D1.2

Framework for a flexibility-centric energy and cross-sector value chain, business use cases and KPI definition

BeFlexible

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Document Contributors

Deliverable responsible	INESC TEC		
Contributors	**Organization**	**Reviewers**	**Organization**
Ricardo Bessa	INESC TEC	Jean-Christophe Pazzaglia	SAP
José Villar	INESC TEC	Stéphane Dotto	SAP
Fábio Coelho	INESC TEC	Pau Lloret	TV
Luís Rodrigues	INESC TEC		
Kamalanathan Ganesan	INESC TEC		
João Mello	INESC TEC		
Diogo Faria	INESC TEC		
Matteo Troncia	COMILLAS		
José Pablo Chaves	COMILLAS		
Miguel Ángel Ruiz Hernández	COMILLAS		
Eliana Carolina Ormeño Mejía	COMILLAS		
Tomás Gomez	COMILLAS		
Leonor Ruiz	SOULSIGHT		

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List of abbreviations

BAU	Business-As-Usual
BESS	Battery Energy Storage System
BM	Business Model
BMC	Business Model Canvas
BMS	Building Management System
BRP	Balance Responsible Party
BSP	Balancing Service Provider
BUC	Business Use Case
CaaS	Charging as a Service
CEC	Citizen Energy Community
CPO	Charging Point Operator
DEP	Data Exchange Platform
DER	Distributed Energy Resource
DOA	Description of Action
DP	Digital Platform
DR	Demand Response
DSO	Distribution System Operator
EaaS	Energy as a Service
EC	Energy Community
EMS	Energy Management System
ENA	Energy Networks Association
ESaaS	Energy Storage as a Service
ESCo	Energy Service Company
EU	European Union
EV	Electric Vehicle
EVA	Electric Vehicle Aggregator
EVCS	Electric Vehicle Charging Station
EVSE	Electric Vehicle Supply Equipment
FMO	Flexibility Market Operator

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FSP	Flexibility Services Provider
GDBN	Grid Data and Business Network
GDPR	General Data Protection Regulation
HEMRM	Harmonized Electricity Market Role Model
HEMS	Home Energy Management System
HPWH	Heat Pump Water Heater
HV	High Voltage
HVAC	Heating, Ventilation, and Air Conditioning
ICT	Information and Communication Technologies
KPI	Key Performance Indicator
LFMO	Local Flexibility Market Operator
LV	Low Voltage
MV	Medium Voltage
NEMO	Nominated Electricity Market Operator
NMF	Neutral Market Facilitator
P2P	Peer-to-Peer
PV	Photovoltaic
REC	Renewable Energy Community
SaaS	Solar as a Service
SCo	Service Company
SGAM	Smart energy Grid Architecture Model
SHaaS	Smart Home as a Service
SW	Software
ToU	Time of Use
TSO	Transmission System Operator
VC	Value Chain
WP	Work Package
XaaS	Anything as a Service

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1. Executive Summary

This deliverable is developed in the scope of the BeFlexible project, which aims to increase energy systems flexibility. BeFlexible main goals are to enhance cooperation between system operators, while easing involvement from all energy-related actors. This is to be achieved through the validation and demonstration of adapted and proven cross-sector services, along with the creation of interoperable platforms for smart grids. This approach involves further developing pre-existing solutions and establishing a comprehensive system architecture framework essential for fostering new Business Models (BMs). These BMs will offer additional value to address consumers' needs, while complying with a stable regulatory framework.

This document presents the work conducted and the outcomes derived from Task 1.3 – Design of a flexibility-centric energy and cross-sector value chain (T1.3) and Task 1.4 – Business Use Cases and Key Performance Indicators (KPIs) definition (T1.4), part of Work Package 1.

1.1. Flexibility business models and flexibility value chain

T1.3 is centred in the analysis of flexibility-centric services and BMs, the identification of the flexibility energy and cross-sector Value Chain (VC), and the functional specification of the Grid Data and Business Network (GDBN), an interoperable digital platform to support and facilitate the activities of the flexibility-centric VC.

First, a literature review of pre-existing BMs, either proposed in other projects or adopted by companies is carried out. The revised BMs are grouped in seven areas: BMs for Distributed Energy Resources (DERs) provision, BMs for DERs provision as a Service (including Energy as a Service (EaaS)), BMs to reduce electricity bills of flexible consumers, BMs for cross-sector activities, BMs for the operation of power grids, BMs for supplying electricity to consumers, BMs for communities. Here, it is identified a wide range of proposals and commercial models suitable for increasing consumer-side flexibility, operating grids, and create additional value from cross-sector activities such as mobility, safety, security, and healthcare.

From the roles identified in the revised BMs, a role model is proposed, which includes the essential stakeholders to support the main activities to be developed within the VC. This approach assumes that BMs can be characterized by the different roles taken by the involved actors. Roles are performed by actors. Each actor can have several roles and, although each role can usually be played by several actors, legal issues may arise from the existing regulation.

Most of the roles included in the BeFlexible role model are already envisioned in the Harmonised Electricity Market Role Model (HEMRM), with some new ones being added to complement certain activities, namely cross-sector BMs. The possible and most important interactions between these roles are presented in the following diagram.

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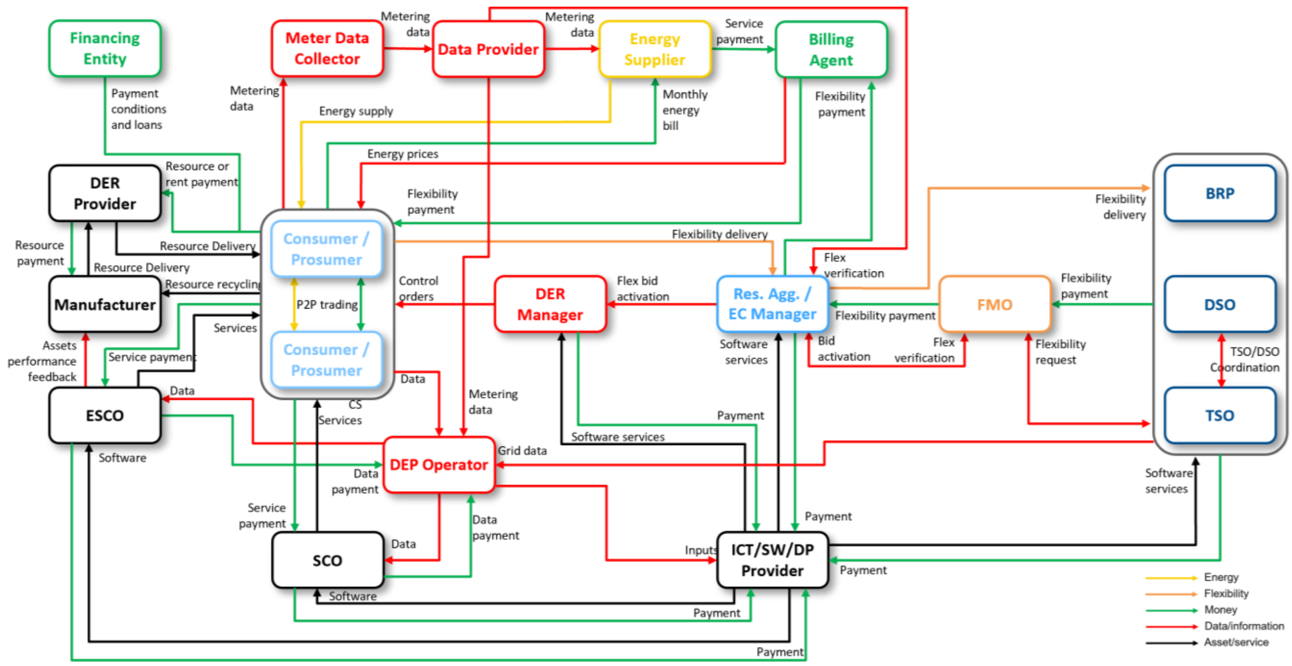

Figure 1.1 – Flexibility-centric and Cross-sector VC design

As a summary of the BMs analysed, a set of eight main BMs is identified:

- BM1: Traditional retailer.
- BM2: Flex assets acquisition.
- BM3: EaaS from retailer.
- BM4: DERs from retailer.
- BM5: Grid flexibility.
- BM6: Cross-sector services.
- BM7: Flexible EC.
- BM8: Flexible EC with shared assets.

The description of each BM is supported by a BM canvas, and they are also classified according to an evaluation methodology proposed by the authors. Furthermore, finance is examined by reviewing financing mechanisms (e.g., equity, debt, crowdfunding, etc) and evaluating their viability to support the proposed BMs.

From the flexibility-centric BMs analysed and identified, the flexibility-centric VC is developed and described. The goal of the VC is to identify and characterize all the main primary and supporting activities needed for the flexibility provision and the actors involved. This is the base for the design of the GDBN to provide support to these activities. Indeed, the GDBN should facilitate the enrolment and support the engagement of flexibility stakeholders regardless of their role and flexibility potential. Moreover, it must provide means for energy markets to adapt to flexibility services and make DERs available and interoperable for all parties, thus contributing to unlock the flexibility of consumers' assets.

The VC is divided in six stages, which are summarized next:

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- Flexibility Capacitation: Identify the available consumers' side flexibility and includes the acquisition and retrofit of assets using the BMs previously described.
- Integration/Enablement: Operate and manage the assets previously installed, the configuration of Energy Management Systems (EMS) and Home EMS (HEMS), metering data processing, and the integration of consumers with digital platforms.
- Aggregation: Operation of digital platforms by Aggregators and controlling assets after flexibility is negotiated.
- Negotiation Preparation: Determine flexibility needs, identify flexibility zones, and calculate flexibility bids to be submitted.
- Market Operation: Operation of a flexibility market platform, which collects bids and helps flexibility procures to select bids and formalize contracts.
- Activation and Settlement: Activate contracted flexibility and settle it according to the contractual agreements.

For each stage, the main roles along with primary and support activities essential for its operation are identified. The VC was presented to and validated with all the partners involved in WP1 during a workshop session.

These phases, the primary and support activities of the flexibility VC and the main roles participating in the activities are represented in Figure 1.2.

	Flexibility capacitation	Integration /Enablement	Aggregation	Negotiation preparation	Market operation	Activation & Settlement
Main activities (regular operation)	• Asset provision and installation or retrofit	• Assets OM • HEMS/EMS (cross-sector and local Aggregator constraints) • (Sub)Metering	• Aggregator/EC DP management • Bidding • Activation • Verification (baseline) • Settlement	• Flexibility needs • Flexibility zones • Bids preparation • TSO-DSO coordination	• Market DP operation • Bids selection	• TSO-DSO coordination • Activation • Monitoring • Verification (baseline) • Settlement • Billing
Main activities (done once)	• Registration • Contracting support • Financing	• Aggregator DP integration • Financing	• Market registration • Aggregator/EC DP algorithm development • Aggregator pre-qualification • Contracting support	• DSO pre-qualification • Market DP integration • Baseline computation	• Contracting support	
Secondary activities	• Energy services: sizing, efficiency, diagnostics, optimal aggregation, EC creation support, education • Maintenance and support services	• Links with cross-sector services • Maintenance and support services	• Energy services: sizing, efficiency, diagnostics, optimal aggregation, REC creation support, education	• Market analysis • Market simulation • Bidding strategies • Forecasting • Grid analysis	• Market analysis and reporting	• Statistics
Main roles	• Consumer • DER Provider • ICT Provider • Manufacturer • ESCo, SCo	• DER Manager • Consumer	• Resource Aggregator • EC manager	• Resource Aggregator • BRP • DSO • TSO	• Flexibility Market Operator	• Resource Aggregator • DER Manager • Meter Data Collector • DSO and TSO • Billing Agent

Figure 1.2 – Flexibility-centric and Cross-sector VC design

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From the VC it is possible to design the functional architecture of the GDBN, a digital platform to be developed in the scope of BeFlexible WP3 (T3.3). As already said, the GDBN is a multi-stakeholder platform that provides an integrated ecosystem to support the parties involved in the flexibility VC, such as consumers, Aggregators, service providers, and DSOs.

To develop this functional specification, a review of pre-existing digital platforms was carried out, since the GDBN might include similar functionalities or interact with similar platforms, especially in the case of market platforms (e.g., OMIE platform, Piclo Flex, etc), where the objective of the GDBN is not to replace them but to offer an interoperable gateway to operate with them. This review includes the most advanced or widespread platforms identified and operating in Europe. Afterwards, by analysing the actors and systems interactions along the VC activities, the data exchange requirements of the GDBN, i.e., the information it might receive, store, and send, are identified.

An essential part of the GDBN is the support to the provision and activation of flexibility. Consequently, it is crucial to identify or propose an end-to-end methodology for the provision of flexibility supported by the GDBN, which is also outlined in this document. It is divided in five phases, including:

- Pre-qualification: Deals with the certification of Aggregators and flexible assets, ensuring they are financially and technically able to provide flexibility and participate in flexibility markets.
- Negotiation Preparation: DSO forecasts grid constraints and if potential grid constraints are identified, and it is deemed that flexibility can solve them, the DSO forwards its needs to the market, so that Aggregators can submit bids.
- Market Operation: Market clearing is done by the market platform, and final bids are selected by the DSO.
- Activation: Flexibility from consumer-side assets is activated.
- Validation & Settlement: Flexibility provided by each Aggregator is calculated using pre-agreed baselines, resulting in remuneration/penalties to be settled between the Aggregators and DSO. This last phase can be done with or without the support of the GDBN, as decided by the DSO.

For each phase the main actors and systems and the timeline of their interactions and the conceptual data exchanged are identified and described.

This proposal also addresses the definition of flexibility products that will be supported by the GDBN for demonstration purposes (although other products could easily be added), based on a literature review of existing flexibility products used in the revised platforms or proposed in other projects. The resulting products include:

- Short-term Dispatched: the DSO procures, ahead of time, a pre-agreed change in the Aggregator's output based on its forecasted network conditions. It is used in situations where the DSO is certain that the flexibility will be needed, so that, when selected, the Aggregator reschedules its resources to comply with the selected flexibility. The aim is to help DSOs manage network constraints with high certainty, so the flexibility activation decision is taken well in advanced.

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- Short-term Scheduled: the DSO procures, ahead of time, the option to activate a pre-agreed change in the Aggregators output based on its forecasted network conditions. However, the activation remains pending of a DSO decision closer to real time and according to actual grid condition, corresponding to a situation when the DSO is not certain if the flexibility will be needed.

1.2. Business use cases to be demonstrated

In T1.4, using the inputs from Task 1.1 – Regulatory framework for fostering flexibility deployment: roles and responsibility of existing and new agents, Task 1.2 – Proposal for flexibility mechanisms designs: from standalone mechanisms to efficient combinations, and T1.3, and in collaboration with Task 3.1 – Definition of services and use cases (T3.1), the Business Use Cases (BUCs) to be demonstrated in the project pilots are designed, developed and described using the IEC 62559 use case methodology and template.

This deliverable also describes the use cases drafted in BeFlexible for the business level of the Smart Grids Architecture Model (SGAM) framework, which enables the identification of business requirements for flexibility-centric services covering DSOs, TSOs, Aggregators, energy services providers, and other sectors such as mobility and water distribution.

In BeFlexible, the identification and writing of BUCs drew inspiration from established methodologies, such as those in EU projects like FP7 evolvDSO, H2020 TDX-ASSIST, H2020 InteGrid, and H2020 OneNet, as well as the IEC 62559 standard. Initiated through an online workshop in January 2023, discussions with consortium members and end-users identified five key topics, leading to 20 new or improved business processes. Subsequent workshops and analyses resulted in a consolidated list of 13 BUCs across four domains: consumer/community-centric flexibility, grid-centric flexibility, TSO-DSO flexibility coordination, and cross-sector flexibility boosters. The BUCs, presented in a standardised template, form the foundation for the system use cases (SUCs) in WP3 and contribute to the overall project objectives. Figure 1.3 depicts the BeFlexible BUCs.

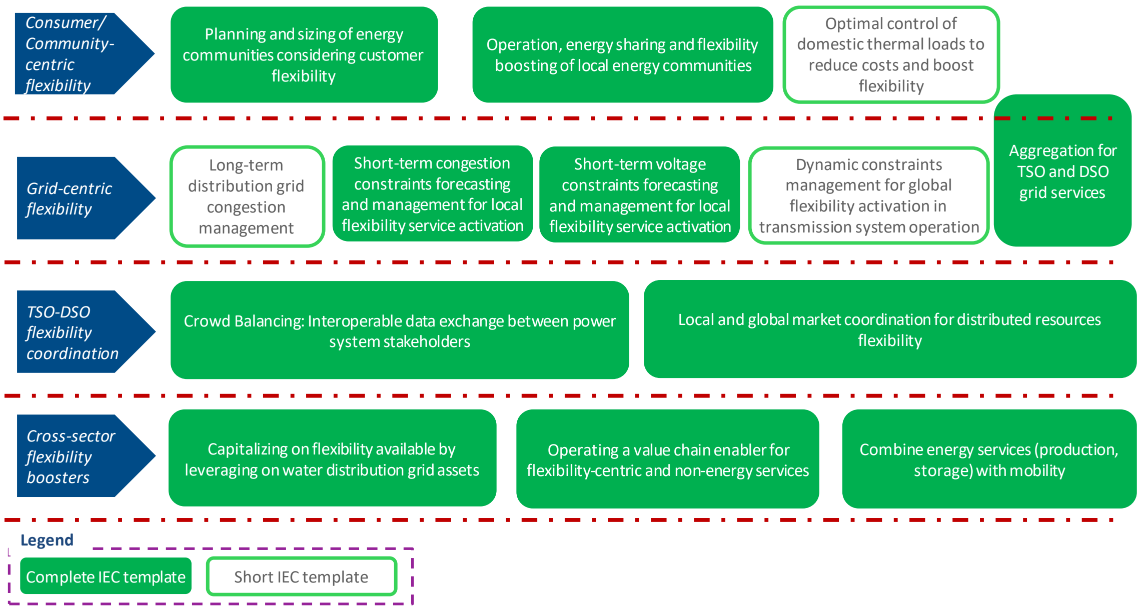

Figure 1.3 - BeFlexible's BUCs divided by domain.

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Table 1.1 presents a summary of the BUCs.

Table 1.1 – Description of BUCs by domain

Domain	Business Use Case	Short Description
Consumer/community-centric flexibility	BUC01 – Planning and sizing of energy communities considering customer flexibility	For planning renewable energy communities (REC) and citizen energy communities (CEC), led by the Energy Community Manager, focuses on optimising capacities, sizing assets, and simulating pricing mechanisms. It emphasises social and environmental benefits and de-risks shared energy investments, maximises community gains, and contributes to sustainable, citizen-centred energy practices aligned with EU directives.
	BUC02 – Operation, energy sharing and flexibility boosting of local energy communities	For managing energy communities, led by the Energy Community Manager, explore market-based and centralised operation modes. The objective is to share energy among community members for self-consumption and provide flexibility to the DSO. It involves optimising economic performance, considering various asset ownership models, and defining allocation coefficients and flexibility indicators.
	BUC03 – Optimize domestic thermal loads to reduce costs and boost flexibility	Optimal control of domestic thermal loads aims to enhance flexibility provision, decrease energy consumption, and lower associated costs. The approach includes strategies like peak-shaving, dynamic tariff optimisation, and device retrofitting to optimise energy use, reduce costs, and contribute to demand response services.
Grid-centric flexibility	BUC04 – Long-term distribution grid congestion (and voltage constraints) management	Long-term congestion and voltage constraints management in the distribution grid. It aims to integrate flexibility into DSO grid planning processes, evaluating its value and potential contribution to smarter grid planning. Involves the procurement of local flexibility products to manage long-term congestions, deferring or eliminating the need for traditional system investments.
	BUC05 – Aggregation for TSO and DSO grid services	Aggregating flexibility from household thermal assets, battery energy systems, and building energy management systems. It aims to offer flexibility in the local market to the DSO for solving short and long-term congestion issues and provide flexibility to the TSO for various purposes. The Resource Aggregator engages in flexibility procurement processes, incentivises users to offer flexibility, decides on participation in different markets, and settles the flexibility provision, ensuring effective coordination with both TSOs and DSOs.
	BUC06 – Short-term congestion constraints forecasting and management for local flexibility service activation	Short-term congestion management through the procurement of local flexibility products by the DSO. It aims to integrate flexibility into DSO grid operation processes. The system evaluates the ability of the operator to procure the right amount of flexibility for congestions, ensuring responsiveness from Flexibility Service Providers (FSPs) in adhering to activation signals within specified characteristics and contractual terms. The process involves engaging in both day-ahead and intraday markets for flexibility procurement, monitoring delivery, and implementing penalties for non-compliance.
	BUC07 – Short-term congestion constraints	Short-term voltage constraint forecasting and management in the distribution grid. The objective is to compensate for local voltage

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	forecasting and management for local flexibility service activation	violations using available active power flexibility from resources installed in the grid. The short-term control is performed on a day-ahead basis, and the resulting activation signal is adjusted using updated forecasts and grid conditions, requiring monitoring devices for enhanced grid observability and knowledge of the electrical grid model.
	BUC10 – Dynamic constraints management for global flexibility activation in transmission system operation	Integrating distribution grid-connected resources into global flexibility procurement and avoiding indirect contingencies on DSOs. The Traffic Light Model is implemented for coordination, where DSO constraints guide TSO resource selection, requiring coordinated prequalification processes and a secure data exchange platform.
TSO-DSO flexibility coordination	BUC08 – Crowd Balancing: Interoperable data exchange between stakeholders	Describes how TSO, DSOs, and Balance Service Providers (BSPs) can register flexibility resources and exchange data via the Flexibility Register functionality during the resource prequalification process, facilitating TSO-DSO common information exchanges and BSPs participation through a single channel for multiple markets access. Moreover, it supports transactions for market operations and Traffic Light data exchange between stakeholders, enabling secure coordination between local markets and global markets.
	BUC09 – Local and global market coordination for distributed resources system service provision	Coordinating TSO and DSO procuring DER system services through local and global markets. Market-based coordination aims for efficient resource allocation, preventing over-procurement, avoiding network constraint violations, enabling value stacking, and enhancing overall economic efficiency. Coordination involves market phases to increase liquidity and depends on factors like service location, primary buyer, market usage, and TSO's direct acquisition from distribution-connected resources.
Cross-sector flexibility boosters	BUC11 – Capitalizing on flexibility available by leveraging on water distribution network assets	Explore methods to enhance cross-sector flexibility between water and electricity distribution systems. Objectives include leveraging the Water Distribution Network's flexibility to address electrical grid issues. The focus is on understanding water distribution assets, establishing monitoring processes for flexibility assets, and quantifying the flexibility potential for integration into electrical grids.
	BUC12 – Operating a value chain enabler for flexibility-centric energy and non-energy services	Operation of a flexibility-centric value chain enabler. Objectives include unlocking consumer flexibility, simplifying customer identification for Demand Side Flexibility services, establishing renewable energy communities, and creating business opportunities by connecting Prosumers, Aggregators, DSOs, and local flexibility platforms through the Grid Data Business Network.
	BUC13 – Combine energy services (production, storage) with mobility	Focuses on Electric Vehicle Supply Equipment (EVSE) powered by renewable energy, emphasising charging flexibility, digital platforms, and data sharing. The main actor, the Energy Facility Manager, aims to decarbonise corporate fleets, provide uniform EV charging tariffs, maximise local and grid renewable energy usage, and ensure optimal EVSE availability. It incentivises EV drivers for cost-effective and carbon-friendly charging, offers convenient tariffs, optimises energy consumption

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		at homes, and facilitates data access for cross-sector service development.

