. 1	Semantic model of the substation	The solution supports various functionalities that enable easy and standardized	Service provider	Issues of interoperability and data interpretation arise. The subsystems	Within the distribution network, various subsystems store data in	A unified and standardized semantic model of the substation

		access to a unified model of the substation.		have been implemented and ready for further use.	different formats and lack interoperability. Standardizing data exchange and unifying component identifiers are necessary to enable further data usage and simplify interpretation.	has been implemented for use by various stakeholders within the distribution network.

4.2 Steps – Scenarios

Scenario								
Scenario name:		Semantic model of the substation						
Step No.	***Event***	***Name of process/ activity***	***Description of process/ activity***	***Service***	***Information producer (actor)***	***Information receiver (actor)***	***Information Exchanged (IDs)***	***Requirement, R-IDs***
St. 1	Data available from GIS	Model import	PowerCIM requests new IEC 61970-552 CIM XML formatted network model data from the GIS system for creating semantic model of the substation. The data includes network assets, geographic layout, physical connectivity and network element parameters.	GET	GIS model	PowerCIM	Inf. 1	D.1, D.2, D.3, D.6, O.1, Conf.1
St. 2	Metering system measurement model data available	Model import	PowerCIM requests new Metering model for creating semantic model of the substation. The data includes electrical measurement points/sensors, telemetry system measurement identifiers and references to the elements the measurements apply to.	GET	Metering model	PowerCIM	Inf. 2	D.1, D.2, D.3, D.6, O.1, Conf.1
St. 3	Environment model data available	Model import	The data includes various temperature and weather measurement points/sensors and references to the elements the measurements apply to.	GET	Environmental model	PowerCIM	Inf. 3	D.1, D.2, D.3, D.6, O.1, Conf.1
St. 4	DTR/DLR parameter update	Model import	Models and data stored in the DTR edge are input for creating a unified semantic model of the substation.	GET	DTR edge	PowerCIM	Inf. 4	D.1, D.2, D.3, D.6, O.1, Conf.1

St.5	DLR parameter update	Model import	Models and data stored in the DLR edge are input for creating a unified semantic model of the substation.	GET	DLR edge	PowerCIM	Inf. 5	D.1, D.2, D.3, D.6, O.1, Conf.1
St. 6	Changes have been made in the subsystem by the User	Merging models	Merging models into a unified and standardized semantic model of the substation.	EXECUTE	PowerCIM	PowerCIM	x	D.4
St. 7	Data validation is required at each exchange	Data validation	The solution validates data retrieved from separate subsystems on each data exchange.	EXECUTE	PowerCIM	PowerCIM	x	D.4, D.5, D.7
St. 8	Changes have been made in the subsystem by the User	Data entry	PowerCIM requests IEC 61970-552 CIM XML formatted network model data from the GIS system and imports the changes to the PowerCIM repository GIS model branch creating a new GIS model version.	CHANGE	GIS model	PowerCIM	Inf. 5	D.2, D.3, D.6, O.1, Conf.1
St. 9	Data validation is required at each exchange	Data validation	The solution validates data retrieved from separate subsystems.	EXECUTE	PowerCIM	PowerCIM	x	D.4, D.5, D.7
St. 10	Changes have been made in the subsystem by the User	Data entry	User edits a measurement model template table. PowerCIM applies changes to relevant substation models updating the measurement point models.	CHANGE	Metering model	PowerCIM	Inf. 6	D.1, D.2, D.3, D.6, O.1, Conf.1
St. 11	Data validation is required at	Data validation	The solution validates data retrieved from separate subsystems.	EXECUTE	PowerCIM	PowerCIM	x	D.3, D.4, D.6

	each exchange							
St. 12	Changes have been made in the subsystem by the User	Data entry	DSO edits a substation environment model template table. PowerCIM applies changes to all substation models using this template creating new versions of the substation models.	CHANGE	Environment model	PowerCIM	Inf. 7	D.1, D.2, D.3, D.6, O.1, Conf.1
St. 13	Data validation is required at each exchange	Data validation	The solution validates data retrieved from separate subsystems.	EXECUTE	PowerCIM	PowerCIM	x	D.4, D.5, D.7
St. 14	Changes are being made in the DTR edge	Data entry	PowerCIM applies changes to relevant substation models updating DTR edge outputs.	CHANGE	DTR edge	PowerCIM	Inf. 8	D.1, D.2, D.3, D.6, O.1, Conf.1
St. 15	Data validation is required at each exchange	Data validation	The solution validates data retrieved from separate subsystems.	EXECUTE	PowerCIM	PowerCIM	x	D.4, D.5, D.7
St. 16	Changes are being made in the DLR edge	Data entry	PowerCIM applies changes to relevant substation models updating DLR edge outputs.	CHANGE	DLR edge	PowerCIM	Inf. 9	D.1, D.2, D.3, D.6, O.1, Conf.1
St. 17	Data validation is required at each exchange	Data validation	The solution validates data retrieved from separate subsystems.	EXECUTE	PowerCIM	PowerCIM	x	D.4, R5, R7
St. 18	Data validation is required at each exchange	Data query	DSO seeks access to validated data related to the substation for analysis and subsequent calculations in operational processes and	GET	DSO	PowerCIM	Inf. 10	O.1