The BUC writing methodology served as a tool to document functional requirements, capturing the impact of energy flexibility, smart grid implementation, evolving market structures, and regulatory frameworks. Functional requirements align with the step-by-step use case description, ensuring clarity. Business requirements were identified for diverse aspects like regulation and market dynamics.

The key business requirements identified in the BUCs descriptions were categorised into market and regulatory, social sciences and consumer engagement, and other requirements, including data privacy and security.

The analysis focuses on DSO remuneration, regulatory experimentation, energy communities, aggregation, submetering, baseline, acquisition mechanisms, and market structure in the market and regulatory domain. It emphasises aligning BUC processes with existing regulations, addressing challenges in DSO remuneration, promoting regulatory experimentation, steering energy community regulations, ensuring compliance in aggregation activities, addressing submetering challenges, defining baselines for flexibility provision, handling acquisition mechanisms, and considering new market structures.

The social science and consumer engagement domain highlight requirements for local energy communities, emphasising the need to clarify shared resource benefits, address data sharing concerns, establish contractual agreements, ensure effortless device/software installation for thermal loads, provide user control in automated processes, and prioritise non-energy services to drive user participation.

This analysis also highlighted the significance of General Data Protection Regulation (GDPR) compliance across all BUCs involving customers, emphasising the commitment to legal and ethical standards in handling personal information and data.

Finally, Key Performance Indicators (KPIs), categorised as technical, social, economic, and environmental, have been defined for each BUC in the project. Information includes type, definition, alignment with the Description of Action (DoA), targets, calculation methodology, and data collection procedure.

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2. Introduction

2.1. BeFlexible project

The BeFlexible project, started in 2022, aims to boost energy system flexibility, improve cooperation between Distributions System Operators (DSOs) and Transmissions System Operators (TSOs) and ease participation for all energy-related actors. This is to be done by validating and demonstrating cross-sector services, creating interoperable smart grids platforms, and refining pre-existing solutions. To achieve these goals, it is crucial to establish a robust system architecture framework which can foster new Business Models (BMs) that address consumers' needs while complying with a stable regulatory framework.

2.2. Work Package 1 organization and interaction with other Work Packages

The main objective of Work Package 1 (WP1) is to set the general framework for BeFlexible. This is to be achieved by setting out proposals for the regulatory framework, market mechanisms, a background for flexibility-centric services and reference BMs, and by defining the Business Use Cases (BUCs) to be tested in the demonstrators along with the KPIs to evaluate the project outcomes.

WP1 is divided in fours tasks:

- Task 1.1 – Regulatory framework for fostering flexibility deployment: roles and responsibility of existing and new agents (T1.1)
- Task 1.2 – Proposal for flexibility mechanisms designs: from standalone mechanisms to efficient combinations (T1.2)
- Task 1.3 – Design of a flexibility-centric energy and cross-sector value chain (T1.3)
- Task 1.4 – Business Use Cases and KPIs definitions (T1.4)

The goal of T1.1 is to propose a framework to overcome existing regulatory barriers hindering the deployment of flexibility. This proposal involves strategies to address regulatory experimentation, establish remuneration schemes that include flexibility, establish ownership rules, ensure a level playing field in the use of flexible resources owned by system operators and third parties, and enable the aggregation of these resources. In T1.2 the goal is to propose new acquisition mechanisms and regulations that promote an efficient exploitation of flexibility and foster customer engagement. The results of T1.1 and T1.2 are provided in D1.1.

Regarding the tasks associated with this document, T1.3 and T1.4. First, in T1.3, the objective is to design an energy and cross-sector VC to sustain flexibility-centric services and BMs. Since the VC is also meant to serve as the basis for the development of the Grid Data and Business Network (GDBN) in WP3, its pre-specification is included in this task. T1.4 is centred on the design and development of high-level BUCs to be demonstrated in the project pilots, and in the definition of KPIs, which are defined considering different dimensions: technical, economic, environmental, and social.

In what concerns the interactions between these tasks and between this WP and other WPs (see Figure 2.1), T1.1 and T1.2 provide inputs to T1.3 and T1.4 (i.e. results of the regulatory framework analysis and efficient combination of flexibility acquisition mechanisms). Regarding the interactions with other WPs, outcomes of

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WP2 help to define the VC and BMs in T1.3 and T1.4. Additionally, WP1 provides inputs for the implementation of the GDBN in WP3. For WP4, WP5 and WP6, associated with the project's pilots, the interaction with WP1 is essential for the definition of the BUCs. At last, WP7 leverages on WP1 to address the assessment of the project and demonstrators' results, and WP8 relies on WP1 outcomes for communication and dissemination activities.

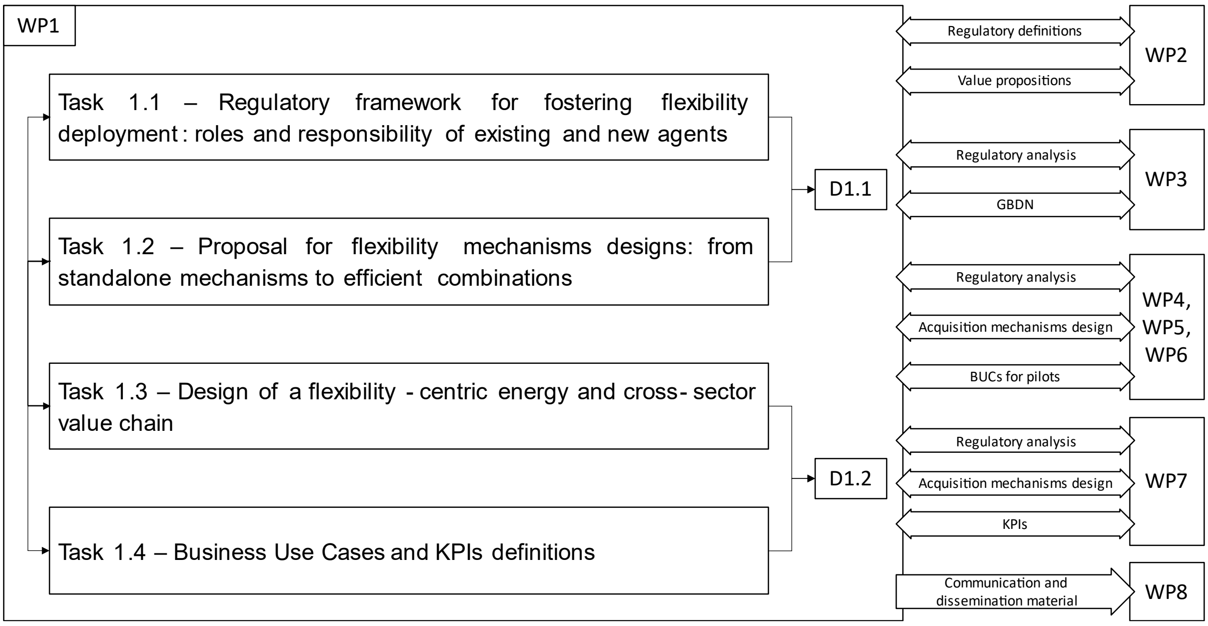

Figure 2.1 – Overview of the interactions between WP1 and other WPs

2.3. Scope and objectives of this deliverable

This document presents the work carried out in T1.3 and T1.4.

Regarding T1.3, its main goal is to design an energy and cross-sector VC to sustain flexibility-centric services and BMs. For that purpose, it is created a role model, which includes pre-existing and new market actors, and details the interactions between them. A set of new BMs is proposed, which are supported by a literature review of contemporary BMs implemented by companies and other projects. These new BMs are described using the proposed role model, and by using a Business Model Canvas (BMC). Additionally, they are evaluated according to an original evaluation methodology proposed by the authors of this work. At last, financial aspects are examined by assessing the most suitable financing mechanisms to fund the proposed BMs.

Since the energy and cross-sector VC is also expected to be used as the basis for the development of the GDBN in WP3, its pre-specification is also described here. To conduct this work, first it is done a review of digital platforms associated with the provision of flexibility, since the GDBN has the potential to interact with similar systems in the future. Additionally, and to define data exchange requirements within the GDBN, it is important to anticipate the information it might receive, process, and transmit. Therefore, it is vital to describe a methodology for the provision of flexibility when incorporating the GDBN, which is outlined in this document. It is divided in multiples stages and includes all the main activities and steps for the provision of flexibility to system operators. It also includes the definition of flexibility products, supported by a literature

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review of pre-existing flexibility products used in other digital platforms, or proposed in other projects. The pre-specification of the GDBN is complemented by an overview of its services, deployment, and life cycle, and how it supports the proposed VC.

In T1.4, the BUCs to be demonstrated in the pilots are designed, developed, and described using the IEC 62559 use case methodology and template, along with the KPIs to assess the project outcomes.

2.4. Deliverable structure

The structure of this deliverable is the following:

- Chapter 3 presents the reviewed BMs, the BeFlexible role model, a set of BMs proposed for this project and the financing mechanisms available to support them.
- Chapter 4 illustrates the flexibility-centric energy and cross-sector VC, explaining its main steps and activities and actors involved in each one of them.
- Chapter 5 presents the reviewed digital platforms, the proposed flexibility exchange framework, and the envisioned products. Additionally, it provides the pre-specification of the GDBN, including its services, data payloads and life cycle.
- Chapter 6 describes the standardized methodology adopted for writing the BUCs, identifies business requirements and KPIs. Moreover, it provides an overview of all the BUCs included in this project.
- Chapter 7, as a conclusive chapter, summarizes the work done and the objectives accomplished.

Regarding the annexes, Annex I includes a summary and the results of a workshop where the design of the Flexibility-centric VC was presented to and validated with all the partners involved in WP1, Annex II presents the template used for the writing of the BUCs, Annex III includes all the BUCs developed within the project and, at last, Annex IV details all the KPIs.

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3. Energy and Cross-sector Flexibility Centric of Business Models

3.1. Business Models review

In this section the most significant Business Models (BMs) identified in the reviewed literature are summarised and organized according to their nature, parties involved and objectives. The BMs selected are related to the provision of flexibility to third parties but are not limited to flexibility and try to account for other very linked activities such as the provision of flexibility resources or the management of these resources. The relationships between the roles/actors participating in these BMs are later described in section 3.2.

3.1.1. BMs for DERs provision

This first set of BMs is related to the provision of flexible and cross-sector resources to Consumers. In this BM a company supplies flexible assets to a residential, commercial, or industrial Consumer. In some cases, a Financing Entity can facilitate the access to the required funds. In general, the DERs provision BMs equip Consumers with assets that allow them to benefit from their own flexibility to optimize their economic efficiency, or to share the flexibility with other stakeholders, such as other Consumers, Retailers, Aggregators, DSOs, among others. The reviewed companies and projects and the most relevant BMs identified in each one are collected in Table 3.1.

Table 3.1 - Most relevant reviewed companies and projects regarding BMs for DERs provision

Area	Business Model	Reviewed companies and projects
DERs Provision	Photovoltaic (PV) systems provision	IBERDROLA, edp, SUNPOWER, Trinasolar, OTOVO
	Battery Energy Storage System (BESS) provision	TESLA, edp, Alphaess, CONNECTED ENERGY, POWERVAULT
	HEMS provision	QORVO, ABB, SMART HOMES SOLUTIONS, Control4, amazon, TITAN
	Water Heating (WH), Heat Pump (HP) and Heating, Ventilation, and Air Conditioning (HVAC)provision	IBERDROLA, edp, THERMOVAULT

3.1.1.1. PV systems provision

In this BM, a firm, acting as DER Provider, supplies solar PV systems to private and/or public property owners wishing to have a set of PV panels on their property whose primary use is typically self-consumption. In this case, the property owner, the DER Owner, and Consumer are all the same entity. There are several variations of this BM [1] that are described next.

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One alternative BM, adopted by some firms, is to simply sell the components necessary for a solar PV installation, allowing Consumers to choose between acquiring individual parts or a complete package with all the components [2]. However, in the most widespread BMs, the DER Provider offers solar PV systems tailored to the needs of each client that are ready for immediate use through a hassle-free process [3], [4].

Some companies extend their offers with services to provide even more complete solutions. For instance, they might expand into other activities such as PV system maintenance and monitoring, or act as mediators between the Consumer and institutions that provide financing for the projects [1].

Certain DER Providers even sell other equipment [5], [6], such as EV chargers, water heaters, heat pumps and batteries, which are meant to complement the PV system by better profiting from the self-consumed energy and create additional value to the Consumers when used together [1]. If the DER Provider is not a Manufacturer, it must acquire large quantities of the different parts from wholesalers or Manufacturers and combine them into packages, which are sold at a higher price to generate profit [1].

From the companies providing PV panels analysed, some are also Energy Suppliers, such as the cases of [6] and [5], showing how these firms often behave also as DER Providers.

Regarding finance, Consumers can often choose between a single payment or monthly payments. Moreover, and due to environmental policies to promote RES, Consumers can also benefit from reduced VAT rates when acquiring PV panels [5] or from other governmental funds or subsidies that support the acquisition of these systems [7], [8]. Although none of the companies mentioned in this section use crowdfunding as a finance mechanism, it is a viable option for these types of BMs, and some examples can be found online [9]. For instance, in [10] PV systems are financed via crowdfunding, allowing impact-driven individuals to invest in projects aimed at fighting climate changes and help businesses to be more sustainable and to lower their energy costs, while receiving a financial return from these investments.

3.1.1.2. BESS provision

The typical BM consists in a company which takes role of DER Provider and sells BESS for users for behind the meter applications, such as ensuring backup power provision, increasing PV self-consumption, reducing demand during peak hours, benefiting from Time-of-Use (ToU) tariffs and providing flexibility to other parties [11]. There are plenty of companies selling new BESS to Consumers [12], [13], with some of them selling the batteries together with PV panels since BESS are a mean to increase PV panels value [14].

However, as an alternative to the delivery of new batteries, as described in [15], it is also possible to use second-life EV batteries to manufacture BESS. These BESS can be sold to residential, commercial, and/or industrial Consumer, being installed in their property. The buyer either pays for the system upfront or can ask for a loan to a Financial Entity, with the DER Provider acting as a mediator [15]. This technology allows thousands of used batteries with different levels of degradation to be aggregated, operated and used as one single stationary BESS [15]. As the number of EVs increases, more 2nd life batteries will become available, boosting this BM and helping to drive the shift to a circular economy, reducing waste and making these storage systems more affordable [16].

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3.1.1.3. HEMS provision

Nowadays, Home Energy Management Systems (HEMS) are a growing sector. HEMS create value to Consumers by helping them to save energy and money by combining control and scheduling options, which can be used to help to adapt energy usage [17].

In this BM, the companies selling the HEMS system (DER Provider) usually produce custom made solutions to match the home and requirements of each Consumer [18], [19].

The systems available in the market are capable of not only overseeing energy consumption and change the behaviour of appliances, but also of performing automated tasks to enhance comfort and security to homeowners [20].

Since most HEMS are highly personalized solutions, not a lot of information is available regarding under which conditions they are supplied to the Consumers. As such, there is a gap of information associated with payment terms, so it is not clear if, in real life implementations of this BM, Consumers are expected to pay for the system upfront or if they are allowed to pay it in multiple instalments. However, by analogy with to what happens in other BMs, possibly both options are available.

3.1.1.4. WH, HP and HVAC provision

In some cases, WH and HP are provided directly to Consumers by the Manufactures, but most commonly they are sold by a large reseller (DER Provider). Additionally, certain Retailers are selling smart WH to their Consumers, with the option to either make a one-time payment or recurring monthly payments until the cost of the device is covered, as in [21] and [22].

Comparably, HVAC systems are usually sold to the Consumers either by manufactures or resellers. Some Retailers also sell this equipment to Consumers, allowing them to opt between making a one-time payment or paying a recurring monthly, as in [23] and [24]. In these BMs, the Retailer, acting as DER Provider is, once again, responsible for installing and maintaining the device.

Other BMs are based on retrofit hardware to control and optimise the consumption of electric WH, heaters and HP, helping their owners to lower energy bills, to automatically set heating schedules for time periods with lower prices, and to increase self-consumption (if available) [25].

3.1.2. BMs for DERs provision as a Service

Apart from the traditional BM where a Supplier simply sells the resource to the Consumer, a BM that is often found across multiple sectors is the EaaS, a variation of the Anything as a Service (XaaS) [26]. EaaS is a BM in which a product is presented to a Consumer as a Service [26], that is, the product is not sold, but is instead rented to a Consumer who is charged for using it. From an economic perspective, this means that the customer swaps capital expenses for operational expenses. The seller is in charge of maintaining and repairing the product during the contract and can use information via the Internet of Things (IoT) for real-time supervision and improvements [27].

The XaaS concept is not new, being introduced over sixty years ago by a company to promote the use of their copy machines in offices [27]. Nowadays, there are multiple examples of companies from inside and outside the energy sector adopting this type of BM, as evidenced by the existence of Solar as a Service, Energy Storage

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as a Service, Charging as a Service, HVAC as a Service, Smart Home as a Service, Heating as a Service (see Table 3.2) but also Analytics as a Service, Blockchain as a Service, Data Storage as a Service, etc [28].

There are several advantages related to the EaaS BMs for the companies adopting it. The first advantage is particularly important for firms suppling costly or premium products. Because the EaaS model does not require customers to make upfront investments, expensive products become more affordable to a larger selection of customers, leading also to predictable and recurring revenue and/or cost streams. Another advantage of deploying an EaaS option is the continuous feedback loop received from the constant contact with the customer. This gives the Supplier valuable data to continuously learn about customer experience, enhance their products, and improve their services. A third advantage is the chance to increase customer's loyalty. By making improvements based on the received feedback, it is possible to improve the quality of the service provided, increasing the loyalty of the Consumers [29].

Table 3.2 - Most relevant reviewed companies and projects regarding BMs for DERs provision as a Service

Area	Business Model	Reviewed companies and projects
DERs Provision as a Service	Solar as a Service	REPSOL, edp, plico, BRUSOL, Göteborg Energi, OTOVO
	Energy Storage as a Service	Green Mountain Power, frv, Younicos, WattLogic
	Smart Home as a Service	qorvo, veea
	Charging as a Service	tridens technology, evconnect, OODLES Energy, Shell Recharge Solutions, WattLogic
	HVAC as a Service	VENWIZ, PrimexVents

3.1.2.1. Solar as a Service

In Solar as a Service (SaaS), also known as PV as a Service, Consumers make use of their rooftops to install PV panels owned and managed by a 3rd party company. In this case, the 3rd party company is a DER Provider who is also responsible for the installation and maintenance of the equipment [30]. This BM might be attractive for Consumers since it allows them to enjoy the benefits of self-consumption without assuming any risks for the PV installation [31]. There are several companies implementing variations of this BM, as described next.

In [32], the DER Provider is a Retailer. The advantages presented to the Consumers who adopt this BM are no investment costs, a maintenance service for the entire duration of the contract, a continuous monitoring of the PV plant in a control centre, and access to an energy management platform where it can be seen energy consumption and production from the PV panels [32]. This Retailer offers two variations of the SaaS BM. In the first one, the Consumer pays a monthly fee for the use of the panels that is proportional to the energy they produce (no fee if no energy is produced), with the Retailer ensuring that the monthly fee is always lower than the monthly savings resulting from self-consumption. Meanwhile, in the second one, the Consumer pays a fixed monthly fee, which depends on the characteristics of the installation and on the

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expected production (forecasted savings). In both cases, the contract lasts up to 15 years, and once it is over, the Consumer can choose to become the owner of the PV panels at no additional cost, renew the contract an keep using the panels as a Service or not renew the contract and return the equipment to the Retailer [32], [33]. The same company also presents a BM more aligned with collective self-consumption and Energy Communities. To create such community, a Consumer with available space for installing PV panels start by contacting the DER Provider (who is also their Retailer). After a validation phase, neighbours are recruited to join the community and the PV panels are then installed. After they start producing, both the Prosumer and the neighbours receive a portion of the solar energy generated at a discounted price. Furthermore, they contribute to a more sustainable society, enhance their sense of community by being part of a sustainable energy sharing network and receive solar energy without any investment [34].

An alternative BM is depicted in [35], where another Retailer acting as DER Provider installs, operates and maintains a solar PV system on the roof of a selected user (roofer). The roofer can consume the energy produced by the panels and, in the case of a surplus, supply it to nearby Consumers (matchers), who are the other active participants in this program. Additionally, at the end of the 15 years contract, the roofer can keep the panels for free, improving their property's energy certificate. Since the DER Provider is also the Retailer, this simplifies the energy sharing and billing, and the compensations for the roof renting. In this case, billing is divided into 3 different components: fixed monthly tariff (for matchers), unique billing scheme for self-consumption (for matchers), and an unique billing scheme for electricity consumed from the grid (for matchers and roofers) [36].

There are other private entities offering subscription-based BMs for PV panels apart from those already described, such as [37] and [38].

3.1.2.2. Energy Storage as a Service

Equivalent to SaaS, Energy Storage as a Service (ESaaS) allows Consumers to benefit from a BESS without purchasing it [39], paying a rental fee for the duration of the contract [40].

However, while various companies presenting SaaS BMs were found, not so many appear to be implementing ESaaS as a standalone option. Indeed, batteries are usually not offered as a Service on their own, but together with PV panels. This situation appears to imply that BESS don’t present as much value to Consumers as PV panels or can only complement PV panels to bring real value.

Even so, a few examples of companies adopting ESaaS were still found, such as in [41], where Consumers pay a monthly fee for the battery [42], similar to the BMs offered by others in [40] and [43].

3.1.2.3. Smart Home as a Service

In Smart Home as a Service (SHaaS) the Consumer pays a monthly subscription for a HEMS system delivered by a DER Provider. This is a model that is meant for Consumers who want the convenience of a smart home without having to worry about any technical details [44]. Instead, it is the DER Provider that is responsible for supplying, installing and assuring the proper operation of all the devices related with the HEMS [45].

In the reviewed BMs, it is mentioned how the DER Provider role can be taken by companies such as telecommunications operators, including Internet Service Providers (ISP) or cable TV providers [44], [45].

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3.1.2.4. Charging as a Service

Charging as a Service (CaaS) can be used as an alternative to owning private EV Charging Stations (EVCS). This is regarded as a risk-free option for Consumers, without any upfront investments, where the only running costs are a monthly or annual fee paid to the DER Provider, who delivers a finished product and is responsible for operating and maintain the stations [46]. As such, the company offering the EVCS takes not only the role of DER Provider but is also a Charging Point Operator (CPO).

According to [46], the EVCS remains under the ownership of the DER Provider. Once the contract is over, the two parts can negotiate what do to next. For instance, the Consumer can buy the charging station from the DER Provider, or the contract can be extended, and the equipment upgraded or replaced by new models.

The advantages associated with CaaS are the lower initial costs, more predictable expenses (avoids costly and unexpected repairs), lower risk, ease to upgrade (often included in the subscription) and easy scalability (adjustable for different EV charging needs over time) [47]. Furthermore, certain chargers allow users to profit from flexibility provision [48]. As a BM, CaaS seems to be broadly used by DER Providers, with multiple companies using this BM with only slight variations.

3.1.2.5. HVAC as a Service

HVAC as a Service (HVACaaS) is a new BM where a Manufacturer or DER Provider offers a subscription-based service for using their HVAC system, which they own and maintain. The equipment is actively operated and monitored by the DER Provider, who's entirely responsible for its maintenance and to ensure a proper functioning of the device [49].

3.1.3. BMs to reduce the electricity bills of flexible Consumers

The next BMs are related to the reduction of electricity bills for Consumers, including residential, commercial, and industrial Consumers. They are summarized in Table 3.3 and described next.

Table 3.3 - Most relevant reviewed companies and projects regarding BMs for the reduction of electricity bills for flexible Consumers

Area	Business Model	Reviewed companies and projects
Reduce the electricity bills of flexible Consumers	Small Consumers optimizing electricity bills	integrid (bridging the gap), IBERDROLA, electric Ireland, USEF
	Large Consumers optimizing electricity bills	integrid (bridging the gap), HyBalance, USEF

The separation between small and large-sized Consumers takes place merely because their capacities and purposes are significantly different. For instance, a large industrial unit might dismiss an Aggregator because it already has a substantial load [50].

3.1.3.1. Small Consumers optimizing electricity bills

In this BM, small-sized Consumers, such as households and small commercial or industrial firms, use their own flexibility to reduce electricity bills. The main strategies to reach this goal include:

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- Energy price response – A type of implicit flexibility [51] which encourages Consumers to adapt their consumption patterns to variable electricity prices [50]. Directive 2019/944, gives Consumers the right to have a tariff with dynamic price and, as such, there are multiple Retailers offering this option to their clients [52], [53].
- Network tariff response – Another part of the implicit flexibility related to the grid access tariffs [51] which also encourages Consumers to react to variable, yet time-dependent, network tariffs [50]. Indeed, the integral tariff of the customers includes both the energy price, and the network access tariffs.
- Energy Performance Contracts – An external organisation can sign an Energy Performance Contract with a Consumer [50]. Under an EPC, the external organisation implements a project on the Consumer's property (e.g., renewable energy project or a project to increase energy efficiency) and uses the streams of income, which come from the renewable energy production and/or from the energy bill reduction, to repay the costs of the investment [54].
- Installation of DERs and self-consumption – Consumers can install DERs, produce electricity, and become Prosumers. So far, the most common technologies are solar PV panels and, if costs continue to decrease, BESS [50] (see 3.1.1 and 3.1.2).
- Provision of flexibility – Consumers can offer their flexibility to other parties, usually on a flexibility market and through an Aggregator [50] (see 0).
- Energy Communities – As recently defined in Directives 2019/944 and 2018/2001, RECs and CECs are meant to allow Consumers and Prosumers to cooperate in electricity generation and consumption following an approach that enables them to reduce costs [50] (see 3.1.7).

3.1.3.2. Large Consumers optimizing electricity bills

In this BM, a large-sized Consumer, e.g., an industrial unit, makes use of its internal flexibility to reduce electricity bills [50]. There are multiple strategies and mechanisms through which these Consumers can increase and/or take advantage of their internal flexibility for self-benefit:

- Energy price response – A type of implicit flexibility [51] which encourages Consumers to adapt their consumption patterns to variable electricity prices, for instance by altering working hours or shifts, in the case of industrial Consumers. This can be particularly attractive for energy-intensive Consumers, whose operating costs are highly affected by energy expenses [50].
- Network tariff response – Another part of the implicit flexibility related to the grid access tariffs [51] which also encourages Consumers to react to variable network tariffs. Since network charges are more stable and predictable than energy prices, they can be a more interesting option for industrial Consumers, as it avoids recurrent changes in production schedules [50].
- Installation of DERs – Consumers owning generators can fulfil part of their demand. Complementarily, they can install storage systems, such as BESS, to store generation surpluses [50].

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- Hydrogen production – Another option is the production of hydrogen, which can be stored in tanks and later used to produce electricity, used as a fuel for vehicles, employed in industrial processes [55], or sold to nearby facilities [56].
- P2P trading – Consumers can exchange energy among themselves via peer-to-peer transactions [50].
- Provision of flexibility – Consumers can offer their flexibility to other parties, usually on a flexibility market (see 0).

3.1.4. BMs for cross-sector activities

This next set of BMs is related to activities not directly linked to the energy and flexibility VC, such as mobility, safety/security and healthcare services, as shown in Table 3.4.

Table 3.4 - Most relevant reviewed companies and projects regarding BMs for cross-sector activities

Area	Business Model	Reviewed companies and projects
Cross-sector activities	Optimizing EV charging	FLOWER. WeaveGrid bia
	Safety/security, healthcare, and social services for residential Consumers	interconnect SONY ABB SMART HOMES SOLUTIONS Control4 TITAN ALARM & FIRE
	Minimizing non-renewable consumption	Nobel Grid Smart energy for people

3.1.4.1. Optimizing EV charging

In the first BM of this group, based on the one presented in [57], an EV Aggregator (EVA) connects a set of EV to the grid by means of a digital platform, enabling them to provide flexibility by controlling the charging process. By pulling data directly from the EV, the EVA uses a software that helps to predict aspects such as when EV users are more likely to charge their vehicles based on driving patterns, how quickly the number of EV is growing in a certain area and how that might affect the capacity limits of power lines. By allowing their EV to provide flexibility for system operators via an EVA, Consumers get access to cheaper electricity tariffs [58]. In some cases the exchanged data is sent directly from the EV to the online platform, because some chargers are not yet capable of sharing the necessary information [59].

EVA can help to flatten peak loads, minimize EVs batteries degradation, reduce energy costs and decrease carbon emissions by ensuring more vehicles charge during the hours with more production from RES [60] and less grid overload.

3.1.4.2. Safety/security, healthcare, and social services for residential Consumers

This BM is enabled by smart meters and HEMS and can be implemented in residential buildings to deploy safety/security, healthcare, and social services.

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Residential energy data obtained from smart meters can be used to check the health and wellbeing of the inhabitants. This involves a remote and non-intrusive load monitoring process through which the usage of electrical appliances (e.g., ovens, washing machines, kettles, etc) can be recognised. Then, algorithms can create a time map of routine behaviours and activities and detect anomalous behaviour or unexpected inactivity, informing family members or caregivers to potential changes in the health or wellbeing status of less able people living alone, allowing them to act quicker [61].

Regarding social services, it is suggested that governments can use smart meter data related to low credit thresholds and emergency credit activation to detect households undergoing financial struggles. These data can be used to provide aid or to improve social services such as grants [61].

To effectively deploy security services, it is important that the residence is equipped with sensors and alarms that can detect intruders or other hazardous situations such as fires, floods, dangerous CO/CO_2 levels among other events [61], [62]. Although these safety and security services are not directly enabled by energy data, the same HEMS installed to adapt consumption, reduce energy costs, provide flexibility, or maximize self-consumption, can also incorporate additional devices and fucntionalities. For instance, it can integrate smoke detectors, water leak sensors, lighting controls which simulate occupancy to deter intruders while homeowners are away, along with cameras or motion sensors for added secuity.

Since this BM suggests the utilization of Consumer's data, it is important to respect data privacy requirements. The General Data Protection Regulation sets the principles on how Consumer's data must be handled and used. Since metering data is treated as Consumer's property it can only be accessed by third-parties authorized by the Consumer [50].

3.1.4.3. Minimizing non-renewable consumption

In this BM, an entity designated as Carbon Cooperative provides information to the Consumers about grid carbon intensity, allowing the more concerned users to shift consumption to periods of higher renewable generation, thus reducing consumption during the most carbon intensive levels. Joining the service is seen as more of an ethical choice, which is not expected to be driven by financial incentives. Nonetheless, if the Consumer is also a company, it is possible it might sell its non-used emission's credits to other businesses who are not able to keep their emissions below a certain threshold. This could also be attractive to a company wishing to advertise their brand as environmentally friendly [63].

3.1.5. BMs for the operation of power grids

With the growth of renewable energy, the development of grid smart grids and grid digitalisation, new BMs are appearing, which mostly benefit grid operator and, consequently, all grid users. The reviewed projects and firms are provided in Table 3.5.

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Table 3.5 - Most relevant reviewed companies and projects regarding BMs for the operation of power grids

Area	Business Model	Reviewed companies and projects
Operation of power grids	Flexibility acquisition for grid operation	integrid; Universal UMEI; Nobel Grid; USEF; SP Energy Networks; piclo
	Data acquisition for grid management and control	integrid; Nobel Grid; reactive technologies

3.1.5.1. Flexibility acquisition for grid operation

In this BM, flexible Consumers (equipped with PV panels, BESS, HP, HVAC, EMS, EV…) provide explicit flexibility to entities such as DSOs (for constraint management) and TSOs (for power balancing) in a flexibility market (flexibility can also be provided to Balance Responsible Parties (BRPs), not for grid operation, but for portfolio optimization, as described in 3.1.6.2). Here, Aggregators play a central part, being responsible for acquiring flexibility from Consumers, aggregating it into a portfolio, and using it to offer services and bid in flexibility markets. The financial reward received from participating in those markets is then shared with the Consumers who provided the delivered flexibility [51]. Because aggregation is an activity that is not yet well defined and regulated in many countries [64], and whose revenues might be scarce [65], this role is sometimes assumed by Retailers.

This BM enables DSO to procure and activate the necessary flexibility to prevent or mitigate constraints in the distribution grid. Using this strategy, the DSO can expect to reduce capital and operating expenses, both in the short and long-term [50] by postponing grid upgrades and by avoiding the overload of components, such as power transformers [66]. The DSO exchanges information and services with Consumers either directly or through an Aggregator [51]. In addition, it is possible that the DSO receives data from a forecaster, who provides localized generation and consumption forecasts, which can help to predict future flexibility needs. This role can be subcontracted to a third-party, or it can be internal to the DSO [50]. TSO/DSO coordination mechanisms can be involved in the acquisition of flexibility by these parties. The level of coordination may depend on grid topology and can be used to validate assignments before allowing the activation of flexibility [67].

Apart from flexibility markets, there are other mechanisms through which Consumers can provide flexibility, such as:

- Flexible access and connection agreements – Consumers (and Producers) can make agreements with system operators to temporarily have their available network capacity reduced upon request by the DSO. This change in access rights might be prompted by certain events or specified for pre-defined time periods. For instance, demand can be temporarily reduced during peak demand, while generation can be curtailed to prevent voltage issues or congestions. In return, these grid users might benefit from lower

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connection charges, a faster connection to the grid (since less upgrades are required), and/or economic compensations when activated. This mechanism is exclusively meant for new network users [50], [67].

- Dynamic network tariffs – Network tariffs can depend on time and location, thus being adjusted to reflect the necessary temporal and spatial cost variations. By using dynamic network tariffs, Consumers (and Producers) are encouraged to adjust their consumption and/or production patterns in order to meet network needs [67].
- Administrative prices for local flexibility – As a replacement for the creation of a flexibility market, the DSO, following regulatory guidelines, can define administrative prices and activate the necessary flexibility from Consumers who previously agreed to provide it [50]. Unlike flexible access and connection agreements, this mechanism is usually applied to pre-connected Consumers [67].
- Mandatory provision – When under more extreme situations (e.g., threats to grid security) the DSO can order the activation of the available flexibility, usually compensating Consumers for generation or load curtailment. Normally, this mechanism is used only as a last resort option and the resulting compensations are quite high [50], making it even more unfavourable.
- Obligations – Defines the mandatory an not remunerated provision of flexibility [67].

3.1.5.2. Data acquisition for grid management and control

In this BM the DSO and/or TSO make use of the available grid data. The increasing availability of grid data is a result of grids digitalization and includes data which might be privately owned by Consumers, data from smart-meters and data collected by sensors at multiple levels. This information can be used for multiple ends, including:

- Maintaining grid assets – The acquired data is used to evaluate the condition of grid assets, including breakers, transformers, and cables. Thus, the overcharging of these components can be avoided, preventing failures, prolonging their lifetime, and reducing costs [63].
- Increasing service quality reliability – By continuously monitoring power quality, it is possible to point out abnormal grid power levels more efficiently, thus reducing the response time to these issues and minimizing failures and maintenance costs and increasing reliability for the Consumers. As a result, this usage of grid data can help operators to cut on the penalties they must pay due to a lack of quality and reliability [63].
- Managing incidents and blackouts – Grid data can be used to monitor incidents on the network infrastructure and manage them using an efficient and time-responsive approach, possibly avoiding bigger issues (e.g., full, or partial power outages). As a result, the grid operator can make a better planning of the resources required for maintenance tasks, reduce maintenance costs and the time of response to incidents. Moreover, historical incident data can be used to identify recurring incidents/failures and provide solutions to prevent them in the future [63].

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3.1.6. BMs for supplying energy to Consumers

BMs for the supply of energy to Consumers are also evolving, with Suppliers having more active roles, which can benefit Consumers, as seen next. The reviewed initiatives and BMs are given in Table 3.6.

Table 3.6 - Most relevant reviewed companies and projects regarding BMs for the supply of energy to Consumers

Area	Business Model	Reviewed companies and projects
Supply of energy to Consumers	Traditional retailing model	IBERDROLA, edp, electric Ireland
	Retailers managing Consumers' flexibility	integrid, USEF

3.1.6.1. Traditional retailing model

The traditional retailing BM is the most widespread model within this sector [68]. Due to the liberalization of the retail market, Retailers are able to profit from purchasing electricity from Producers and supplying it to Consumers [69], while being free to make their own commercial offers.

3.1.6.2. Retailers managing Consumers' flexibility

In a more innovative BM, a Retailer who is also BRP uses their clients' flexibility for its own economic benefit. This can be implemented through Building Management Systems (BMS) and allows Retailers to exploit Demand-Response in two separate ways: to reduce imbalance costs or to participate in ancillary services markets, following different strategies to achieve these goals [50]:

- Internal portfolio balancing – Retailers handle energy imbalances by trading in the intraday markets or otherwise they suffer economic penalties. With the spread of aggregation and technologies such as BMS, Retailers can use their Consumers' flexibility to better comply with their committed schedules, reduce imbalances and avoid penalties [50].
- Flexibility to perform price arbitrage – Retailers may also use this flexibility to perform price arbitrage between day-ahead and intra-day energy markets. For instance, in a situation where prices are higher in the day-ahead market than in the intraday market, if a Retailer can forecast this differential, it can buy less energy in the day-ahead and buy the remaining in the intraday, using flexibility as a tool to limit financial losses [50].
- Providing flexibility to the TSO – If allowed by the regulation, Retailers may aggregate the flexibility from multiple Consumers to provide balancing services to the TSO [50].

3.1.7. BMs for communities

Nowadays, and according to the European Legislation, RECs and CECs are entitled to [70]:

- Producing, consuming, storing, and selling renewable energy, including though renewable Power Purchase Agreements.

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- Sharing, within the Energy Community (EC), renewable energy that is generated in own units.
- Accessing all suitable energy markets, both directly and through an Aggregator.

A review of the regulation on ECs can be found in D1.1 [71].

For those reasons, some Consumers might have the opportunity and the motivation to form or join an EC, such as a REC or a CEC. The reviewed companies and projects and their main BMs are grouped in Table 3.7.

Table 3.7 - Most relevant reviewed companies and projects regarding BMs for ECs

Area	Business Model	Reviewed companies and projects
Energy Communities	Energy cooperatives	integrid, RESCOOP.EU
	Community flexibility aggregation	newcomers, FLEXCoop
	E-mobility cooperatives	Som mobilitat, mobicoop

3.1.7.1. Energy cooperatives

So far, in Europe, many ECs are organized as energy cooperatives. They are initiatives led by citizens where Consumers join to raise the necessary funds for owning generation systems, being centred on open and voluntary membership rules. They can be created to benefit specific communities through self-consumption and sale of generation surpluses, with profits being invested in the EC, but they can also be created with the purpose of providing cheaper energy from RES to its members [72].

The advantages for Consumers who join these cooperatives include reduced electricity bills, a decrease of emissions, higher energetic independence, reduced network connection fees, and remuneration derived from generation surpluses [70].