			network planning.					
St. 19	PowerCIM receives a request for data exchange	Data retrival	PowerCIM serves validated data.	EXECUTE	PowerCIM	DSO	Inf. 11	D.2, D.3, D.4, D.5, D.6, D.7, O.1, Conf.1

5 Information exchanged

Information exchanged			
Information exchanged (ID)	***Name of information***	***Description of information exchanged***	***Requirement, R-IDs***
Inf. 1	Network model	CIM network model (geographic + network elements + topology + network element parameters)	D.1
Inf. 2	Substation electrical measurement model	Substation electrical measurement model (measurement points/sensors + monitored physical elements)	D.1
Inf. 3	Substation environment measurement model	Substation environment measurement model (measurement points/sensors + monitored physical elements)	D.1
Inf. 4	DTR and DLR results	Output results from DTR and DLR edge calculations that are implemented in SUC-SL-01.1. and SUC-SL-01.2.	D.1
Inf. 5	Updates and changes in the GIS	Updates and modifications are entered into the subsystem (GIS) used by the Distribution system operator.	D.2
Inf. 6	Updates and changes in the Metering system	Updates and modifications are entered into the Metering model used by the Distribution system operator.	D.2
Inf. 7	Updates and changes in the environmental system	Updates and modifications are entered into the Environmental model used by the Distribution system operator.	D.2
Inf. 8	Updates and changes in the DTR/DLR edge	Updates and modifications are entered into the DTR edge used by the Distribution system operator.	D.2
Inf. 9	Updates and changes in the DLR edge	Updates and modifications are entered into the DLR edge used by the Distribution system operator.	D.2
Inf. 10	Data access request	Request for validated data related to the substation.	D.2, D.3, O.1
Inf. 11	Unified CIM model	Unified and validated CIM substation and network model (Inf. 1 + Inf. 2 + Inf. 3 + Inf. 4)	D.2, D.3, D.4, D.5, D.6, D.7, O.1, Conf.1

6 Requirements

Requirements		
Categories ID	**Category name for requirements**	**Category description**
D	Data Management Issues	Type of source of data, correctness or validity of data, timeliness or time stamping of data, volume of data, synchronization, or consistency of data across systems, timely access to data, validation of data across organizational boundaries, transaction management, data naming, identification, formats

		across disparate systems, maintenance of data and databases.
Requirement R-ID	**Requirement name**	**Requirement description**
D.1	Correctness of source data	Data should be correct.
D.2	Management of accessing different types of data to be exchanged	Data and models exchanges go every few days or weeks.
D.3	Management of data across organizational boundaries	Data exchanges go across boundaries between system developed by different vendors.
D.4	Naming of data items	Components need to be assigned unique identifiers.
D.5	Validation of data exchanges	All data must be validated on each data exchange.
D.6	Management of large volumes of data that are being exchanged	The solution facilitates the utilization and management of large models along with their dependencies.
D.7	Data verification	The solution enables data accuracy verification.

Requirements		
Categories ID	**Category name for requirements**	**Category description**
O	Regulatory obligation related to privacy	2016/679 GDPR (General Data Protection Regulation)
Requirement R-ID	**Requirement name**	**Requirement description**
O.1	Data privacy	It is necessary to ensure secure data exchange.

Requirements		
Categories ID	**Category name for requirements**	**Category description**
Conf	Configuration	Locations, distances, communication layout, commonly used communication protocol media, network bandwidth, existing protocols, number of devices, systems, volume of data items, expected growth, etc.
Requirement R-ID	**Requirement name**	**Requirement description**
Conf.1	Commonly used data model	Include here the data models used for the information exchange. This relates to the Information Layer – Canonical Data Model view in SGAM.

7 Common Terms and Definitions

Common Terms and Definitions	
Term	**Definition**
DSO	Distribution system operator
DTR	Dynamic thermal rating
DLR	Dynamic line rating

GIS	Geographic information system
CIM	Common information model

4 SUC-SL-02.2 – ML ALGORITHM FOR ENHANCED NETWORK MANAGEMENT AND PLANNING

1 Description of the use case

1.1 Name of the use case

ID	Area / Domain(s) / Zones(s)	Name of Use Case
SUC-SI-02.2	Distribution system, DER, substation	ML algorithm for enhanced network management and planning

1.2 Version management

Version Management			
Version No.	Date	Name of Author(s)	Changes
1.0	10.05.2024.	Tomislav Antić	Document initiation
1.1.	15.05.2024.	Tomislav Antić, Tomislav Capuder	First draft version of SUC-SI-02.2
2.0.	16.05.2024.	Tomislav Antić, Tomislav Capuder	Revision of SUC-SI-02.2
2.1.	24.05.2024.	Tomislav Antić, Tomislav Capuder	Revision of SUC-SI-02.2
2.2	28. 06.2024.	Tomislav Antić	Revision of SUC-SI-02.2
3.0	12.07.2024.	Tomislav Antić	Revision of SUC-SI-02.2
3.1.	19.07.2024.	Tomislav Antić	Revision of SUC-SI-02.2
4.0.	04.09.2024.	Tomislav Antić	Changing "Requirements" according to the IEC 62559-2 template

1.3 Scope and objectives of use case

Scope and Objectives of Use Case	
Scope	Helping DSOs to enhance planning and operation of smart distribution networks by relying on IoT devices and advanced ML algorithms.
Objective(s)	1. Data analysis, detection of errors in measurements and development of methods for errors removing 2. Identification of DERs in secondary distribution networks 3. Forecast of technical parameters measured at secondary substations
Related business case(s)	BUC-SI-02,

1.4 Narrative of use case

Narrative of Use Case
Short description
This system use case aims to identify relevant measurements and fully utilise their potential in helping DSOs enhance the planning and operation of distribution networks. Three solutions are applied in the use case, each representing a separate machine learning (ML) algorithm. The first ML algorithm is used for preprocessing measurements collected from installed IoT devices, specifically identifying and removing anomalies in data, preventing its use in further application in the planning and operation of distribution networks. The second solution involves detecting of DERs in the network after the transformation in the substation. Based on measured technical parameters (power, voltage, current) and weather data, the ML algorithm provides demand or generation curves and the DER installed capacity. The final algorithm uses ML techniques to predict the values of measured values.
Complete description
The system use case aims to DSOs in planning and managing distribution networks by applying ML algorithms for to process the measurements collected from installed IoT devices. In total, three ML algorithms will be applied in this system use case. The DSO is first requested to provide collected data and electrical measurements (power, voltage, currents). Additionally, weather data collected at the geolocation and substation will be used in the network analyses that will be conducted in this system use case. Furthermore, the calculation of DTR and DLR performed in related system use cases are used to improve the accuracy of algorithms and make the conclusions more applicable to the network planning and management. Finally, the substation semantic model will be used to better understand and analyse collected data, as well as to match the measurements with specific substation through the unique identification process. The SUC is separated into two different scenarios. Although all algorithms are based on ML techniques, the scenarios require different data, and separate algorithms are used for each. The first algorithm is not a scenario on its own, but it serves as a prerequisite for successful implementation of both scenarios and is integrated into each. The algorithm is an anomaly detection algorithm, which detects measurements that in some ways do not fit with the rest of the data, e.g., if measured voltage values are around 400 V, an occurrence of 4,000 V can be identified as an outlier. Once such anomalies are detected, they are removed and replaced with more appropriate values by applying statistical analysis and techniques. This functionality is applied each time measured data is requested and collected. Furthermore, data pre-processing is essential before applying any network analysis, as using invalid measurements can lead to the wrong conclusions and endanger the safe and reliable operation of the distribution network. Although the DSO provides the data and the data analyst is the primary user of data, the results of applying the algorithm can also be valuable for the DSO since they provide better insight into measured values and serve as a warning if something is wrong for an extended period. The second ML tool is used in the DER detection and capacity assessment, and is a crucial part of the first scenario in this SUC. In this scenario, fully processed electrical and weather measurements, resulting from the anomaly detection and removal process, are used in network planning. Unlike the first functionality tested in the use case, this tool is not applied continuously. Once a specific DER technology is detected, its capacity will not change rapidly, i.e., there is no need to use the tool in the near real-time operation. The tool is more useful during the planning stage, since the DSO can apply the product in assessing the contribution of DERs to the aggregated demand curve measured at the substation level. After the detection, there is no need to continuously run the analysis. The trigger for the new analysis is the change in demand pattern of the values of some other electrical values such as voltage magnitude. Having detected the existing DER capacity on a substation level enables the calculation of the network's the hosting capacity, considering the calculated DTR for the specific substation. In the second scenario, ML algorithms are used to forecast the values of electrical parameters measured at the substation level. The tool can be used both in the planning and operation stages, but the main idea is for the DSO to use it in network operation, either day-ahead or timestep-