3.1.7.2. Community flexibility aggregation

A more complex BM foresees the provision of flexibility to grid operators through an Aggregator. Flexibility markets are not accessible to small Consumers. But, the manager of an EC, while acting as an Aggregator, can pool the available flexibility from multiple Consumers, achieve the required volume to make offers in those markets and thus enable the participation of small Consumers flexibility markets. For that, the EC Manager and the Consumers sign bilateral contracts where they commit to changing consumption patterns to deliver fixed amounts of flexibility, and, in return, benefit from reduced electricity bills. The failure to deliver flexibility can result in penalties for Consumers [72]. The EC Manager/Aggregator can also provide resources (sensors, smart meters, HEMS) and monitoring apps to EC Members to help them in delivering the contracted flexibility [73].

Besides the advantages previously detailed in 0, this BM enhances financial benefits to Consumers, who are reward for providing flexibility [70]. Moreover, the required sensors, HEMS and smart meters might help Consumers to access the value-added cross-sector opportunities described in 3.1.4.2.

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3.1.7.3. E-mobility cooperatives

Cooperatives based on E-mobility are suitable for communities where many citizens have EV. These vehicles, besides helping to maximize local self-consumption, can be exploited to provide flexibility (via Aggregators, using V2G and G2V technologies) and to reduce bills by charging during off-peak periods. Additional social benefit can be created by engaging participants to provide community public transportation, car-sharing or car-pooling services [72].

3.2. Role model and characterization of BeFlexible Business Models

From the literature and commercial proposals analysed previously, it was concluded BMs can be characterized by:

1. Properly identifying the role model with all the relevant roles involved in the BMs related to the flexibility provision, including cross-sector activities that can provide added value.
2. Identifying actors, and associating roles to actors. Indeed, the roles the actors adopt define the BM, as the description of the main BMs provided in this section show.

3.2.1. Energy and Cross-sector Flexibility Centric Role Model

As a result of the above revision, and the flexibility VC identification described in section 4.1, Figure 3.1 shows the complete role model identified with the main activities among roles.

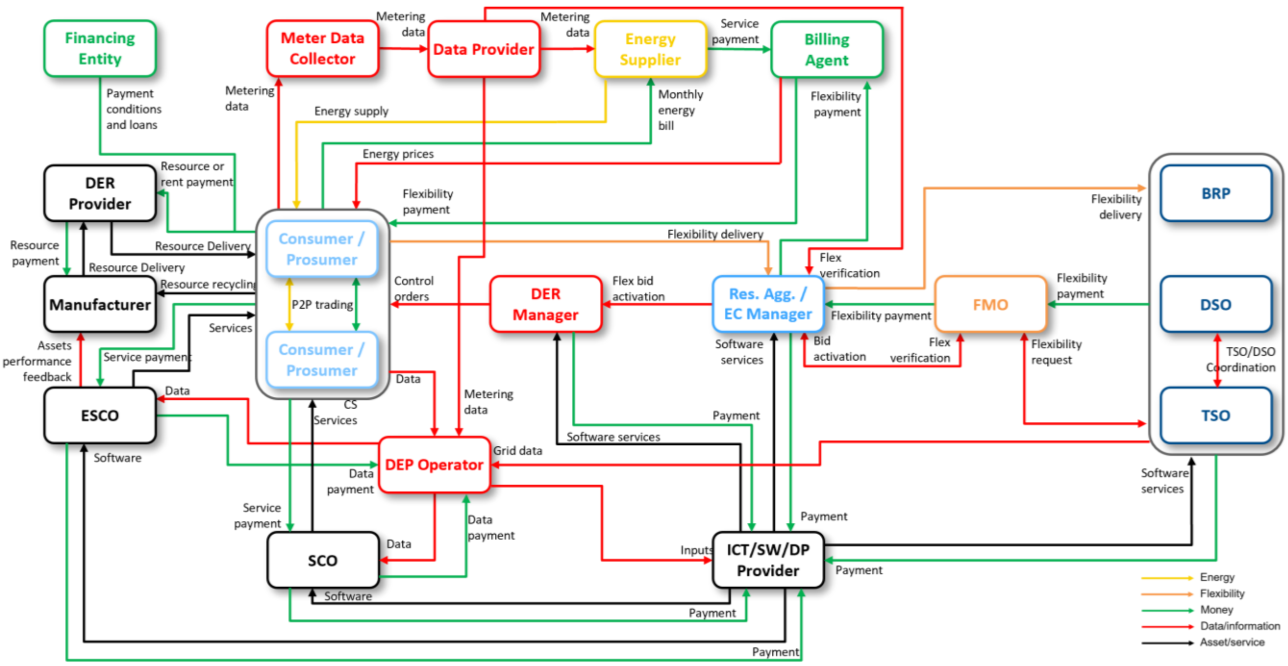

Figure 3.1 – The Role Model of the flexibility VC

The proposed Role Model includes a total 20 participants. It contains the necessary roles to support all the main activities envisioned for the Flexibility-centric and Cross-Sector VC, including flexibility capacitation, integration/enablement and aggregation of flexible resources, and participation in flexibility markets, described later in section 4.1. This work was also presented and published at the 2023 19th International

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Conference on the European Energy Market (EEM) in the paper "Analysis of Flexibility-centric Energy and Cross-sector Business Models" [74].

The focus of the envisioned Role Model is on Consumers and Prosumers. They receive flexible DERs from a DER Provider, who acquire them from a Manufacturer. A Financing Entity can help the Consumers/Prosumers to buy these resources. Service Companies and Energy Service Companies can sell their services to the Consumers/Prosumers and a DER Manager can control their DERs. A Resource Aggregator, or an Energy Community Manager (besides supervising an EC), can facilitate the participation of Consumers/Prosumers in Flexibility Markets, operated by a Flexibility Market Operator, where flexibility can potentially be supplied to DSOs, TSOs and BRPs. There are other roles, such as Meter Data Collector and Data Provider who will supply energy data to Energy Suppliers to bill Consumers/Prosumers via a Billing Agent, and to a Resource Aggregator to verify the delivery of flexibility. There is also the DEP Operator who can exchange energy and non-energy data, and an ICT/SW/DP Provider who offers IT services (e.g., technical platforms, algorithms) to several of these players.

Most of the roles incorporated in the proposed Role Model are included in the Harmonised Electricity Market Role Model (HEMRM) [75]. However, since this role model focus on energy activities, new roles were needed to fill the existing gaps, namely those related to financing, asset provision and the cross-sector activities that will later be included in the proposed VC. This resulted in a role model that can be applied to activities beyond the energy sector but related to and providing added value to the flexibility provision as the main activity. All the roles encompassed in the BeFlexible Role Model are described in Table 3.8 where it is signalled whether they are already included in HEMRM or proposed by the authors (BeFlexible RM).

Table 3.8 – Description of the roles included in the BeFlexible Role Model

Role	Description	Source
BRP	A party in charge of its imbalances, that is, the difference between the energy volume injected to or withdrawn from the system and the final nominated energy volume, including every imbalance adjustment within a certain imbalance settlement period.	HEMRM
Billing Agent	The Billing Agent is responsible for invoicing a concerned party.	HEMRM
Consumer	A party connected to the grid which purchases and consumes electricity.	HEMRM
DEP Operator	Owns and operates a communication system to transfer data.	HEMRM
Data Provider	Has a mandate to provide data to other parties	HEMRM
DER Manager	Responsible for controlling DERs.	BeFlexible RM
DER Provider	Responsible for installing and/or maintaining assets related with distributed energy equipment (e.g., batteries, PV panels, smart devices), which are provided or sold to other market agents.	BeFlexible RM
DSO	Responsible for the security of supply and reliability of the distribution network. For that, it continuously monitors the grid to detect potential issues and, whenever necessary, it uses multiple resources to solve such problems, including network reconfiguration and/or requesting assistance from market operators or directly from contracted customers.	HEMRM
EC Manager	Responsible for managing business activities within an Energy Community.	BeFlexible RM
Energy Service	Offers energy related services but is not directly active in the energy VC. Might provide insights and energy management services, as well as implementation of energy efficiency and renewable energy projects.	HEMRM (adapted)

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Company		
Energy Supplier	Supplies or takes electricity from a party connected to the grid	HEMRM
Financing Entity	A party in a financing arrangement who provides money, property, or other assets to a certain financed entity.	BeFlexible RM
Flexibility Market Operator	A neutral party that transparently provides a service between buyers and sellers to facilitate the communication and coordination of all processes related to the procurement of capacity and/or energy bids, i.e., grid or asset registration on its marketplace, matching of bids, validation (through market monitoring) and settlement.	HEMRM
ICT/SW/DP Provider	Supports other entities with ICT, software, or DP.	BeFlexible RM
Manufacturer	Manufactures specific products, which are later supplied to other market agents.	BeFlexible RM
Meter Data Collector	Responsible for meter reading and quality control of the reading.	HEMRM
Prosumer	A Consumer who can also produce electricity, joining the roles of Consumer and Producer under one role. In BeFlexible it is also assumed that a Prosumer also adopts an active role in the energy chain, by, for example, be willing to joint self-consumption structures or provide flexibility.	HEMRM
Resource Aggregator	Aggregates (i.e., collects and combines) multiple resources for usage by a service provider for energy market services.	HEMRM
Service Company	A party that offers non-energy related services, generating revenue by service provision instead of selling products. Can provide cross-sector services.	BeFlexible RM
TSO	Responsible for security of supply and reliability of a transmission network, real time operation and monitoring, building, expanding, and maintaining the system.	HEMRM

3.2.2. BeFlexible Business Models

The rest of this section formalizes and summarizes the BMs identified by describing them with their BM Canvas (BMC), describing the roles and actors involved, and evaluating qualitatively their main characteristics in terms of complexity, risk, and value:

- Complexity was assessed based on the number of roles associated with the BMs and the technology necessary for its implementation. Complexity can also be seen graphically when analysing the particularization of the general role model of Figure 3.1 to each of the BMs described.
- Risk was assessed based on potential regulatory concerns and the expected cost of the BM for the Consumers.
- Finally, Value was assessed based on the economic and non-economic value created to all participants.

The manner under which each parameter is assessed is presented on Table 3.9.

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Table 3.9 - BM evaluation methodology

Parameters		Level				
		○	◔	◑	◕	●
Complexity	Number of roles	1 – 4	5 – 8	9 – 12	13 – 16	+17
	Necessary tech	BM does not require any new technology	BM should not require many new technologies	BM requires several new technologies	BM requires complex technologies	BM requires complex and new technology
Risk	Regulatory concerns	Little to no concerns (BM seems fully appropriate for current regulation)		Some concerns (BM mostly fits in the current regulation, but with some gaps and issues)		Severe challenges (BM does not seem compatible for the regulation)
	Costs (consumers)	None or very little additional costs		Moderate costs (e.g., rent payment)		High costs (e.g., one-time payment)
Value	Economic value	Limited economic value to just a few of the intervening roles		Creates economic value to most of the intervening roles		High economic value to all roles
	Non-economic value	Limited non-economic value to just a few of the intervening roles		Additional non-economic value to most of the intervening roles		Large amount of non-economic value to all roles

Regarding the BMC, it consists of a template used to describe the main dimensions of a BM (see deliverable D2.1 [76] for an in-depth introduction to BMs and associated tools). It includes nine building blocks, shown and described in Table 3.10, which are organised as follows:

- The four blocks on the left of the BMC (key actors, key activities, key resources, and costs) focus on how value is being created by a business activity.
- The value proposition block, located in the centre of the BMC draw attention to the value being generated.
- The last four blocks (actors’ relationship, channels, customers segment and revenues) communicate how value is delivered and captured [72].

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Table 3.10 – BMC structure and building blocks

<table>
<tr><th>Key actors:</th><th>Key activities:</th><th>Value proposition:</th><th>Actors' relationship:</th><th>Customers segment:</th></tr>
<tr><td rowspan="3">Actors, such as partners and suppliers, providing inputs essential for the operation of the BM, including equipment, data, and services [63].</td><td>Essential and most critical tasks to be performed [63].</td><td rowspan="3">The value being delivered to customers [77].

The set of products and services presented, their main properties, the needs that they meet and their worth [63].</td><td>The type of relationship established between the actors of each BM [77].</td><td rowspan="3">Includes the people and organizations for which value is created [78].

For instance, it can be a niche market, such as eco-friendly consumers, or a broader one, such as low-voltage households and businesses [63].</td></tr>
<tr><th>Key resources:</th><th>Channels:</th></tr>
<tr><td>The most important inputs required [63].

Can include human, physical, intellectual, and financial resources [63].</td><td>Describes how the interaction with customers is made [63], [78].

Defines how the value propositions are delivered [63], [78].</td></tr>
<tr><th colspan="3">Costs:</th><th colspan="2">Revenues:</th></tr>
<tr><td colspan="3">The most important costs inherent to the BM [77].

Can include fixed and variable costs [77].</td><td colspan="2">The most relevant sources of revenue [77].</td></tr>
</table>

3.2.2.1. BM1: Traditional retailer

BM1 resembles the traditional electricity commercialization model, which was boosted by the liberalisation of energy markets and is now the predominant model within the sector [68]. In the liberalized retail market, Retailers profit from selling electricity to the Consumers bought from the Producers in the wholesale market [69], being free to set up their own commercial offers in those countries where the retail market has been liberalized. Traditionally, electricity comes from large scale power plants, often ran with non-renewable energy sources [68]. More recently, green energy can also be sold to the Consumers, ensuring that the electricity sold by the Retailer was bought from renewable power plants, as in [79], [80]. However, as it stands, in this BM Consumers do not provide flexibility to the grid.

In this traditional model, the relationship of the Consumers with their Retailers remains typically distant. This generates instability in the Consumers side since the added value offered by the Retailer is blurred, and Consumers tend to think only of the highest bidder, being common to switch to companies that offer more transparency, other types of relationships, or benefits as simple as clearer and more understandable bill. This distant relationship has also traditionally generated a lack of trust and transparency on the Retailers. This has also led Consumers to a) produce their own energy to reduce the dependence on the traditional Retailers; b) organise in energy communities and c) joining energy cooperatives and other type of social organisation where values such as justice, transparency, fairness, and social wellbeing are the basis of different and closer types of relationships.

The Retailer takes the roles of Energy Supplier and Billing Agent, the DSO, as it is usually the case in the EU, takes the roles of Meter Data Collector and Data Provider [81] and the Consumer simply consumes and pays for the consumed energy. The relation between actors and roles for BM1 is given in Table 3.11, while the interactions between roles are provided in Figure 3.2 from the general role model in Figure 3.1.

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Table 3.11 - Match between actors and roles in BM1

Actor	Roles
Retailer	Energy Supplier Billing Agent
Consumer	Consumer
DSO	Meter Data Collector Data Provider

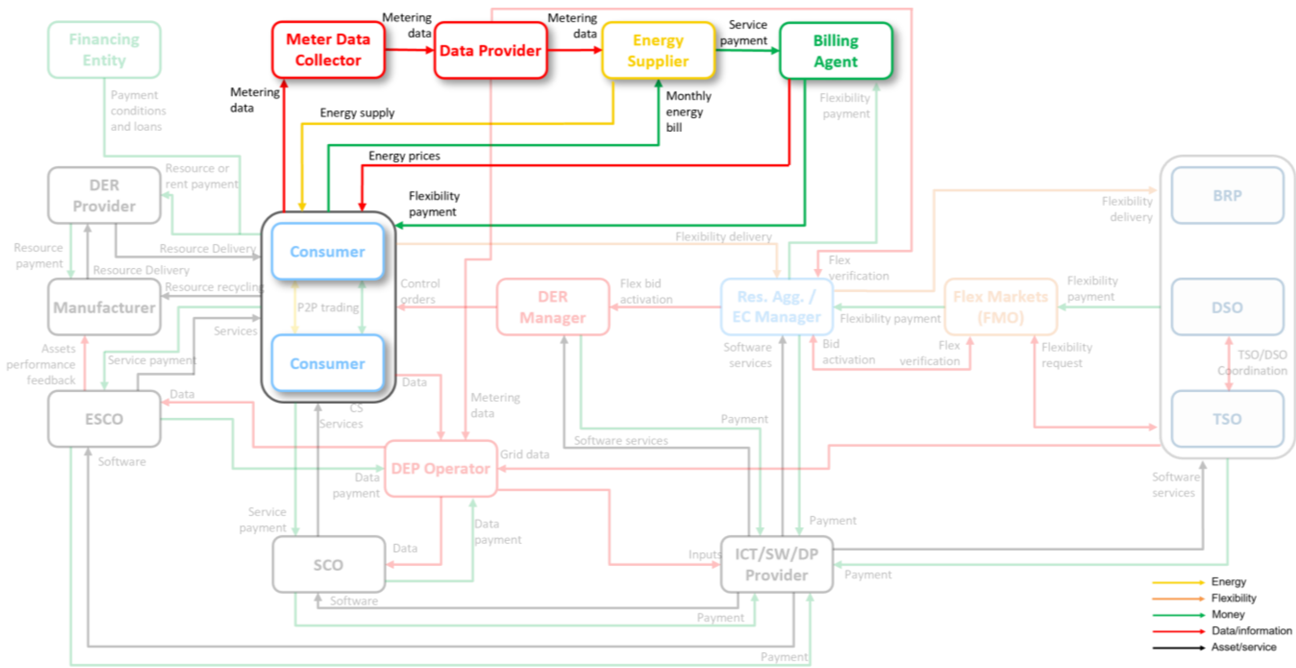

Figure 3.2 – The Role Model adapted to BM1

This BM is evaluated according to the proposed BM evaluation methodology, and the results are given in Table 3.12. As can be seen, BM1 has a low Complexity due to the small number of roles involved and because no new technologies are needed for its implementation. The Risk is also perceived as low because there are no regulatory concerns (the BM is widely disseminated) and there are no new costs for Consumers, as they only pay for the energy they consume and other associated taxes. However, the Value that is created is rather small, especially non-economic value.

Table 3.12 – BM1 evaluation

Parameters	Number of roles	Necessary tech	Regulatory concerns	Costs (consumers)	Economic value	Non-economic value	Average
Complexity	◔	○	——	——	——	——	◔
Risk	——	——	○	○	——	——	○
Value	——	——	——	——	◔	○	◔

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The BMC of BM1 is given in Table 3.13.

Table 3.13 - BMC of BM1

<table>
<tr><th>Key actors:</th><th>Key activities:</th><th>Value proposition:</th><th>Actors' relationship:</th><th>Customers segment:</th></tr>
<tr><td rowspan="3">- Retailer
- Consumers
- DSO</td><td>- Supplying electrical energy to Consumers
- Billing Consumers
- Managing Energy Meters readings</td><td rowspan="3">- Safe, mature, and widely used BM
- Predictability (consumers can foresee how much they will be billed)
- Convenient (relatively hassle free to Consumers)</td><td>- Usually, long term between Retailer and a Consumer</td><td rowspan="3">- All types of Consumers (residential, commercial, and industrial)</td></tr>
<tr><th>Key resources:</th><th>Channels:</th></tr>
<tr><td>- Billing service
- Energy Meters</td><td>- Retailer's physical help desks
- Virtual channels (web sites, mobile apps, email, etc…)</td></tr>
<tr><th colspan="2">Costs:</th><th colspan="3">Revenues:</th></tr>
<tr><td colspan="2">- Consumers pay for the electrical energy they consume, grid tariffs, and taxes</td><td colspan="3">- Retailers profit from selling electrical energy to Consumers</td></tr>
</table>

3.2.2.2. BM2: Flex assets acquisition

The main objective of BM2 is to equip regular Consumers with flexible assets.

Some of the most common ways to facilitate Consumers acquire new flexible resources are, on one side, the request for either government or public subsidies, to pay the whole or part of the investment on the new equipment, or, on the other side, to rent the equipment from the Retailer or an ESCo for a specific period and for a specific amount of money (as in BM3). Something to consider regarding the economic constraints of Consumers when acquiring new equipment is that, for most Consumers, the investment is still high, the information regarding what to install and how is still blurred, and the way to operate their resources to maximise their benefit is still only for a small target of Consumers able to adopt these technologies faster than the rest. In order to mitigate this, access to public subsidies should be easier, the information on what the Consumers should install should be much more personalised and the operation of the flexible resources, which includes the data they interact with, should make them feel secure and allow with some control on the resources and the feeling that they are receiving back the value they seek. For that reason, in many cases an external entity (DER Manager) is required to provide the assets controlling service and consequently guarantee a better use of the resources, and time and work saving to the Consumers.

Here, Consumers buy assets such as DERs and/or smart devices from a DER Provider, who acquires them from a Manufacturer. A Financing Entity can support the Consumer with the necessary funds to acquire those assets. For that purpose, there are multiple financing schemes available [82]. Again, similarly to BM1, the Retailer supplies energy and bills the Consumers, with the DSO acting as Meter Data Collector and Data Provider.

At this point, Consumers can manage their assets on their own or contract an ESCo, who takes the DER Manager role, and can help them based on its expertise. The ESCo can offer services such as asset maintenance and energy optimization, helping Consumers to benefit from their implicit flexibility [83] by

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adjusting their behaviour according to price signals. A SW Company, acting as ICT/SW/DP Provider, can also sell its services to the ESCo, backing them with data management and data processing tools [84]. At the end of their lifespan, assets returned to the Manufacturer can be recycled, enabling other BMs [15] according to the principles of circular economy [85] such as second-life BESS. The correspondence between actors and roles for BM2 is given in Table 3.14 and the interaction between them are pictured in Figure 3.3.