ahead. Accurate forecasts are a prerequisite for the safe operation of distribution networks, especially in ones with the high share of intermittent and unpredictable DERs. Novel algorithms help overcome these challenges, allowing DSOs to rely on the algorithm important for identifying what comes next at the substation level.

1.5 Key performance indicators (KPI)

ID	Name	Description	Reference to mentioned use case objectives
KPI_1	*Number of AI/ML tools edge-cloud tools for consumers*	Number of developed AI/ML tools that will be developed and used in this SUC	The objective is to improve the distribution system's observability and enhance the planning and operation by exploiting the efficiency of developed AI/ML tools for different purposes states as the objectives of this SUC. The goal is to have **3** fully developed and tested AI/ML algorithms that will be used in the demo site by the end of **Y3**.
KPI_{22}	*Increase DERs participation in flexibility provision*	The increase in flexibility potential in secondary distribution networks provided by DERs	The installed capacity of DERs in secondary distribution networks is identified in this SUC. By controlling the operational region of DERs, it is possible to increase the network's flexibility through different approaches. The goal is in line with the one set in the grant agreement, 5% Y1, 10% Y2, 15% Y3, 20% Y4, 25% Y5+.

1.6 Use case conditions

Use case conditions
Assumptions
• Separate systems with different functions within a distribution network. • Data and model storage in various formats. • The systems do not exchange data with each other. • Request for system interoperability.
Prerequisites
• Installed metering devices in a sufficient number of nodes • Availability of historical measurements with a satisfactory accuracy

1.7 Further Information to the use case for classification / mapping

Classification Information
Relation to other use cases
Linked to BUC-SL-02: Enhanced network manageability and observability. Linked to SUC-SL-02.1: Semantic model of the substation Linked to SUC-SL-01.1: Dynamic Thermal Rating edge calculation.
Level of depth
Prioritisation
Generic, regional or national relation
Nature of the use case

Further keywords for classification

1.8 General Remarks

General Remarks

2 Diagrams of use case

Diagram(s) of use case

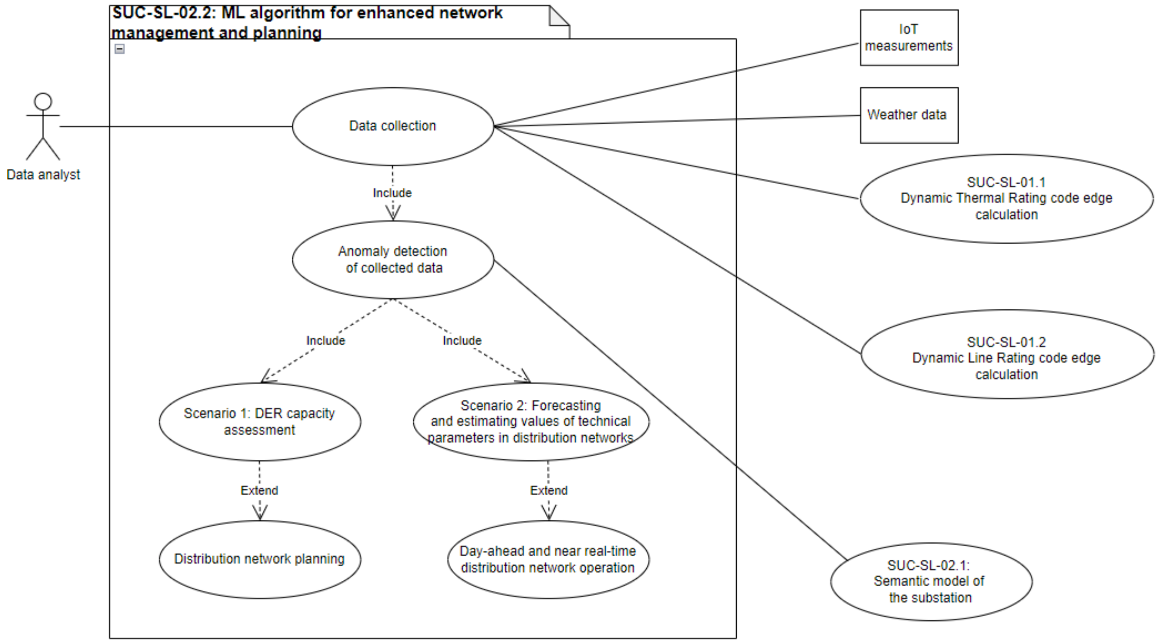

FIGURE 7: UML USE CASE DIAGRAM

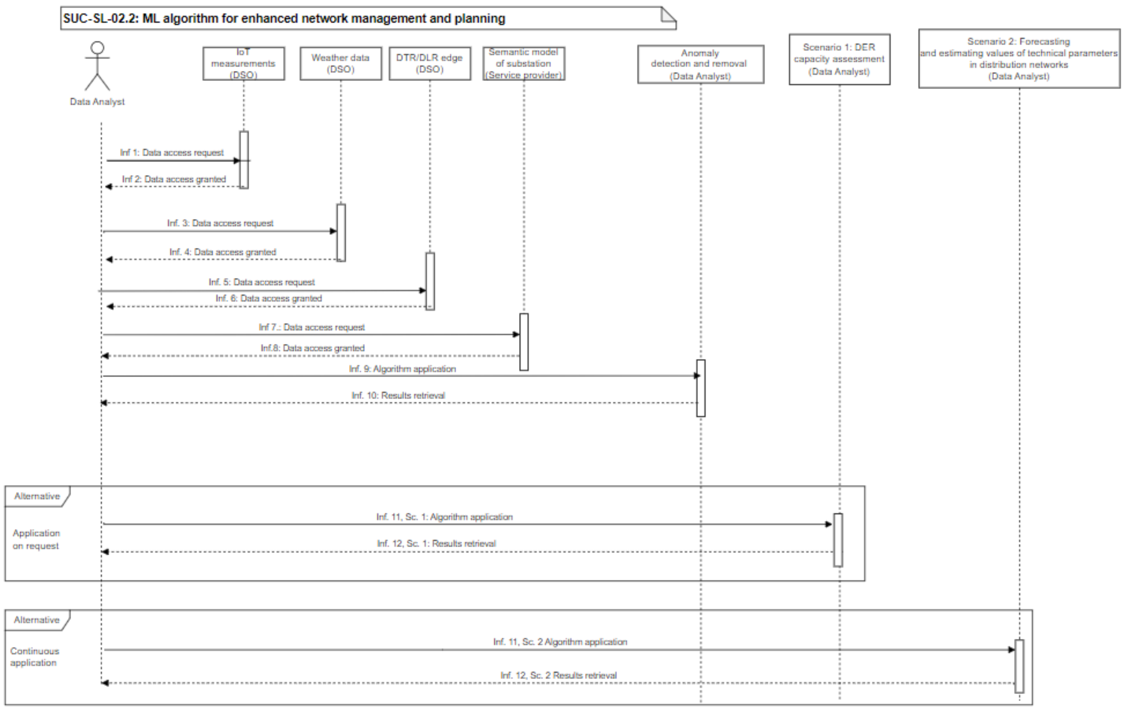

FIGURE 8: UML SEQUENCE DIAGRAM

3 Technical details

3.1 Actors

Actors			
Actor Name	***Actor Type***	***Actor Description***	***Further information specific to this use case***

DTR edge	Logical Actor	Calculated values of DTR that are input in ML algorithms in this SUC (BUC-SI-01, SUC-S1_01.1)	Elektro Gorenjska
DLR edge	Logical Actor	Calculated values of DLR that are input in ML algorithms in this SUC. (BUC-SI-01, SUC-S1_01.2)	ELES DOO Sistemski Operater Prenosnega Elektroenergetskega Omrezja
IoT devices	Logical Actor	Besides increasing the network's observability, IoT devices installed in distribution networks are used to measure and collect electrical values, enabling defined analyses.	Elektro Gorenjska
Weather stations	Logical Actor	Weather station measurements and weather data in the demo, in general, help to improve the accuracy of ML algorithms and to find the correlation between different measured and forecasted/detected electrical values.	Elektro Gorenjska
DERs	Logical Actor	By conducting analyses with one of the developed ML algorithms, different DERs located after the transformation in a substation will be identified. The goal is to identify the installed capacity and generation/consumption patterns of weather-dependent DERs, such as PVs or heat pumps/air conditioners. Also, in this SUC, the investigation of the possibility of identifying EV charging patterns will be conducted.	Elektro Gorenjska
DSO	Business Actor	DSO is an actor responsible for planning and operating distribution networks. It is also an actor that is affected the most by the changes in the network. Therefore, DSOs will need to start relying on more advanced tools based on ML techniques. An example of such tools is developed within this SUC. The goal is to demonstrate the DSO functionalities of the tools, which will be used in the planning stage and day-to-day operation.	Elektro Gorenjska
Semantic model of the substation	Logical Actor	A software solution offering a semantic model of a substation integrates data from disparate, non-communicating systems within the DSO. It functions as a library associating identifiers and various metadata with components, facilitating understanding and data retrieval for use in ML and algorithms.(SUC-SI-02.1)	Koncar Digital