Table 3.14 - Match between actors and roles in BM2

Actor	Roles
Manufacturer	Manufacturer
ESCo	ESCo DEP Operator DER Manager
DER Provider	DER Provider
Financing Entity	Financing Entity
Retailer	Energy Supplier Billing Agent
Consumer	Consumer Prosumer
DSO	Meter Data Collector Data Provider
SW Company	ICT/SW/DP Provider

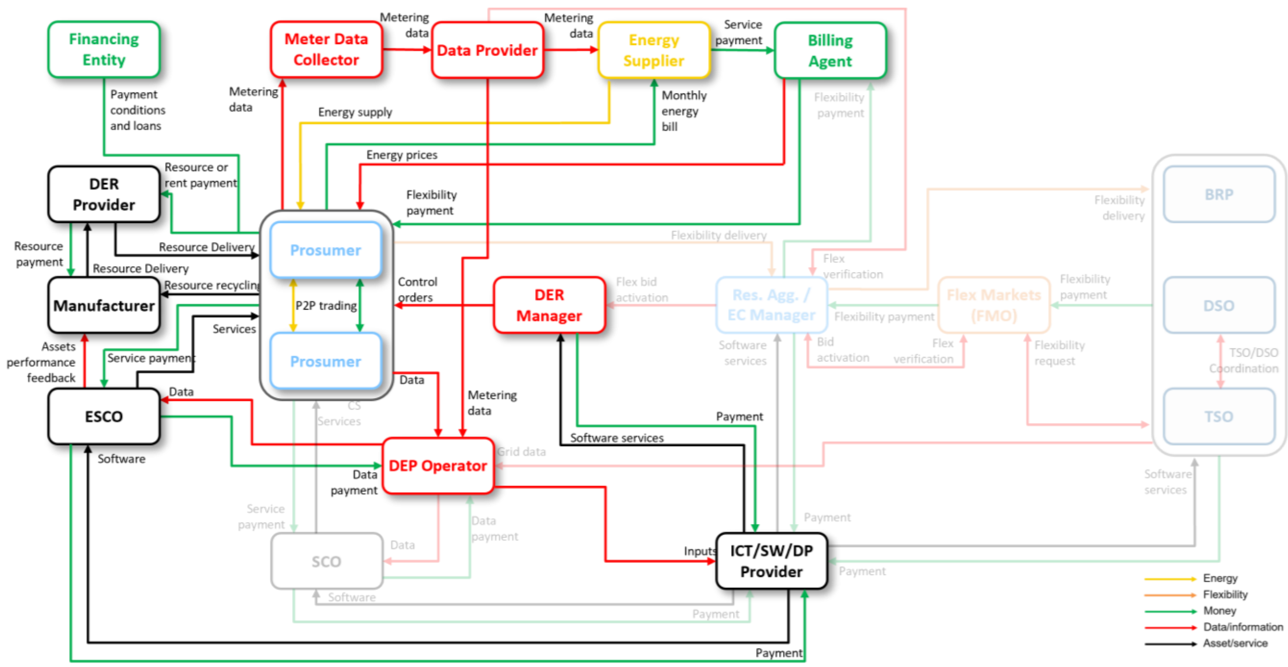

Figure 3.3 - The Role Model adapted to BM2

From the BM2 evaluation provided in Table 3.15, it can be concluded that BM2 has a moderate complexity, involving 13 roles but not requiring many technologies that are not already widely available. Risk is also moderate, and there are no regulatory concerns. However, the cost for Consumers, who purchase assets by their own initiative, is high. According to this methodology, the value created by BM2 may be low.

Table 3.15 – BM2 evaluation

Parameters	Number of roles	Necessary tech	Regulatory concerns	Costs (consumers)	Economic value	Non-economic value	Average
Complexity	◕	◔	——	——	——	——	◑
Risk	——	——	○	◕	——	——	◔
Value	——	——	——	——	◔	◔	◔

The BMC of BM2 is given in Table 3.15.

Table 3.16 - BMC of BM2

<table>
<tr><th>Key actors:</th><th>Key activities:</th><th>Value proposition:</th><th>Actors' relationship:</th><th>Customers segment:</th></tr>
<tr><td rowspan="3">- Manufacturer
- ESCo
- DER Provider
- Consumer</td><td>- Running campaigns to sell assets to Consumers
- Presenting financing options for asset acquisition to Consumers
- Asset O&M (offered by ESCo)
- Assets recycling</td><td rowspan="3">- Shift demand patterns
- Reduce electricity bills
- Boost renewable production
- Environmental protection</td><td>- Transactional (between DER Providers and Consumers)
- Automated services and personal assistance (from ESCo to Consumers)</td><td rowspan="3">- All types of Consumers
- But more appropriate to residential and small-sized commercial or industrial Consumers</td></tr>
<tr><th>Key resources:</th><th>Channels:</th></tr>
<tr><td>- DER (PV panels, BESS, EV Charging Stations…)
- HEMS, Smart devices (HVAC, heat pumps, water heaters…)</td><td>- Physical and/or online stores
- Virtual channels (web sites, mobile apps, email, etc…)</td></tr>
<tr><th colspan="2">Costs:</th><th colspan="3">Revenues:</th></tr>
<tr><td colspan="2">- Consumers pay to the DER Provider for the asset they acquire
- Consumers pay to the ESCo for the provided services
- Consumers pay for the electrical energy they consume, grid tariffs, and taxes</td><td colspan="3">- Financial return to DER Provider from asset sale
- Financial return to ESCo from service provision
- Retailers profit from selling electrical energy to Consumers</td></tr>
</table>

3.2.2.3. BM3: EaaS from retailer

In this BM, a Retailer equips Consumers with assets using an EaaS approach, with the assets being rented instead of sold [26].

As explained in BM2, the constraints Consumers experience when acquiring new resources should be mitigated to incentivize their participation in the energy business. When a Retailer rents the equipment to the Consumers, the "time" factor plays a key role in the relationship among them. For this reason, Retailers should be capable of maintaining the exchange of value throughout the time the Consumer is renting the

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equipment. For this, transparency and communication are fundamental pillars to further develop for this type of BM. Something that also happens in this type of BM is that, by establishing a long-term relationship with Consumers, it is possible to offer additional services and products if the Consumers are satisfied with their relationship with the Retailer. Therefore, Retailers should make additional efforts in getting to know their Consumers' energetic behaviour and offer more value over time with additional services and products. Also, this BM can contribute to minimise the high initial investment for Prosumers in buying the resources and accessories. The investment will be integrally paid during the contract length by a monthly or yearly rent payment while the Prosumer saves money by self-consuming its own production and even gain an extra revenue by providing flexibility.

As a result, in this BM the Retailer typically assumes many roles. Again, it acts as Energy Supplier and Billing Agent, but also as Financing Entity and DER Provider, granting the assets in exchange of a regular fee. It can also act as ESCo, DER Manager and DEP Operator, controlling, maintaining, and repairing the DERs installed at the Consumer's property based on the collected data. Since the Retailer has control over its Consumers' assets, it can also profit from their flexibility for its own benefit. For instance, the Retailer can use the available flexibility to reduce energy imbalances [50], by offering an energy discount or an explicit flexibility payment to their Consumers. The match between actors and roles and their respective interactions are given in Table 3.17 and Figure 3.4, correspondingly.

Table 3.17 - Match between actors and roles in BM3

Actor	Roles
Manufacturer	Manufacturer
Retailer	Financing Entity Energy Supplier Billing Agent DER Provider ESCo DEP Operator DER Manager BRP
Consumer	Consumer Prosumer
DSO	Meter Data Collector Data Provider
SW Company	ICT/SW/DP Provider

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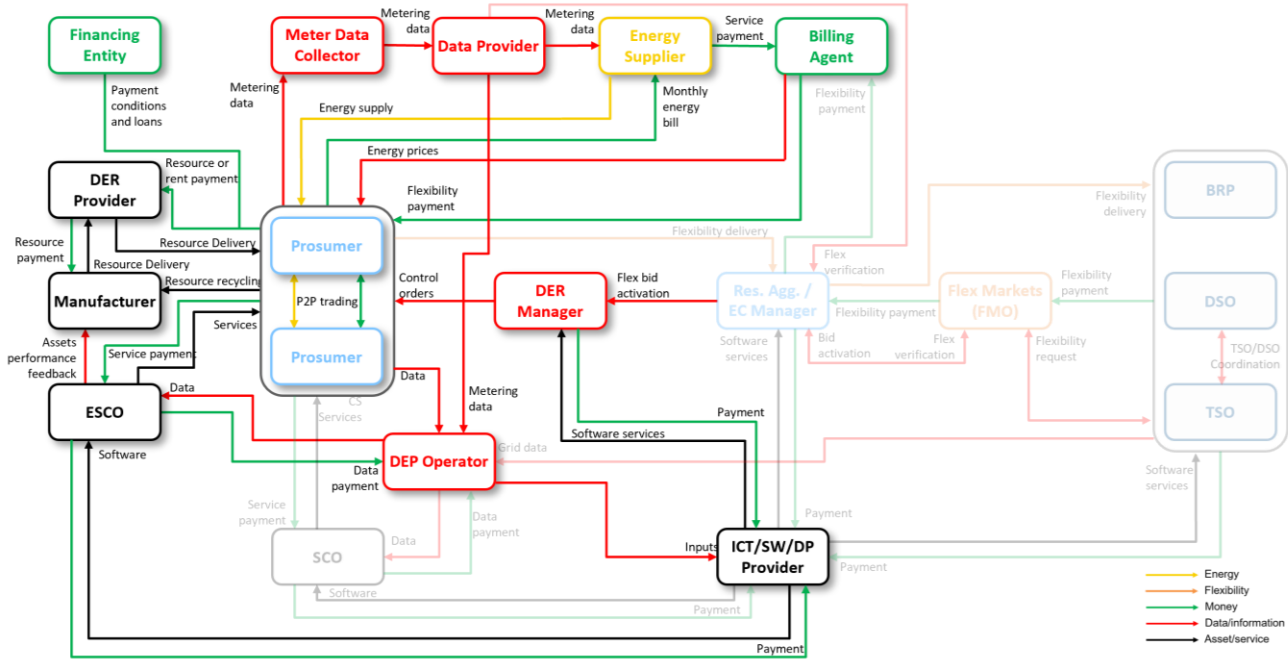

Figure 3.4 - The Role Model adapted to BM3

Table 3.18 summarizes the results of the assessment of BM3. BM3 has a moderate Complexity and Risk. There are no apparent regulatory issues and, due to the EaaS nature of this BM, the cost for Consumers is small. However, the value is also low.

Table 3.18 – BM3 evaluation

Parameters	Number of roles	Necessary tech	Regulatory concerns	Costs (consumers)	Economic value	Non-economic value	Average
Complexity	◕	◔	——	——	——	——	◑
Risk	——	——	○	◔	——	——	◔
Value	——	——	——	——	◔	◔	◔

The BMC of BM3 is give in Table 3.19.

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Table 3.19 - BMC of BM3

<table>
<tr><th rowspan="3">Key actors:
- Manufacturer
- Retailer
- DSO
- Consumer</th><th>Key activities:</th><th rowspan="3">Value proposition:
- Shift consumption patterns
- Reduce electricity bills
- Lower upfront costs and lower risks
- Consumer is not responsible for maintenance
- Boost renewable production
- Environmental protection
- Retailers can reduce imbalances</th><th>Actors' relationship:</th><th rowspan="3">Customers segment:
- All types of Consumers
- But, just as before, more appropriate to residential and small-sized commercial or industrial Consumers</th></tr>
<tr><td>- Running campaigns to draw Consumers in
- Presenting the advantages of EaaS
- Asset O&M</td><td>- Usually long term, for the duration of the contract between Retailer and the Consumers receiving EaaS</td></tr>
<tr><td>Key resources:
- DER (PV panels, BESS, EV Charging Stations…)
- HEMS, Smart devices (HVAC, heat pumps, water heaters…)
- Smart meters</td><td>Channels:
- Physical and/or online stores
- Virtual channels (web sites, mobile apps, email, etc…)</td></tr>
<tr><td colspan="3">Costs:
- Recurring payments from Consumer to Retailer, resulting from the EaaS
- Consumers pay for the electrical energy they consume, grid tariffs, and taxes</td><td colspan="2">Revenues:
- Retailer profits from selling electrical energy to Consumers
- Retailer receives a recurring payment from EaaS
- Retailers acting as BRP can reduce expenses from imbalances</td></tr>
</table>

3.2.2.4. BM4: DERs from retailer

In BM4, the Retailer assists Consumers willing to purchase DERs by offering them beneficial conditions to acquire those assets. The Retailer acts as DER Provider and Financing Entity. However, differently from BM3, the Retailer does not own the DERs, which belong to the Consumer. The Consumer controls those assets or can contract an ESCo to do it, similarly to BM2. Moreover, Consumers who own flexible assets can join a Resource Aggregator and supply their flexibility to other entities, as described next in BM5. The role of Resource Aggregator can be taken up by the Retailer or by a specific actor called Aggregator. Since aggregation is still a role not properly regulated in many countries [64] and whose revenues may be low if coming only from the value the flexibility buyers may be willing to pay [65], Retailers often assume this role.

With the relationship already created with the provision of electricity by Retailer, the Prosumer can benefit from discounts or special campaigns for the acquisition of resources, which can contribute to a stronger relationship between Retailer and Prosumer. This relationship can result in a win-win situation, with the Retailer winning from flex provision by the Consumer, possibly assuming the Aggregator role, and the Prosumer benefiting with lower initial investments.

The correspondence between actors and roles and their interaction are shown in Table 3.20 and Figure 3.5.

Table 3.20 - Match between actors and roles in BM4

Actor	Roles
Manufacturer	Manufacturer
ESCo	ESCo DEP Operator DER Manager

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Retailer	Financing Entity Energy Supplier Billing Agent DER Provider
Aggregator	Resource Aggregator
Consumer	Consumer Prosumer
DSO	Meter Data Collector Data Provider
SW Company	ICT/SW/DP Provider

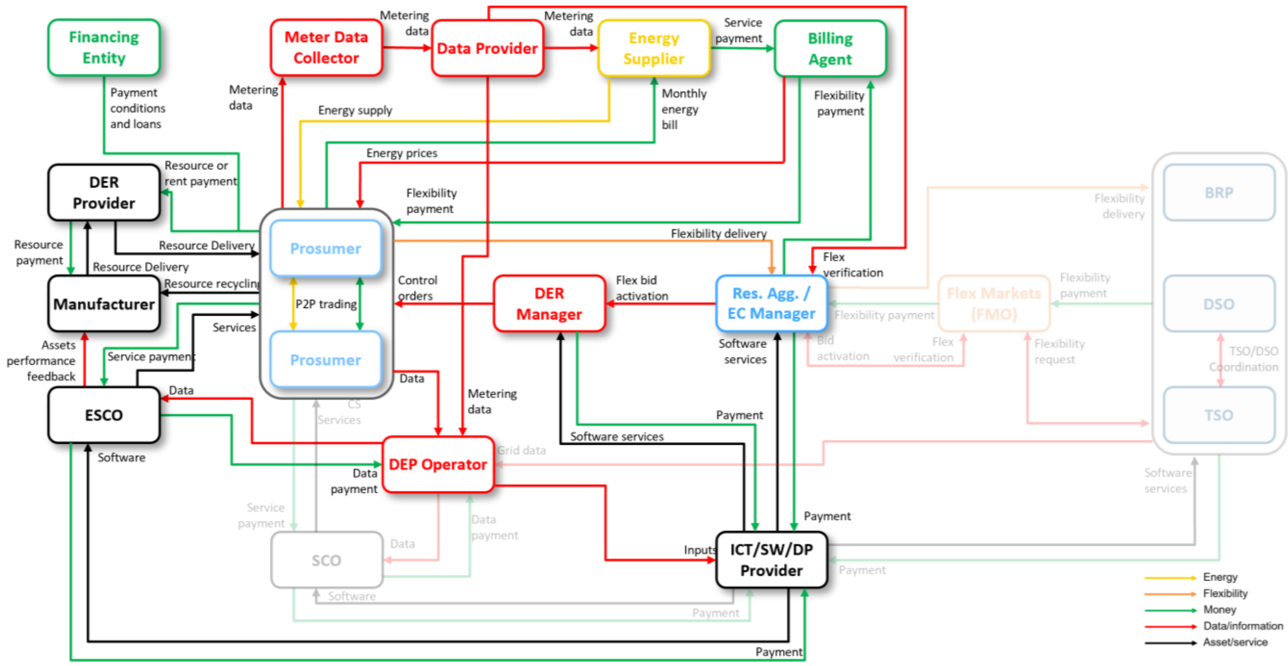

Figure 3.5 - The Role Model adapted to BM4

The evaluation of BM4 is summarized in Table 3.21. The Complexity of BM4 is high and the Risk and Value are both moderate.

Table 3.21 – BM4 evaluation

Parameters	Number of roles	Necessary tech	Regulatory concerns	Costs (consumers)	Economic value	Non-economic value	Average
Complexity	◕	◑	———	———	———	———	◕
Risk	———	———	◑	◑	———	———	◑
Value	———	———	———	———	◑	◔	◔

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Table 3.22 - BMC of BM4

<table>
<tr><th>Key actors:</th><th>Key activities:</th><th>Value proposition:</th><th>Actors' relationship:</th><th>Customers segment:</th></tr>
<tr><td rowspan="3">- Manufacturer
- ESCo
- Retailer
- Aggregator
- Consumer</td><td>- Retailer running campaigns to sell assets to their set of Consumers
- Offering beneficial financing options to their Consumers</td><td rowspan="3">- Shift demand patterns
- Reduce electricity bills
- Boost renewable production
- Environmental protection</td><td>- Usually, short term between Retailers and the Consumers (one time purchase)</td><td rowspan="3">- All types of Consumers
- But, just as before, more appropriate to residential and small-sized commercial or industrial Consumers</td></tr>
<tr><th>Key resources:</th><th>Channels:</th></tr>
<tr><td>- DER (PV panels, BESS, EV Charging Stations…)
- HEMS, Smart devices (HVAC, heat pumps, water heaters…)</td><td>- Physical and/or online stores
- Virtual channels (web sites, mobile apps, email, etc…)</td></tr>
<tr><th colspan="3">Costs:</th><th colspan="2">Revenues:</th></tr>
<tr><td colspan="3">- Assets purchase from the Retailer
- Consumers pay to the ESCo for the provided services
- Some Consumers pay membership fee to Aggregator
- Consumers pay for the electrical energy they consume, grid tariffs, and taxes</td><td colspan="2">- Retailer receives a monthly payment for the electrical supply and unique payment for the asset acquisition</td></tr>
</table>

3.2.2.5. BM5: Grid flexibility

BM5 is available for Consumer who decide to join a Resource Aggregator. After doing so, they can provide flexibility to grid operators or BRPs via a flexibility market [86], which is managed by a Flexibility Market Operator (FMO) [75]. This is a BM which is mainly focused on the flexibility value, in terms of what the flexibility procurers may be willing to pay, either to solve grid constraints (in case of the system operators) or expected imbalances (in case of BRPs), and the benefits that flexibility provision might provide to the Consumers.

Energy as a concept is something Consumers understand as a way to gain or receive benefits. As explained in the Consumer research held in BeFlexible for the Value Propositions and Engagement Strategy (addressed in WP2 - Market actors value propositions, engagement, and legal & ethics compliance), the economic side of flexibility services is key for users to perceive value in exchange for their participation. However, if the economic signal is not enough rewarding, Consumers perceive injustice and can even prefer to share it for before "giving it to the grid", that is "waste it", as the economic return is not significant and therefore unfair. Generally, Consumers that participate in flexibility services are technologically advanced and understand how energy works, so they fully understand how their energy is being bought, sold and resold in exchange for the value of their effort.

Since the value of flexibility may be low compared to the initial investments and complexities associate with its provision, BM6 intends to complement BM5 by increasing the Consumers value with additional revenue streams or services.

The link and interactions among actors and roles are illustrated in Table 3.23 and Figure 3.6.