3.2 References

References						
No.	***Reference Type***	***Reference***	***Status***	***Impact on use case***	***Originator / organisation***	***Link***

4 Step by step analysis of use case

4.1 Overview of scenarios

Scenario conditions						
No.	**Scenario name**	**Scenario description**	**Primary actor**	**Triggering event**	**Pre-condition**	**Post-condition**
Sc. 1	DER capacity assessment	The solution enables identifying the capacity and generation/consumption patterns of DERs installed in secondary distribution networks.	Data Analyst	The installed capacity of DERs does not frequently change and the algorithm is triggered once the changes in the analysed patterns are detected. For identifying the consumption and generation patterns, the algorithm is continuously running.	Metering devices are installed in distribution networks and they are continuously measuring data which is then stored in database. The database needs to be accessible on request.	Fully developed and implemented algorithm for enhancing distribution network planning in the presence of the high share of DERs and increasing the network's observability.
Sc. 2	Forecasting and estimating values of technical parameters in distribution networks	The solution enables forecast of technical measurements with the increased accuracy. Electricity demand and generation, if existing, are technical measurements forecasted in the highest number of cases. However, in case of collecting some other measurements and their values, those can also be forecasted and also used in finding correlation between different parameters.	Data Analyst	There is no specific triggering event since the algorithm is planned to be used on a day-to-day basis in the operation of distribution networks.	Availability of historical measurement of the values that are forecasted so the algorithm can be trained and used by a DSO	Fully developed algorithm enhancing the operation of distribution networks and allowing DSOs to use the tool and improve the needed forecast accuracy.

4.2 Steps – Scenarios

Scenario								
Scenario name:		DER capacity assessment						
Step No.	***Event***	***Name of process/ activity***	***Description of process/ activity***	***Service***	***Information producer (actor)***	***Information receiver (actor)***	***Information Exchanged (IDs)***	***Requirement, R-IDs***
St. 1	Data available from substation measurements	Data retrieval	The data includes measurements of different technical parameters at the substation level, including electricity demand and generation, voltage and current measurements, etc.	GET	DSO	Data Analyst	Inf. 1 and Inf. 2	QoS.1 QoS.2, QoS.3, QoS.5, D.1, D.2, D.3, D.7, Conf.1, Conf.4, Conf.5, Conf.6, O.X
St. 2	Weather data	Data retrieval	The data includes various temperature and weather measurement values	GET	Weather stations	Data Analyst	Inf. 3 and Inf. 4	QoS.1 QoS.2, QoS.3, QoS.5, D.1, D.2, D.3, D.7, Conf.1, Conf.4, Conf.5, Conf.6, O.X
St. 3	Calculating DTR/DLR values	Data retrieval	Calculation of DTR and DLR values needed for further analyses	GET	DSO	Data Analyst	Inf. 5 and Inf. 6	QoS.2, QoS.3, QoS.5, D.2, D.3, D.4, D.6, D.7, D.8, Conf.1
St. 4	Accessing data	Data query	The request to access the data needed by the data analyst for distribution network analyses	GET	DSO	Data Analyst	Inf. 1, Inf. 2, Inf. 3, Inf. 4, Inf. 5, Inf. 6	QoS.1, QoS.4, Sec.1, Sec.2, D.4, D.6, D.7, D.8, Conf.1, Conf.2, Conf.3, Conf.4, Conf.5, Conf.6, O.X
St. 5	Semantic model of substation	Data retrieval	Enabling the connecting electrical measurements and weather data to a specific substation	GET	Service provider	Data Analyst	Inf. 7 and Inf. 8	QoS.1 QoS.2, QoS.3, QoS.5, D.1, D.2, D.3, D.7, Conf.1, Conf.4, Conf.5, Conf.6, O.X
St. 6	Identifying anomalies in	Data validation	Based on analysing the accessed data and	Execute	Data Analyst	DSO, Data Analyst	Inf. 9 and Inf. 10	QoS.2, QoS.4, D.2, D.4, D.6, D.7,

	data		identifying certain patterns, measurements that should not be a part of the set are identified					Conf,1, Conf.2, Conf.3, Conf.4, Conf.5, Conf.6
St. 7	Removing anomalies from the dataset	Data validation	Identified anomalies need to be removed before using them in any further analysis	Execute	Data Analyst	DSO, Data Analyst	Inf. 9 and Inf. 10	QoS.2, QoS.4, D.2, D.4, D.6, D.7, Conf,1, Conf.2, Conf.3, Conf.4, Conf.5, Conf.6
St. 8	Assessing DER capacity	Results calculation	Calculating the capacity of weather-dependent DERs in the secondary substation, assessing the generation and demand, and estimating the additional allowable space for integration of new DERs	Execute	Data Analyst	DSO	Inf. 11 and Inf. 12	x

Scenario								
Scenario name:		Forecasting and estimating values of technical parameters in distribution networks						
Step No.	***Event***	***Name of process/ activity***	***Description of process/ activity***	***Service***	***Information producer (actor)***	***Information receiver (actor)***	***Information Exchanged (IDs)***	***Requirement, R-IDs***
St. 1	Data available from substation measurement s	Data retrieval	The data includes measurements of different technical parameters at the substation level, including electricity demand and generation data, voltage and current measurements, etc.	GET	DSO	Data Analyst	Inf. 1 and Inf. 2	QoS.1 QoS.2, QoS.3, QoS.5, D.1, D.2, D.3, D.7, Conf.1, Conf.4, Conf.5, Conf.6, O.X
St. 2	Weather data	Data retrieval	The data includes various temperature and weather measurement values	GET	Weather stations	Data Analyst	Inf. 3 and Inf. 4	QoS.1 QoS.2, QoS.3, QoS.5, D.1, D.2, D.3, D.7, Conf.1, Conf.4, Conf.5, Conf.6, O.X
St. 3	Calculating	Data	Calculation of DTR and DLR	GET	DSO	Data Analyst	Inf. 5 and Inf. 6	QoS.2, QoS.3,

	DTR/DLR values	retrieval	values needed for further analyses					QoS.5, D.2, D.3, D.4, D.6, D.7, D.8, Conf.1
St. 4	Accessing data	Data query	The request to access the data needed by the data analyst for distribution network analyses	GET	DSO	Data Analyst	Inf. 1, Inf. 2, Inf. 3, Inf. 4, Inf. 5, Inf. 6	QoS.1, QoS.4, Sec.1, Sec.2, D.4, D.6, D.7, D.8, Conf.1, Conf.2, Conf.3, Conf.4, Conf.5, Conf.6, O.X
St. 5	Semantic model of substation	Data retrieval	Enabling the connecting electrical measurements and weather data to a specific substation	GET	Service provider	Data Analyst	Inf. 7 and Inf. 8	QoS.1 QoS.2, QoS.3, QoS.5, D.1, D.2, D.3, D.7, Conf.1, Conf.4, Conf.5, Conf.6, O.X
St. 6	Identifying anomalies in data	Data validation	Based on analysing the accessed data and identifying certain patterns, measurements that should not be a part of the set are identified	Execute	Data Analyst	DSO, Data Analyst	Inf. 9 and Inf. 10	QoS.2, QoS.4, D.2, D.4, D.6, D.7, Conf,1, Conf.2, Conf.3, Conf.4, Conf.5, Conf.6
St. 7	Removing anomalies from the dataset	Data validation	Identified anomalies need to be removed before using them in any further analysis	Execute	Data Analyst	DSO, Data Analyst	Inf. 9 and Inf. 10	QoS.2, QoS.4, D.2, D.4, D.6, D.7, Conf,1, Conf.2, Conf.3, Conf.4, Conf.5, Conf.6
St. 8	Forecasting technical parameters and electrical values in distribution networks	Results calculation	Electrical values including but not limited to generation and demand curves are forecasted/estimated based using the ML algorithm and historical data	Execute	Data Analyst	DSO	Inf. 11 and Inf. 12	x