Table 3.23 - Match between actors and roles in BM5

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<table>
<tr><th>Actor</th><th>Roles</th></tr>
<tr><td>Manufacturer</td><td>Manufacturer</td></tr>
<tr><td>ESCo</td><td>ESCo
DEP Operator
DER Manager</td></tr>
<tr><td>DER Provider</td><td>DER Provider</td></tr>
<tr><td>Financing Entity</td><td>Financing Entity</td></tr>
<tr><td rowspan="2">Retailer</td><td>Energy Supplier
Billing Agent
BRP</td></tr>
<tr><td rowspan="2">Resource Aggregator</td></tr>
<tr><td>Aggregator</td></tr>
<tr><td>Consumer</td><td>Consumer
Prosumer</td></tr>
<tr><td>DSO</td><td>Meter Data Collector
Data Provider
DSO</td></tr>
<tr><td>FMO</td><td>FMO</td></tr>
<tr><td>SW Company</td><td>ICT/SW/DP Provider</td></tr>
<tr><td>TSO</td><td>TSO</td></tr>
</table>

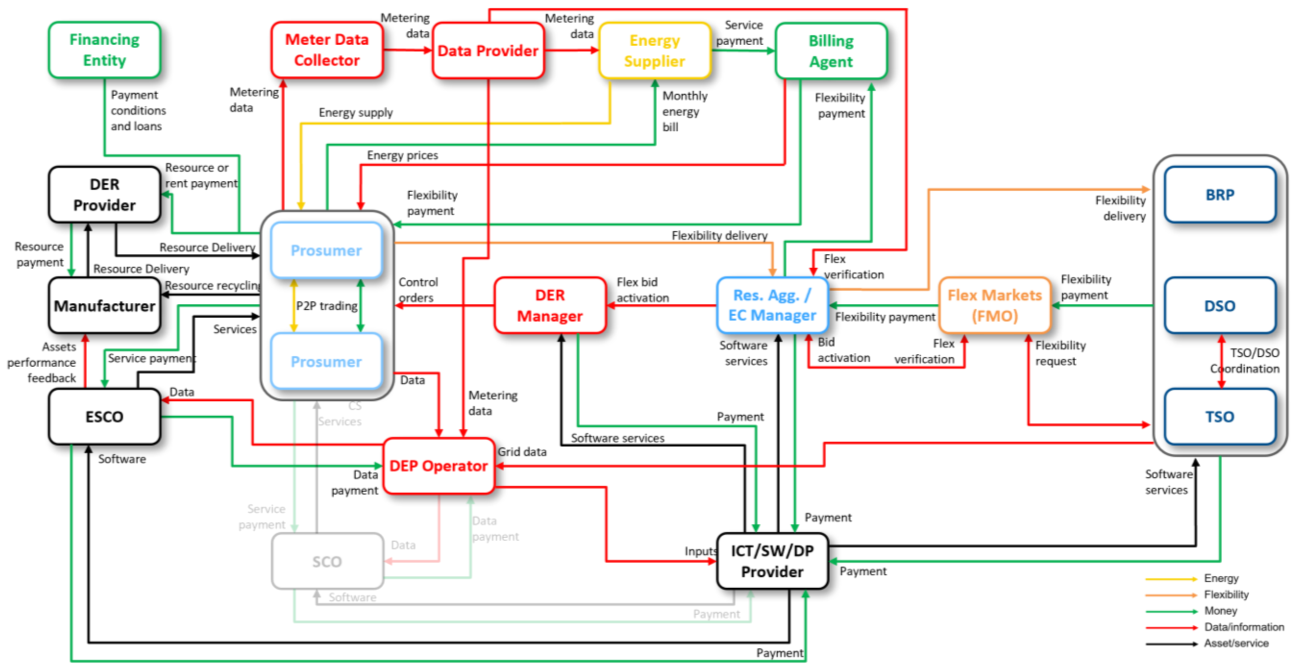

Figure 3.6 - The Role Model adapted to BM5

In BM5, whose evaluation results are provided in Table 3.24, Complexity is very high, due to the large number of roles and required technologies. Risk is high mainly due to regulatory concerns, such as the ones surrounding flexibility markets and aggregation. However, economic value is also very high for all participants and the non-economic value is moderate, leading to a high value.

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Table 3.24 – BM5 evaluation

Parameters	Number of roles	Necessary tech	Regulatory concerns	Costs (consumers)	Economic value	Non-economic value	Average
Complexity	●	◕	——	——	——	——	◕
Risk	——	——	◕	◑	——	——	◕
Value	——	——	——	——	●	◑	◕

The BMC of BM5 is given in Table 3.25.

Table 3.25 - BMC of BM5

<table>
<tr><th>Key actors:</th><th>Key activities:</th><th>Value proposition:</th><th>Actors' relationship:</th><th>Customers segment:</th></tr>
<tr><td rowspan="3">- Consumer
- Aggregator
- DSO
- FMO
- SW Company</td><td>- Aggregation of Consumers
- Trading flexibility in a market
- Operation of the Flexibility market
- TSO/DSO coordination</td><td rowspan="3">- Shift demand patterns
- Prevent or alleviate grid constraints
- Reduce or postpone grid investments
- Reduce operational costs
- Reduce energy losses
- Reduce curtailment compensations
- Reduce electricity bills
- Boost renewable production
- Environmental protection</td><td>- Can potentially be long term between one Aggregator and a set of Consumers</td><td rowspan="3">- All types of Consumers (residential, commercial and industrial)</td></tr>
<tr><td>Key resources:</td><td>Channels:</td></tr>
<tr><td>- DER (PV panels, BESS, EV Charging Stations…)
- HEMS, Smart devices (HVAC, heat pumps, water heaters…)</td><td>- Digital platforms
- Aggregation platform
- Flexibility Market platform</td></tr>
<tr><td colspan="2">Costs:</td><td colspan="3">Revenues:</td></tr>
<tr><td colspan="2">- Consumers pay for the acquired assets
- Consumers pay membership fees to Aggregator
- Consumers pay for the electrical energy they consume, grid tariffs, and taxes
- Consumers pay to the ESCo for the provided services
- DSO purchases flexibility</td><td colspan="3">- Financial revenue to the Aggregator and Consumers from flexibility provision</td></tr>
</table>

3.2.2.6. BM6: Cross-sector services

BM6 is appropriate for Consumers owning houses equipped with smart meters, sensors, smart appliances, and flexible assets, as they can also benefit from cross-sector services provided by SCo.

These cross-sector services can be related to healthcare of vulnerable people and security by using smart meter data to generate alarm signals associated to abnormal changes in the load profiles [62]. Although they are not directly linked to the flexibility provision, they result from or complement it, by profiting from the flexible potential and participation of the Consumers in flexibility services. EV charging can become smart or even respond to flexibility solicitations by adapting its charging profile [87], health or surveillance services

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can be built on top of the energy data [62] and data can be sold to third parties [88], such as SW companies, to allow them to improve forecasting tools [50], DER control and aggregation algorithms [89].

Considering the learnings from WP2, we know that the most digitised and technologically advanced Consumers are willing to plug and play with their resources. But for this connection and aggregation of their resources being of value to potential users, the transversality of the data is fundamental since users need to see them grouped together and understand them properly to continue optimising their resources and acquiring new ones. When moving beyond energy itself, the demand of control from users is key to facilitate the provision of energy or new resources. For that purpose, HEMS can be very useful to integrate the different services.

The correspondence between actors and roles for BM2 is given in Table 3.26 and the interaction between them are pictured in Figure 3.7.

Table 3.26 - Match between actors and roles in BM6

<table>
<tr><th>Actor</th><th>Roles</th></tr>
<tr><td>Manufacturer</td><td>Manufacturer</td></tr>
<tr><td>ESCo</td><td>ESCo
DEP Operator
DER Manager</td></tr>
<tr><td>DER Provider</td><td>DER Provider</td></tr>
<tr><td>Financing Entity</td><td>Financing Entity</td></tr>
<tr><td rowspan="2">Retailer</td><td>Energy Supplier
Billing Agent
BRP</td></tr>
<tr><td rowspan="2">Resource Aggregator</td></tr>
<tr><td>Aggregator</td></tr>
<tr><td>Consumer</td><td>Consumer
Prosumer</td></tr>
<tr><td>DSO</td><td>Meter Data Collector
Data Provider
DSO</td></tr>
<tr><td>FMO</td><td>FMO</td></tr>
<tr><td>SW Company</td><td>ICT/SW/DP Provider</td></tr>
<tr><td>SCo</td><td>SCo</td></tr>
<tr><td>TSO</td><td>TSO</td></tr>
</table>

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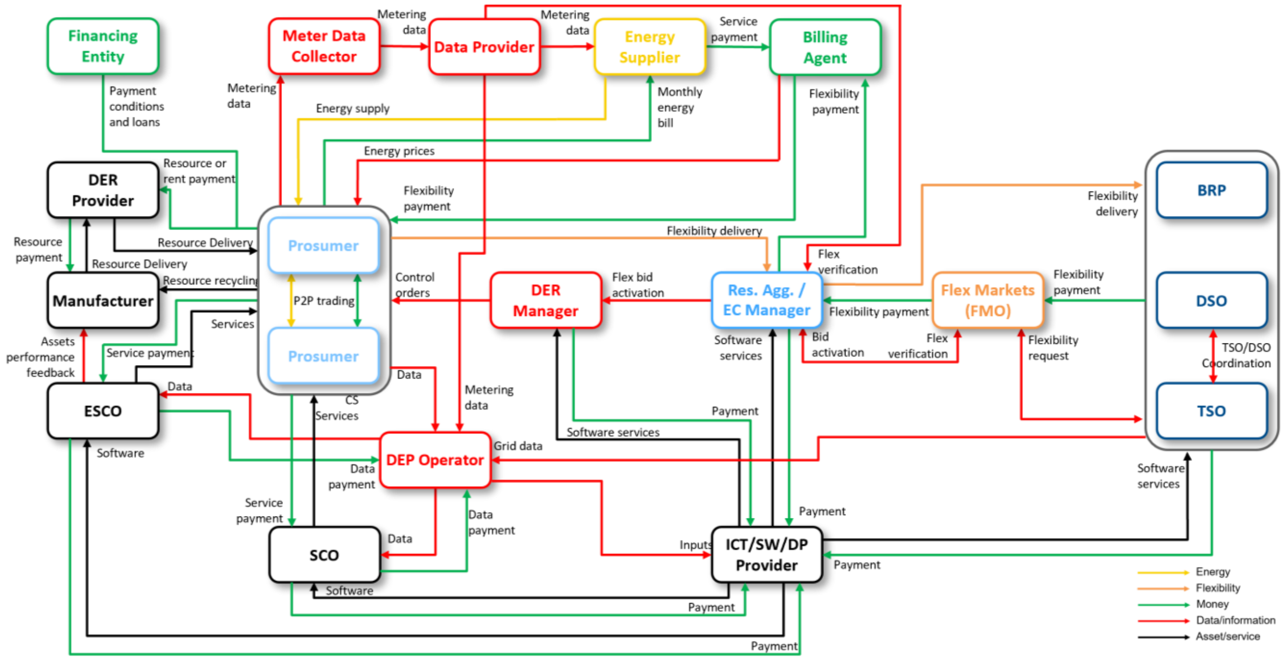

Figure 3.7 - The Role Model adapted to BM6

The evaluation of BM6 is summarized in Table 3.27. Complexity seems very high, including almost the of the roles listed. As in BM5, Risk also seems high due to regulatory concerns regarding flexibility markets and Aggregators. Nevertheless, economic and non-economic value are also very high, resulting in a very high value for all participants, making BM6 the most valuable of all the envisioned BMs.

Table 3.27 – BM6 evaluation

Parameters	Number of roles	Necessary tech	Regulatory concerns	Costs (consumers)	Economic value	Non-economic value	Average
Complexity	●	◕	——	——	——	——	◕
Risk	——	——	◕	◕	——	——	◕
Value	——	——	——	——	●	●	●

The BMC of BM6 is given in Table 3.28.

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Table 3.28 - BMC of BM6

<table>
<tr><th>Key actors:</th><th>Key activities:</th><th>Value proposition:</th><th>Actors' relationship:</th><th>Customers segment:</th></tr>
<tr><td rowspan="3">- ESCo
- Consumer
- SCo</td><td>- Offering and providing cross-sector services (wellbeing, safety, home care and security)</td><td rowspan="3">- Safety and security (alarms, intruder alerts, smoke, and flood detection systems)
- Well-being and home care</td><td>- Usually long term, for the duration of the contract between the Consumers and the SCo</td><td rowspan="3">- All types of Consumers
- But, just as before, more appropriate to residential and small-sized commercial or industrial Consumers</td></tr>
<tr><th>Key resources:</th><th>Channels:</th></tr>
<tr><td>- Smart meters
- HEMS and Smart Devices
- Sensor, alarms, cameras</td><td>- Virtual channels (web sites, mobile apps, email, etc…)</td></tr>
</table>

<table>
<tr><th>Costs:</th><th>Revenues:</th></tr>
<tr><td>- Consumers pay for the acquired assets
- Consumers pay membership fees to Aggregator
- Consumers pay for the electrical energy they consume, grid tariffs, and taxes
- Consumers pay to the ESCo and SCo for the provided services
- DSO purchases flexibility</td><td>- Financial revenue to the Aggregator and Consumers from flexibility provision
- Financial revenue to the SCo (monthly payments for example)</td></tr>
</table>

3.2.2.7. BM7: Flexible EC

In BM7 Consumers can decide to join an EC. For a Consumer, entering an EC brings several advantages as benefiting from cheaper electricity, selling generation surplus, reducing grid dependence, sharing costs and risks and eliminating high upfront costs [72]. The EC Manager, besides directing the community, can also act as Resource Aggregator, combining the available flexibility from within the EC and offering it to system operators via flexibility markets [72], as in Table 3.29 and Figure 3.8.

Energy communities in Europe are starting to be regulated and better understood by Consumers. However, sometimes terms like "energy community" or "community self-consumption" or "solar neighbourhood" make users misunderstand and get confused on the differences and value offered from the different perspectives. Regarding energy communities, the main value added can be clearly beyond energy. Indeed, ECs are not only about producing energy jointly, but also to decide the way to produce and distribute energy among the members, to including mobility options, or to address energy poverty and social wellbeing. This is something to consider when developing services and BMs for energy communities in such a way that, besides offering better prices, highlighting the other individual and social benefits explained earlier in this BM review. Again, ECs can help to mitigate the high initial investment, sharing this investment between all the EC Members, and providing an extra revenue to the Consumers, with a fair benefit sharing according to the energy transactions inside the EC.

Table 3.29 - Match between actors and roles in BM7

Actor	Roles
Manufacturer	Manufacturer

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DER Provider	DER Provider
Financing Entity	Financing Entity
Retailer	Energy Supplier Billing Agent
Consumer	Consumer Prosumer
DSO	Meter Data Collector Data Provider
FMO	FMO
EC Manager	EC Manager Resource Aggregator DER Manager
SW Company	ICT/SW/DP Provider

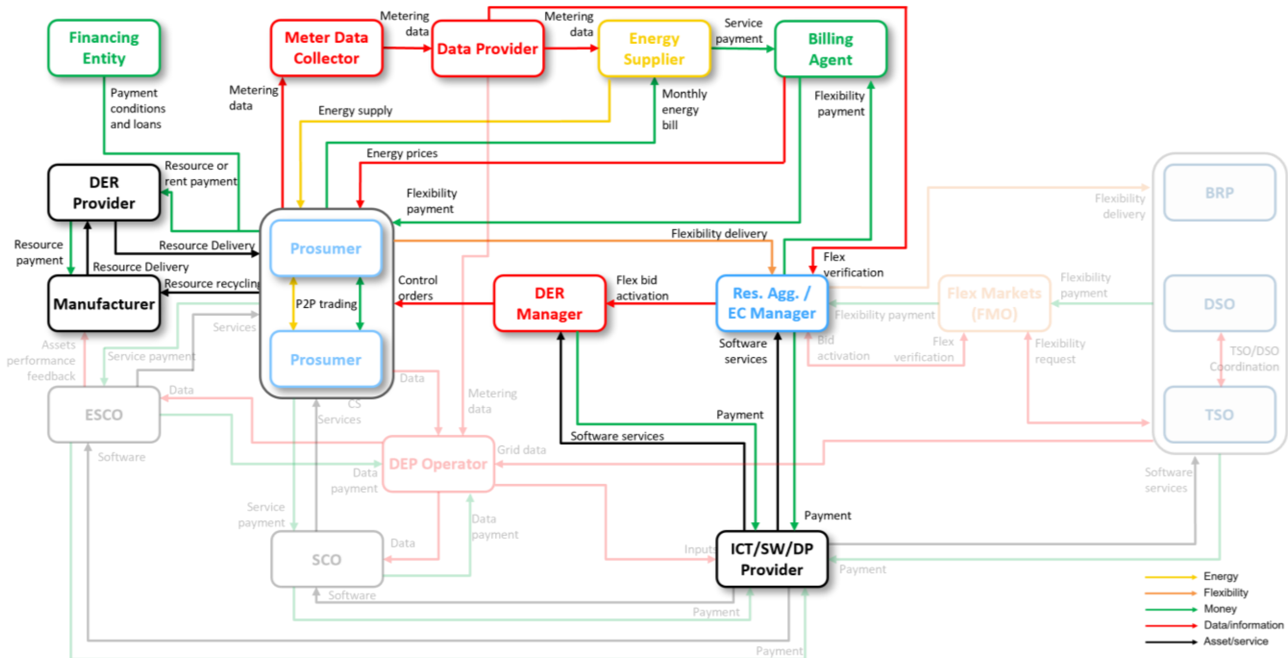

Figure 3.8 - The Role Model adapted to BM7

The results of the assessment of BM7, shown in Table 3.30, demonstrate that the 3 parameters evaluated are quite balanced. Complexity is high and Risk and Value and regarded as moderate.

Table 3.30 – BM7 evaluation

Parameters	Number of roles	Necessary tech	Regulatory concerns	Costs (consumers)	Economic value	Non-economic value	Average
Complexity	◕	◑	——	——	——	——	◕
Risk	——	——	◑	◑	——	——	◑
Value	——	——	——	——	◑	◑	◑

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The BMC of BM7 is given in Table 3.31.

Table 3.31 - BMC of BM7

<table>
<tr><th>Key actors:</th><th>Key activities:</th><th>Value proposition:</th><th>Actors' relationship:</th><th>Customers segment:</th></tr>
<tr><td rowspan="3">- EC Member
- DER Provider
- Financing Entity
- EC Manager</td><td>- Operating the EC (includes management and maintenance)
- Electricity generation
- Aggregation of customers flexibility</td><td rowspan="3">- Reduce electricity bills
- P2P trading
- Revenue from flexibility provision
- Boost renewable production
- Environmental protection
- Increase sense of community</td><td>- Long term contracts between EC Members and EC Manager
- Direct interactions</td><td rowspan="3">- All types of Consumers (neighbourhoods and communities)
- Appropriate for Consumers who care about the environment</td></tr>
<tr><th>Key resources:</th><th>Channels:</th></tr>
<tr><td>- Digital platform to support the EC
- Smart meters
- DER (PV panels, BESS, EV Charging Stations…)</td><td>- Digital platforms
- Virtual channels (web sites, mobile apps, email, etc…)
- Salesmen and technical staff</td></tr>
<tr><th colspan="2">Costs:</th><th colspan="3">Revenues:</th></tr>
<tr><td colspan="2">- Up-front investments for the EC
- Installation, maintenance, and repair costs for the EC
- Costs with electricity purchase for the EC
- Consumers pay for the electrical energy they consume from the grid, grid tariffs, and taxes</td><td colspan="3">- Financial benefits to Consumers from selling electricity and from producing their own energy
- Financial return to EC Manager
- Financial return to DER Provider from asset sale
- Financial revenue from flexibility provision</td></tr>
</table>

3.2.2.8. BM8: Flexible EC with shared assets

ECs, introduced in BM7, are on the rise for Consumers and Prosumers wishing to jointly invest in DERs and exchange energy among themselves. Since some distribution grids experience periodical issues associated with voltage constraints and congestions, the operation of shared DERs can also be beneficial for the DSO [90].

In this context, in BM8, the ownership and operation of certain assets, such as BESS, is shared between the EC Members, who can also provide flexibility to the DSO. This benefits EC Members, who get a higher level of control over their production and consumption and additional revenues, while benefiting the DSO, who can use the flexibility the BESS can provide to solve grid constraints. For this availability, the DSO could participate in the investment or share the cost some other way, for example with a regular fee, which make BESS a more affordable option [90].

According to the current legislation, DSOs are not allowed to "own, develop, manage or operate energy storage facilities" (except under very specific conditions) [91]. Consequently, in the literature supporting the development of this BM8, the BESS are usually property of the EC, and, to the best of our knowledge, works where it is proposed that DSOs have ownership over these devices are not available. Yet, several different approaches can be used to develop BMs centred in asset sharing among EC Members, some of which are summarized next.