5 Information exchanged

Information exchanged			
Information exchanged (ID)	*Name of information*	*Description of information exchanged*	*Requirement, R-IDs*
Inf. 1 and Inf 2	Substation electrical measurements	Values measured at the substation level (aggregated demand, voltage, current, etc.)	QoS.1 QoS.2, QoS.3, QoS.5, D.1, D.2, D.3, D.7, Conf.1, Conf.4, Conf.5, Conf.6, O.X
Inf. 3 and Inf. 4	Weather data	Weather data in the pilot location (temperature, irradiation, etc.)	QoS.1 QoS.2, QoS.3, QoS.5, D.1, D.2, D.3, D.7, Conf.1, Conf.4, Conf.5, Conf.6, O.X
Inf. 5 and Inf. 6	DTR and DLR results	Output results from DTR and DLR edge calculations that are implemented in SUC-SL-01.1. and SUC-SL-01.2.	QoS.2, QoS.3, QoS.5, D.2, D.3, D.4, D.6, D.7, D.8, Conf.1
Inf. 7 and Inf. 8	Semantic model of substation	Connecting accessed data and measurements to a specific substation	QoS.1 QoS.2, QoS.3, QoS.5, D.1, D.2, D.3, D.7, Conf.1, Conf.4, Conf.5, Conf.6, O.X
Inf. 9 and Inf. 10	Anomaly detection	Information whether some anomalies were detected in the data	QoS.2, QoS.4, D.2, D.4, D.6, D.7, Conf,1, Conf.2, Conf.3, Conf.4, Conf.5, Conf.6
Inf. 11 and Inf. 12	ML algorithm application	Applying the ML algorithm with the specific purpose to enable distribution network analysis and enhance network planning and operation	X

6 Requirements

Quality of Service Requirements		
Categories ID	**Category name for requirements**	**Category description**
QoS	Quality of Service	Generic properties that service/SUC should provide – quality attributes.
Requirement R-ID	**Requirement name**	**Requirement description**
QoS.1	Elapsed time response requirements for exchanging data	More than 10 seconds
QoS.2	Availability of information flows	90% + availability - Allowed outage: 1 month per year
QoS.3	Accuracy of data requirements	Requires quality flag indicating at least normal and not normal
QoS.4	Frequency of data exchanges	Periodicity greater than a few seconds

Security Requirements		
Categories ID	**Category name for requirements**	**Category description**
Sec	Security	Authentication of user, confidentiality, integrity, prevention of denial of service, non-repudiation or accountability, error management.
Requirement R-ID	**Requirement name**	**Requirement description**

Sec.1	Eavesdropping: Ensuring confidentiality, avoiding illegitimate use of data, and preventing unauthorized reading of data, is:	Quite important
Sec.2	Information integrity violation: Ensuring that data is not changed or destroyed is:	Quite important

Data Management Requirements		
Categories ID	**Category name for requirements**	**Category description**
D	Data Management	Type of source of data, correctness or validity of data, timeliness or time stamping of data, volume of data, synchronization, or consistency of data across systems, timely access to data, validation of data across organizational boundaries, transaction management, data naming, identification, formats across disparate systems, maintenance of data and databases.
Requirement R-ID	**Requirement name**	**Requirement description**
D.1	Correctness of source data	Source data is usually correct
D.2	Up-to-date management	Received data must be up-to-date within minutes of source data changing
D.3	Data consistency and synchronization management across systems	Minute-by-minute synchronization
D.4	Management of data across organizational boundaries	Data exchanges go across boundaries between system developed by different vendors
D.5	Data maintenance effort: human versus automation	Data maintenance is partially automated but involves some human time and manual data entries
D.6	Validation of data exchanges	Data from different sources must be validated against each other
D.7	Management of large volumes of data that are being exchanged	Major part of step involves handling large volumes of data
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

Discovery and Configuration Requirements		
Categories ID	**Category name for requirements**	**Category description**
Conf	Configuration	Locations, distances, communication layout, commonly used communication protocol media, network bandwidth, existing protocols, number of devices, systems, volume of data items, expected growth, etc.
Requirement R-ID	**Requirement name**	**Requirement description**
Conf.1	Distance between entities	Varies and/or is not relevant
Conf.2	Number of Information Producers	Two to a few
Conf.3	Number of Information Receivers	Two to a few

Conf.4	Communication media	Any
Conf.5	Data exchange methods	Any
Conf.6	Communication access services requirements	Any or all

Other Requirements		
Categories ID	**Category name for requirements**	**Category description**
O	Regulatory obligation related to privacy	2016/679 GDPR (General Data Protection Regulation)
Requirement R-ID	**Requirement name**	**Requirement description**
O.X	All constraints also apply.	All requirements in this category.

7 Common Terms and Definitions

Common Terms and Definitions	
Term	**Definition**
DSO	Distribution system operator
DLR	Dynamic line rating
DTR	Dynamic thermal rating
ML	Machine learning