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In [90], it is described a methodology to minimize electricity expenses of an EC equipped with BESS and PV panels. A community battery is used to improve grid voltage as a service to the DSO. The results suggest that when the EC shares the battery with the DSO, the community only gets a small remuneration for the provided service. In this work it is also suggested that, if possible, the EC and DSO should work in partnership to ensure that the characteristics of the community battery are appropriate to address the voltage problems in the network. In a total-sharing economic approach, proposed in [92], the economic value of the EC is evenly distributed between all the EC Members. Meanwhile, in a proportional-sharing economy approach, also proposed in [92], each EC Member, depending on its share over a given asset, receives exactly its energy share in spite of the needs of other EC Members. This means that, if an EC Members charges a BESS during a certain period with the intention of discharging it in the future, this energy shall be preserved for this member. In this case the EC Manager is responsible for guaranteeing that energy exchanges are done in accordance with the pre-established participation quotas [92]. At last, in [93], it is proposed a three-stage optimization model to operate an EC and provide flexibility to the DSO. The first stage of the model aims at minimizing the bill of each EC Member by calculating optimal schedules for their DERs. In the second stage the objective is to optimize the energy bill of the entire EC by sharing the energy surplus of the members internally and re-dispatching their BESS, while ensuring that each Prosumer's new bill is equal or lower than the bill calculated for this Prosumer from stage one. The third and last stage, which can be performed by the DSO, intends to solve grid constraints by redispatching the DERs.

The figure of an EC Manager, already introduced in BM7, (either physical and digital) is crucial for EC Members to count on a secure way to obtain the benefits of participating in the community warehousing system and to detect when the BESS can provide flexibility to the grid.

Note that battery sharing may imply complex operation models and collective benefits sharing amongst the EC Members considering their assets ownership need to be properly designed and agreed by the community members. This is why the concepts of security, justice and sharing should be carefully addressed among the members of the community to highlights the potential benefits of sharing complex assets. EC Members must ensure that their energy is securely stored and that they can have it as its disposal, either physically or virtually [92], while the DSO may need set constraints to guarantee the required flexibility from the battery.

In addition, social networking effects play a central role in ECs, and they occur when the utility for the user of a product or service depends on the number of other users [94]. This means that EC Members need to understand that their benefit depends on the number of other members correctly operating the shared storage and energy assets. That is why the concept of trust and sharing can become re essential for an EC to work correctly and collaboratively. Therefore, although membership in the community is flexible, i.e., you can join and leave without permanence, the long permanence in the community guarantees the provision of benefits for the rest of the community. That is to say, the more users there are and the longer they stay, the more solid and stable the community and energy provision for all will be.

More specifically when profits are distributed, transparency ways to proceed should be considered so that members understand why they are receiving that profit vs the neighbourhood profit. Something to remember is that a common dynamic in the communities is the comparison of the members with the other members. This is why the effort to make members understand that their own benefit also benefits the other members and understand and agree the benefits sharing procedures in place, are fundamental. For this, a

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digital and dynamic profit-sharing mechanism can mitigate this community risks when sharing assets and the role of the EC Manager or a managing entity is key for the community's correct operation.

EC successful BMs can widen their services from pure electricity generation to shared assets like heating and mobility domains by exploiting the co benefits between the resources. Beyond economic benefits, being able to explode the co benefits, providing environmental, economic and social benefits are key factors for RECs.

The correspondence between actors and roles and their interaction are shown in Table 3.32 and Figure 3.9.

Table 3.32 - Match between actors and roles in BM8

Actor	Roles
Manufacturer	Manufacturer
DER Provider	DER Provider
Financing Entity	Financing Entity
Retailer	Energy Supplier Billing Agent
Consumer	Consumer Prosumer
DSO	Meter Data Collector Data Provider DSO
FMO	FMO
EC Manager	EC Manager Resource Aggregator DER Manager
SW Company	ICT/SW/DP Provider

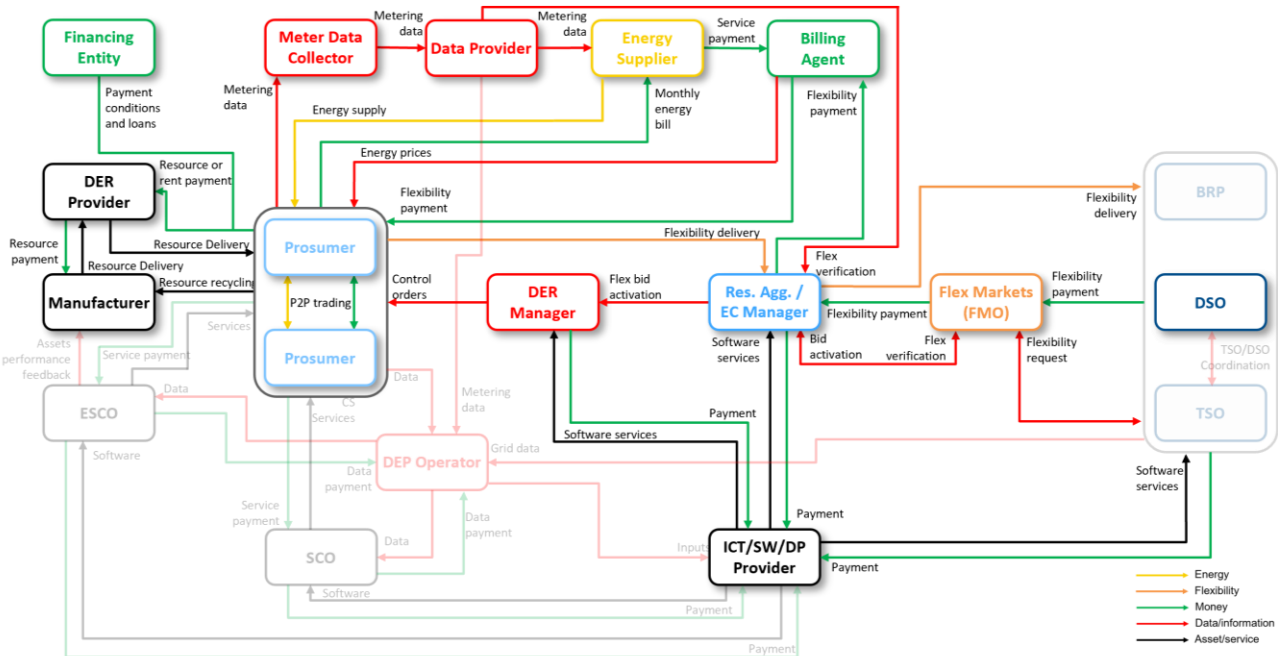

Figure 3.9 - The Role Model adapted to BM8

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The results of the assessment of BM8, Table 3.33, show that it can be complex to manage shared assets in an EC due to the benefits' distribution among the members and the operation mechanisms and constraints of the shared batteries. The high risk, mainly caused by almost no ECs running in Portugal or Spain, and high value that could be provided to users demonstrates BM8 to be a reliable BM.

Table 3.33 – BM8 evaluation

Parameters	Number of roles	Necessary tech	Regulatory concerns	Costs (consumers)	Economic value	Non-economic value	Average
Complexity	◕	◑	——	——	——	——	◕
Risk	——	——	◕	◑	——	——	◕
Value	——	——	——	——	◕	◑	◕

The BMC of BM8 is given in Table 3.34.

Table 3.34 - BMC of BM8

Key actors:	**Key activities:**	**Value proposition:**	**Actors' relationship:**	**Customers segment:**
- EC Member - DER Provider - Financing Entity - EC Manager - DSO	- Operating the battery (includes management and maintenance) - Energy generation and aggregation - Distribution and calculation of energy from battery to households - Energy sharing	- Environmental, economic and social community benefits - Revenue from flexibility provision - Increase self-sufficiency - Improve financial benefits by providing flexibility when sharing with DSO - Prevent or alleviate grid constraints - Reduce or postpone grid investments - Reduce operational costs	- Contract agreements between EC Members and EC Manager - Direct interactions	- Residential consumers - Large-scale prosumers - Local energy producer - City councils and public building (local administrations) - Appropriate for Consumers who care about the environment (Eco) - Appropriate for consumer who are active in energy issues (Adopters)
	Key resources:		**Channels:**	
	- Digital platform to support the EC - Smart meters - DER (PV panels, BESS, EV Charging Stations…) - Internal platform		- Digital platforms - Virtual channels (web sites, mobile apps, email, etc…) - Salesmen and technical staff	

Costs:	**Revenues:**
- Up-front investments for the EC - Installation, maintenance, and repair costs of the battery (shared between EC and DSO) - Consumers pay for the electrical energy they consume from the grid, grid tariffs, and taxes	- Financial benefits to Consumers from selling electricity and from producing their own energy - Financial return to EC manager - Financial return to DER Provider from asset sale - Financial revenue from flexibility provision

3.2.2.9. Summary

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The overall results of the qualitative assessment of the BMs are given in Table 3.35 and summarized next. BM1 presents the lowest Complexity and Risk, but also the lowest Value. Meanwhile, BM2 has a higher Complexity, Risk and Value than BM1. BM3 has a Complexity and Value similar to BM2, but a lower Risk due to the lower entry costs. BM4 and BM5 have a higher Complexity and Risk than all the previous ones, but they also create more Value. BM6, which mixes energy and cross-sector activities, appears as the BM with the highest Complexity, Risk and Value. Finally, BM7 and BM8 offer the most balanced trade-offs between Complexity and Risk and Value.

Table 3.35 - BM evaluation summary

Parameters	Complexity		Risk		Value	
	Number of roles	Necessary tech	Regulatory concerns	Costs (consumers)	Economic value	Non-economic value
BM1	◔	○	○	○	◔	○
	(1/6)		○		(1/6)	
BM2	◕	◔	○	◕	◔	◔
	◑		(1/3)		◔	
BM3	◕	◔	○	◔	◔	◔
	◑		(1/6)		◔	
BM4	◕	◑	◑	◑	◑	◔
	(2/3)		◑		(1/3)	
BM5	●	◕	◕	◑	●	◑
	(5/6)		(2/3)		◕	
BM6	●	◕	◕	◕	●	●
	(5/6)		◕		●	
BM7	◕	◑	◑	◑	◑	◑
	(2/3)		◑		◑	
BM8	◕	◑	◕	◑	◕	◑
	(2/3)		(2/3)		(2/3)	

3.3. Financing mechanisms

In this section the main financing mechanisms found in the literature are described. Subsequently, they are analysed to assess to what extent they can support the implementation of the BMs described in section 3.2. These main financing mechanisms are:

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- Equity.
- Debt.
- Mezzanine.
- Crowdfunding.
- Energy Performance Contract.
- Fiscal incentives.
- Financial incentives.
- Direct financing.
- Self-financing.

3.3.1. Equity

Equity is a financial scheme where investors purchase shares of a company/project (usually traded on a stock exchange), being granted with a certain kind of ownership over the business [82]. When the shares rise in value, equity investors (shareholders) are rewarded in the form of capital gains and/or capital dividends [95]. Under normal conditions, shareholders can hold their shares for as long as they wish [96].

3.3.2. Debt

Debt is created when something, usually money, is borrowed by one party from another [97]. The main ways to finance a business via debt are [82]:

- **Loans**: A loan is a type of credit in which a lender, such as a financial institution (e.g., a bank), provides money to a borrower. When celebrating a loan, certain parameters must be agreed upon, such as the monetary sum to be lend, the interest rate that will be charged and the periods and amounts in which the principal and the interest will be refunded [82].
- **Energy efficiency loans/mortgages**: Energy efficiency loans/mortgages are new products from the banking sector. In exchange for a measurable increase in a property's energy performance, a bank might offer a more favourable interest rate and/or additional funds when a loan/mortgage is secured. This financing mechanism rests in two main assumptions: first, the improvement of the energy performance of the property has a positive impact on its value, reducing the bank's asset risk, and second, borrowers have a lower probability of default due to more disposable income thanks to lower energy bills, decreasing the bank's credit risk [98]. Thus, energy efficiency loans/mortgages offer more favourable terms for financing the purchase, construction and/or renovation of buildings where there is evidence of an energy performance meeting/exceeding pre-defined standards [99]
- **Bonds**: Bonds are debt instruments that represent loans made to the entity issuing them (issuer) [100], that can be marketed to the general public so that other investors can acquire them [82]. Traditionally, bonds pay a fixed interest rate to debtholders and, as such, are referred to as fixed-income instruments. However, nowadays bonds with variable or floating interest rates are fairly common [100]. When issuing bonds, the issuer is free to choose the amount of debt to be created and if some bonds are not acquired,

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they don't receive the desired amount of money [82]. Those who buy bonds receive periodic interest payments, usually twice a year, and also the bond value on a specific date [101].

- **Green bonds**: Green bonds are similar to bonds but designed to encourage sustainability and support environmentally friendly projects and businesses related to energy efficiency, sustainable mobility, waste management, pollution prevention and control and sustainable infrastructures. These bonds may benefit from tax incentives, potentially making them more attractive for investors [102].
- **Asset renting**: Renting assets (e.g., PV panels, batteries) can be done in two main ways [82]:
  - The assets are immediately provided to the borrower, and an initial payment is made followed by periodic payments during a pre-defined period until the price of the assets is covered and the borrower becomes the asset owner. If the borrowing party fails to make the periodic payments, the lender is entitled to block the operation of the assets.
  - The assets are immediately provided to the borrower, who makes periodic payments while intending to use those resources, but without ever getting ownership over them. As before, if the borrower fails the periodic payments, the renter can block the assets.

3.3.3. Mezzanine

Mezzanine is a hybrid of equity and debt that gives the lender the right to convert debt to equity in the project/company in the case of default (the failure to make required repayments on a debt) [103]. Some sources of mezzanine financing usually include private investors, insurance companies, mutual funds, pension funds, and banks. Moreover, it is considered to have a medium to long-term horizon [104].

3.3.4. Crowdfunding

Crowdfunding is employed to raise money for businesses activities and projects. Using online platforms, fundraisers are able to collect smaller amounts of money but from a large group of individuals [105]. There are different types of crowdfunding, namely:

- **Reward-based crowdfunding**: Individuals provide financial support and, in return, expect to receive non-financial rewards at a later stage, such as goods, services, prizes or gifts [105]. A sub-type of reward-based crowdfunding is generation-based crowdfunding for which the return consists in the supply of electricity or a discount in electricity rates [106].
- **Donation-based crowdfunding**: Individuals provide financial support, without expecting a financial or material return for their aid [105], [106].
- **Profit-sharing/revenue-sharing**: The funded activities promise to share future profits or revenues with the crowd at a later stage [105], [106].
- **Peer-to-peer lending**: The crowd agrees to lend money to a business with the understanding that interest will be added to the original loan amount. It is comparable to conventional bank borrowing, with the exception that funding is obtained from multiple potentially small investors [105].

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- **Equity crowdfunding**: Stakes in a company are sold to investors in exchange for financing. Each investor gets a stake proportional to how much they invest in the business. Unlike other capital-raising methods such as equity (where funds come from a small group of professional investors), equity crowdfunding targets a broader group of investors, raising the necessary capital by obtaining small contributions from many individuals [107].

Some authors also admit the existence of hybrid crowdfunding models, which combine the elements of multiple crowdfunding models [105].

3.3.5. Energy Performance Contracts

An Energy Performance Contracts (EPC) is an arrangement between a client or project owners and a DER Provider or an ESCo. They are meant to help saving energy without the need for any upfront capital investments [98]. Under an EPC, the DER Provider/ESCo can execute a renewable energy project or implement a methodology to improve energy efficiency, using the income stream from the cost saving or the produced energy to repay the costs of the project. The ESCo only receives its payment if the project delivers financial benefits [54].

Using this approach, the risk is moved from the client to the ESCo based on performance guarantees provided by the ESCo (performance is measured by the amount of energy produced or saved). An EPC helps to deliver infrastructure improvements to facilities lacking engineering skills, manpower and/or funding [54].

The duration of an EPC usually ranges from 5 to 10 years for a simple project [108], but it can extend to 20 or even 30 years or more for large projects [109]. Regarding risks, those are considered small, with the ESCo assuming performance and credit risks [109].

3.3.6. Fiscal incentives

Fiscal incentives are policies meant to influence the behaviour of individuals and/or companies who take certain actions or act in a particular way by offering them financial rewards [106]. Types of fiscal incentives include tax credit, tax abatement and tax exemption. This kind of incentives is intended to make a particular decision more desirable than it would be otherwise [110].

An example of fiscal incentives is, for instance, when a government, wanting to promote the use of RES and decrease energy consumption, offers a tax credit or tax refund to households investing in technologies such as solar panels or more efficient HVAC systems [110].

3.3.7. Financial incentives

Financial incentives are monetary benefits given to costumers and/or companies to encourage them to change their behaviour take actions which otherwise would not take place [106]. They are sometimes regarded as policy instruments for the state which can be linked to other financial instruments or used as stand-alone mechanisms [111].

Usually, financial incentives can take the form of a loan with preferential terms or a grant/subsidy covering a percentage of the incurred costs. Some examples of financial incentives are [106]:

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- **Grant/subsidy**: Financial assistance, usually provided by the government, foundations, or other institutions to support specific projects or initiatives, typically without requiring repayment.
- **On-tax financing**: On-tax financing is a mechanism used to repay money that was lent to be invested in building improvements meeting a certain "valid public purpose" (e.g., energy saving, renewable energy production, water conservation, etc…). On-tax financing is built upon a pre-existing relationship between municipalities and their citizens: the property tax system. Typically, money is lent up-front to home and business owners, used for upgrades/retrofits in their buildings, and later refunded through an extra fee on property tax. The extra tax should not exceed the energy savings resulting from the retrofits/upgrades made to the buildings (or the value of generated energy), thus resulting in positive cash-flows for the citizens benefiting from this financing mechanism [98].
- **On-bill programs**: On-bill programs are similar to the on-tax financing mechanism, being divided in two main types, on-bill financing (OBF) and on-bill repayment (OBR). In both possibilities a utility or private lender provides capital to a customer to fund energy efficiency or renewable energies projects in buildings, being repaid via regular payments on an existing utility bill. In both OBF and OBR the utility collects repayments from the end customer via its monthly utility bill , with the distinction lying in the source of capital [98]:
    - On-bill financing: The projects are financed using public money, ratepayer funds or utility shareholder funds, with the capital typically coming at very low interest rates.
    - On-bill repayment: The projects are financed using private capital from third-party investors. The interest rate is usually higher than in OBF, however it is often cheaper than the market rate for loans due to the added security provided to investors by attaching the repayment obligation to the customer's utility bill.
- **Revolving funds**: In a revolving fund an organisation has a reserve of money (a fund) which is lend to one or more borrowers to finance a set of activities. Later, each borrower is expected to repay the original amount over a specified period, with an additional sum being charged (interest) to cover administrative costs and to protect the fund from depletion [106]. Loans and revolving funds have similarities, but while the first is a sum of money, borrowed from a lender for many kinds of purposes, and repaid over a specific time, a revolving fund is an ongoing source of capital for pre-defined activities, without a specific end date and where money circulates between the fund and its members. Moreover, revolving funds are usually provided by governmental agencies and non-profit making organizations, but not with banks [112].
- **Recurring funds**: Financial tools focused on vulnerable homeowners with limited or no resources to renovate their houses and improve their quality [106]. Although several other mechanisms already exist to support renovations, several projects are not implemented because other types of incentives frequently require that the eligible activities are completed and paid for before the owner applies to the subsidies. For vulnerable households, those conditions mean that they can't access these support

schemes, as they don't have the required funding to complete and pay for the eligible activities. However, through the recurring funds, they can access these schemes. This fund is neither a subsidy nor a loan. Unlike a subsidy, the recurring fund must be repaid and, unlike loans, repaying it does not involve a recurring repayment. The recurring fund is meant to be self-sustaining, therefore those benefiting from it have to pay back a part of the added value [113]. For instance, if the renovated houses are sold, part of the value of the sales is used to repay the fund, of if the property's value rises over time part of this gain is allocated to the fund. With these repayments, the revolving fund can contribute to other renovation projects [114].

3.3.8. Self-financing

Self-financing refers to the act of raising or providing funds or capital for something oneself, without depending on external sources or intermediaries [115].

3.3.9. Summary

The main characteristics of the described financing mechanisms are summarized in Table 3.37.

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Table 3.36 – Financing mechanisms characteristics

Financing mechanism	Description	Source of funds	Repayment structure	Duration	Risk	Sustainability
Equity	Selling ownership shares of the company/business to investors in exchange for capital.	Investors, who turn into partial owners of the company/business.	Requires no repayment, but shareholders get part of the profits and losses.	Long-term partnership between investors and the company/business	Risk and rewards shared between investors and the company/business.	Source of capital for a sustainable and long-term growth without specific goals
Debt	Borrowing money from a lender with the obligation to repay it along with interest and within a certain period.	Banks, bondholders, and financial institutions, or DER Provider/ ESCo (in the case of asset renting).	Periodic payments of principal and interests.	Variable, from short-term (months) to long-term (decades).	Lenders face the risk of default.	Can support sustainable projects, such as green bonds for environmentally friendly initiatives.
Mezzanine	Converting debt to equity if the borrower fails to make required repayments.	Investors, banks, mutual funds, pension funds and insurance companies.	Variable repayment terms, involving interest payments and a portion of equity or warrants.	Medium to long-term.	Lenders face risk of losing money in the case of company bankruptcy.	Supports business growth, without specific goals.
Crowdfunding	Rasing money from a large number of people, usually online.	Large number of individual contributors.	Variable, depends on the model	Fundraising usually lasts up to several months.	Variable, depends on the model, but backers risk losing their investment.	Can support sustainable projects, such as green technologies and energy communities.
Energy Performance Contracts	Guaranteeing energy savings, with payment linked to level of the resulting savings.	Company (DER Provider/ ESCo) uses its own funds.	Repayments based on the achieved energy savings.	Pre-defined term, usually several years (payback period of the project).	Regarded as low risk, which is assumed by the DER Provider/ ESCo.	Help to increase energy efficiency and reduce energy consumption.
Fiscal incentives	Implementing policies that offer tax benefits or financial advantages to the individuals and businesses promoting specific activities.	Government funds, non-profit organizations, and private companies.	No repayments,	Variable, depends on the policy objectives	No risk, as repayments are not expected.	Can promote sustainability goals by encouraging eco-friendly investments.
Financial incentives	Offering monetary rewards or benefits to encourage investments in certain areas or activities.	Government funds	Depends, some are non-repayable, while others expect repayments.	Often offered as one-time payments or deductions.	Regarded as low risk, or even inexistent in the cases where no repayment is expected.	Used to boost usage of RES, increase energy efficiency can reduce GHG.
Self-financing	Using own funds, without needing external sources or intermediaries.	Own funds	——	——	——	——

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3.4. Business Models financing

In this section the BMs described in section 3.2 are matched with the main financing mechanisms presented in section 3.3. A criteria-based methodology is proposed to support this matching. Here, for a BM to be supported by a certain financing mechanism, it must satisfy a set of key criteria (Table 3.37). For instance, for a BM to be financed by Equity it must fulfil criterion E1, related to the "Possibility to sell ownership over the business/activity". Equally, for a BM to be financed through Mezzanine it must check two criteria simultaneously, which are criterion M1 ("Borrowers can commit to pay/repay the debt/asset (possibly with interests)") and criterion M2 ("Possibility to sell ownership over the business/activity, if necessary").

Table 3.37 – Criteria to match BMs and financing mechanisms

Financing mechanism	Key criteria
Equity	E1: "Possibility to sell ownership over the business/activity" ☐
Debt	D1: "Borrowers can commit to pay/repay the debt/asset (possibly with interests)" ☐
Mezzanine	M1: "Borrowers can commit to pay/repay the debt/asset (possibly with interests)" ☐ M2: "Possibility to sell ownership over the business/activity, if necessary" ☐
Crowdfunding	C1: "Borrowers need a substantial amount of money" ☐ C2: "Borrowers can commit to share financial benefits" ☐ or C2: "Borrowers can commit to pay/repay the borrowed capital" ☐ or C2: "Possibility to sell ownership over the business/activity " ☐ C3: "Business/activity attractive for 3rd parties, with social/environmental benefits ☐
Energy Performance Contracts	EPC1: "Borrowers available to renovate/retrofit their buildings" ☐ EPC2: "Borrowers expecting small, periodic saving in their energy bills" ☐ EPC3: "Borrowers moved by economic and/or environmental reasons" ☐ EPC4: "Individual arrangement between lender and borrower" ☐
Fiscal incentives	Fs1: "Borrowers expecting small, periodic saving in their energy bills" ☐ Fs2: "Business/activity with social/environmental benefits" ☐ Fs3: "Capital provider intents to induce certain behaviour in the receivers" ☐

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Financial incentives	Fn1: "Borrowers expecting small, periodic saving in their energy bills" ☐ Fn2: "Borrowers can commit to slowly pay/repay the debt (only if necessary)" ☐
Self-financing	Sf1: "Own funds available, without requiring financial aid or support" ☐ Sf2: "Availability to accept investment risks (if investment exists)" ☐

The BMs and financing mechanisms are matched according to those criteria, with the results (either if they fulfil or not the criteria) being provided in Table 3.38. In the remaining of this section, it is further detailed how each BM can be supported by the mechanisms assigned to it.

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Table 3.38 – Financing mechanisms and BMs criteria evaluation

BM	Equity	Debt	Mezzanine		Crowdfunding			EPC				Fiscal incentives			Financial incentives		Self-financing	
	E1	D1	M1	M2	C1	C2	C3	EPC1	EPC2	EPC3	EPC4	Fs1	Fs2	Fs3	Fn1	Fn2	Sf1	Sf2
BM1																	X	X
BM2		X	X		X	X		X	X	X	X	X	X	X	X	X	X	X
BM3		X	X			X		X	X	X	X	X			X			
BM4		X	X		X	X		X	X	X	X	X	X		X		X	X
BM5	——	——	——	——	——	——	——	——	——	——	——	——	——	——	——	——	——	——
BM6	——	——	——	——	——	——	——	——	——	——	——	——	——	——	——	——	——	——
BM7	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X
BM8	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X

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3.4.1. BM1: Traditional retailer

Regarding the cost structure of BM1, the only suitable financing mechanism is:

- Self-financing – Consumers pay the energy bill.

3.4.2. BM2: Flex assets acquisition

In BM2, Consumers can be supported via:

- Debt – Consumers can ask for normal loans or energy efficiency loans/mortgages.
- Energy Performance Contracts – The resulting energy savings or cost savings are used to repay the assets [54], [98].
- Fiscal incentives – Again, VAT reductions can be applied not only to energy bills but also to energy efficiency and to renewable energy projects [106].
- Financial incentives – Certain governmental programs provide funds or loans to citizens [106].
- Self-financing – Consumers use their own funds to pay for the assets.

In the context of BM2, fiscal incentives can make the investment in energy efficiency and renewable energy projects (e.g., of PV+BESS, smart HP, or HVAC systems) more affordable to Consumers. There are numerous examples of the utilization of this mechanism in EU countries, for instance, in France [116], Netherlands [117], Belgium [118] and Italy [119]. Moreover, VAT reductions can apply to the energy produced from RES, as in [120], [121], but also be used to help vulnerable citizens and families [122]. Regarding financial incentives, some governments created programmes to support the rehabilitation and decarbonisation of the domestic sector by offering subsidies and loans to citizens to cover a fraction of the costs of eligible projects. These involve renovations to improve energy efficiency and water efficiency of buildings and projects involving low carbon solutions, such as [7], [123], [124]. Meanwhile, through Energy Performance Contracts assets are installed at the Consumer's property without upfront costs, with the resulting savings being used to pay the DER Provider. A few examples of companies offering these possibilities can already be found [125], [126], [127]. Moreover, loans with more favourable conditions for homeowners wishing to improve the efficiency of their houses are offered by several financial institutions, as in [128], [129]. If none of the described mechanisms are available, of if the Consumers choose not to resort to them, the last available option is self-financing.

3.4.3. BM3: EaaS from retailer

For the BM3, the appropriated financing mechanisms are:

- Debt – More specifically asset renting. For this case, it is negotiated a contract between Consumer and DER Provider, in this case Retailer, specifying the periodic fee and other conditions. The equipment is provided immediately after the contract signing. The payment covers asset price and operating and servicing costs [130].
- Energy Performance Contracts – Energy bill savings cover the fee paid by renting the assets [54], [98].

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- This way the Consumer is free from big initial investments and can pay the asset value along the time of its utilization. However, if payments fail, the provider can block the asset operation until the payments aren't resumed.

3.4.4. BM4: DERs from retailer

In the BM4, the financial mechanisms assumed are:

- Debt – Retailers can concede a loan to the Consumers to buy the assets.
- Energy performance contract – The contract will be celebrated between Consumer and Retailer. The cost savings or the renewable energy produced that Consumer presents can be used to repay costs of the investment.
- Self-financing – The Consumer pays the assets total value at once to Retailer.

For this BM, the transactions, whatever they are, will be between Consumer and Retailer. One possibility is to pay all the asset once, after that 100% of the device is Consumer property. Another option is requiring a loan to Retailers companies and paying over the time. The main resources that can be bought under this BM are PV panels and batteries and many times there are packs with the two types of devices, improving the installation reliability [131], [132], [133].

3.4.5. BM5: Grid flexibility

In this BM, it is assumed that the assets are already installed and prepared to supply flexibility to grid operators via Aggregator. So, a financing mechanism doesn´t make sense because this BM is in a step ahead. However, financial mechanism centred in Aggregator, DER Manager or DSO activities can be implemented, but this is not a subject for this section.

3.4.6. BM6: Cross-sector services.

For this BM, the situation is similar to the BM5 in what regards to flexible assets. It is assumed that they are already bought. The payment for cross-sector services requires a contract between Consumers and a Service Company (SCo), however this isn't considered a financing mechanism, because this transaction will be a simple periodic payment, according to the contract [62].

3.4.7. BM7: Flexible EC

To support the development of ECs in BM7 the following mechanisms are available:

- Equity – Investors support an EC by acquiring a portion of it [134].
- Debt – Investors lend money to the EC, asking for a fee in return [134].
- Mezzanine – Debt is converted to equity if not paid back by the EC [135].
- Crowdfunding – Funds for the EC are collected from a large number of people using a platform [106].
- Fiscal incentives – Again, policies like VAT reductions can help in deploying projects involving renewable energies, as is the case of ECs.

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- Financial incentives –Loans provided by the government to EC Members [106].
- Self-financing – Consumers wishing to become EC Members use their own funds.

When equity is used, capital is raised from members of the EC. In return, the EC Members willing to provide funds become co-owners of the community and receive part of the profit, such as annual dividends. Usually, equity is used for the implementation and operation phases of a new EC. Since these early stages are perceived as having a higher risk, most citizens are often not too willing to invest. Meanwhile, when debt is used, the investors providing capital do it in exchange of a regular fee to cover the interest. Once the debt is repaid, those investors no longer have a relation with the EC [134]. A third option is mezzanine, where funds provided to the EC as debt capital can be converted to equity if the loan is not paid back [135]. Crowdfunding can also be used to finance ECs using different methodologies: equity crowdfunding (investors get ownership over the EC, being promised future profits), debt crowdfunding (investors give loans in return for interests) and donation based crowdfunding (investors do not receive anything) [134]. Fiscal and financial incentives promoting the usage of RES are important for the deployment of ECs, reducing the monetary effort for their implementation. At least, Consumers can make use of their own funds to acquire the necessary resources to create/join an EC, but, with such a vast amount of financing mechanisms available, this option should only be used as a last resort.

3.4.8. BM8: Flexible EC with shared assets

- BM8 has a different operation than BM7, but, since their development phases follow similar processes, the financing mechanisms available to support the Consumers/Prosumers in BM8 are the same as described in subsection 3.4.7., which include:
- Equity – Investors support an EC by acquiring a portion of it [134].
- Debt – Investors lend money to the EC, asking for a fee in return [134].
- Mezzanine – Debt is converted to equity if not paid back by the EC [135].
- Crowdfunding – Funds for the EC are collected from a large number of people using a platform [106].
- Fiscal incentives – Again, policies like VAT reductions can help in deploying projects involving renewable energies, as is the case of ECs.
- Financial incentives –Loans provided by the government to EC Members [106].
- Self-financing – EC Members use their own funds

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4. Concept and design of the flexibility value chain

The Flexibility-centric VC democratizes the enrolment and engagement of Flexibility stakeholders despite their **size**, **flexibility potential** or **role**. It provides means for the energy market to adapt to flexibility services and make distributed resources available and interoperable to all parties, contributing to unlock the flexibility potential of the final customers / DER Owners.

The main concept for the Flexibility-centric VC is that it will concentrate in a simple, multi-stage process, the link between providers of flexibility and those procuring it, while at the same time exploring the intrinsic value of being flexible via the adoption of BMs that can create value along the VC and for multiple stakeholders.

The cornerstone of the value chain is the capability to **pair** or **matchmake** stakeholders in each stage, (e.g., allowing Prosumers to join the VC with flexible assets and be paired with Aggregators that are in need to incorporate their flexibility potential) and bind them to a BM that could deliver a profit based on the potentially created value. This is achieved by using digital tools to **coordinate** and **exchange** information between **flexibility assets, flexibility providers** and **grid operators** onboarded in the VC.

Interoperability and **data exchange** tools or enablers are included as a transversal capability, linking each stage with standard or interoperable interfaces. This means that for each main stage, the VC will export a data representation, as standard as possible.

As flexibility encompasses a cross-sector dimension, the VC will allow the creation and track of the B2B or B2C agreements in place at each stage, regulating the participation of each party.

Services available in the VC embody these concepts, focusing on one specific stage or providing a multi-stage service along the VC.

In a nutshell, the VC enables **flexible assets** to be easily incorporated and controlled via **services** that implement **BMs** capable of harvesting the potential of flexibility and beyond flexibility assets, while handling their coordination with key external parties. The flexible assets are made available to the market (i.e., namely via an Aggregator), whose activation or mobilisation is dictated by market conditions and in line with the available BMs of the VC.

Ultimately, the VC provides a one stop enabler for all flexibility related stakeholders to acquire flexible assets, expose them to innovative and attractive BMs and to handle the control and mobilisation of those flexible assets. For Consumers/ DER Owners, it provides a **low-cost** and **low complexity** solution. For businesses, it allows the discovery of candidate Consumers and partnerships and to promote sustainable BMs that avoid shortage of flexibility in the electrical system, due to unattractive value propositions.

A roadmap describing the actions and steps required to operationalise, implement, and sustain the VC was presented to the participants of WP1 in a workshop delivered in May 2023. From the received feedback, it was possible to conclude that the VC suits the mapping of all Use Cases and includes all the necessary stages for boosting distributed flexibility. The structure and the content presented on the workshop is further detailed in Annex I.

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4.1. Value chain design

The BeFlexible VC, presented in Figure 4.1, is divided in six steps: Flexibility capacitation, Integration/Enablement, Aggregation, Negotiation preparation, Market Operation and Activation & Settlement. The description of its design includes the identification of the activities and the main roles involved in each one of those steps, with the activities being divided in main and supporting activities. Moreover, inside the main activities there are two types: activities that happen regularly and contribute to the steady operation of the VC, and activities that only occurs once or with very low frequency but are still essential to the provision of flexibility. The supporting activities are services that are often provided or referred to, can add value to the VC, but are not a requirement.

It is a result from the BMs and Role Model previously described, while part of its structure is based on [51], [136].

	Flexibility capacitation	Integration /Enablement	Aggregation	Negotiation preparation	Market operation	Activation & Settlement
Main activities (regular operation)	• Asset provision and installation or retrofit	• Assets OM • Configure HEMS/EMS (cross-sector and local Aggregator constraints) • (Sub)Metering	• Aggregator/EC DP management • Bidding • Activation • Verification (baseline) • Settlement	• Flexibility needs • Determine flexibility zones • Bids preparation • TSO-DSO coordination	• Market DP operation • Bids selection	• TSO-DSO coordination • Activation • Monitoring • Verification (baseline) • Settlement • Billing
Main activities (done once)	• Registration • Contracting support • Financing	• Aggregator DP integration • Financing	• Market registration • Aggregator/EC DP algorithm development • Aggregator pre-qualification • Contracting support	• DSO pre-qualification • Market DP integration • Baseline computation	• Contracting support	
Secondary activities	• Energy services: sizing, efficiency, diagnostics, optimal aggregation, EC creation support, education • Maintenance and support services	• Links with cross-sector services • Maintenance and support services	• Energy services: sizing, efficiency, diagnostics, optimal aggregation, REC creation support, education	• Market analysis • Market simulation • Bidding strategies • Forecasting • Grid analysis	• Market analysis and reporting	• Statistics
Main roles	• Consumer • DER Provider • ICT Provider • Manufacturer • ESCo, SCo	• DER Manager • Consumer	• Resource Aggregator • EC manager	• Resource Aggregator • BRP • DSO • TSO	• Flexibility Market Operator	• Resource Aggregator • DER Manager • Meter Data Collector • DSO and TSO • Billing Agent

Figure 4.1 – Flexibility-centric and Cross-sector VC design

4.1.1. Flexibility capacitation

Flexibility capacitation addresses the identification of the available or potential flexibility that can be harvest from or deployed on the Consumers' side. Thus, in the first stage, the main activities include the acquisition and/or retrofit of assets for Consumers to participate in the provision of flexibility. Then, Consumers can voluntarily make their flexible assets available in exchange for benefits. The assets being considered are those belonging to the electricity domain, such as PV panels, BESS, and other cross-sector assets such as heat pump water heaters (HPWH) for heating, or EVs for mobility. On the Consumers' side a registration into the system (which is done once) is necessary, and also the contracting and supporting of asset/service providers wishing

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to explore a given BM. The VC should also support assets purchase/retrofit by helping Consumers to find financing mechanisms matching their needs.

In the supporting activities, there are auxiliary services which can help in the installation of assets and create additional value to the Consumer. They include sizing, efficiency improvement, energy behaviour diagnostics, and optimal aggregation services which are important to take advantage of flexibility provision and assets operation. In the case of an EC, like in BM7 (subsection 3.2.2.7), the support for the creation of ECs is an activity that is considered to belong to this VC step, which could, for example, be performed by an ESCo. Energy education services to improve energy literacy and teach good energy practices towards improving efficiency are also considered as supporting activities belonging to flexibility capacitation.

The main roles in this stage are:

- **Consumers**, who receive/acquire the flexible assets from which they will benefit while becoming more environmentally friendly.
- **DER Provider**, responsible for delivering the assets.
- **ICT Provider**, responsible for the communication and control software.
- **Manufacturer**, who produces the assets and delivers them to DER Provider.
- **ESCo/SCo**, who offer their services to the Consumers (as described in the BMs).

4.1.2. Integration/Enablement

The integration/enablement stage includes the operation and management of the assets installed in the previous step. The main activities with regular operation include the configuration of EMS/HEMS, which act as gateways to enable information and instructions exchange, and also the processing of metering and submetering data to register consumption/production levels. To connect the Consumers with the rest of the VC, it is necessary an integration in the aggregation digital platform to allow data delivery to the Aggregator and flexibility assets management from the Aggregator.

Moreover, in this step takes place the integration of cross-sector services from SCo with access to signals and data to provide surveillance, mobility, and health services. For example, in the case of surveillance, the Consumer can hire a SCo to be responsible for the house security. For this purpose, Consumer allows the SCo to access security alarm and sensors signals, including energy data, the later enabled by the VC.

In this step, the main roles and their responsibilities are the following:

- **DER Manager**, responsible for the Consumers assets operation, using the appropriate software and digital platform.
- **Consumers**, to become fully integrated in the flexibility VC.

4.1.3. Aggregation

In the aggregation stage, the main activity is the continuous operation of the aggregation digital platform to respond to flexibility requests from the flexibility procurers. This digital platform, since it has its Consumers' data aggregated, calculates (applying the corresponding aggregation algorithms) the best flexibility offers to

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bid in the flexibility markets. After the offering process, the flexibility needs to be activated by controlling the assets engaged in the bid submitted and accepted to meet the committed flexibility.

A part of the aggregation process is the settlement with the aggregated Consumers for the flexibility provided, and, as such, at this step there is also access to the settlement results to distribute the revenues among the aggregated Consumers (explained later at the settlement stage).

About the activities that only occur once, the Aggregator needs to be pre-qualified and registered as a market actor to be able to participate in the market to provide flexibility. It is also necessary that the Aggregator itself pre-qualifies the Consumers to assure they can indeed provide flexibility, and to prevent problems in the activation process. Finally, to support the operation of aggregation, digital platforms are needed by the Aggregators with the corresponding aggregation algorithms to compute the optimal aggregation of their portfolios according to the flexibility requested, and to compute the corresponding bids.

Regarding supporting activities, the focus are the services that can be applied to the aggregated Consumers (e.g., supporting RECs by setting up and managing digital platforms).

In this step, the main roles and their responsibilities are the following:

- **Resource Aggregator**, or the **REC Manager** behaving as an Aggregator for the EC Members according to the EC BM. All the activities described above are performed by these actors, that are responsible for aggregating Consumers or EC Members to facilitate the negotiation of flexibility.

4.1.4. Negotiation preparation

The negotiation preparation and market operation stages are interrelated. The negotiation stage is the first one and refers to use of market analysis tools to compute the optimal flexibility bids to be sent to the market. Therefore, in the negotiation phase, the main activities are the reception of the flexibility needs from the flexibility procurers (e.g., grid operators), the identification of flexibility zones for the aggregation process, and, finally, the preparation of bids to be submitted to the flexibility markets. The market operation is the next stage, where bid selection is decided.

At this step, the pre-qualification of the Aggregator by the market operator is needed once, to guarantee the financial health of the market participants, and the pre-qualification of DSOs may also be needed once or in a more continuous way, depending on the pre-qualification type to guarantee the correct communication between Aggregator, grid operators and platforms, and assess the impact on the Aggregator assets on the grid constraints.

In this step there are other activities that, despite not being required, can be useful to the computation of the optimal bids. Market analysis and simulation tools help to compute optimal bids according to the expected market behaviour, and to maximize value of the offered flexibility. Moreover, forecasting tools are complementary to market analysis tools to improve the estimation of the expected market behaviour. The weather forecast is an example, allowing a better forecast of the renewable energy production and consequently the flexibility needs for grid operators. Grid analysis is also one of the activities that may help to forecast where the grid constraints could be located, and the type and amount of flexibility needed.

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In this step, the main roles and their responsibilities are those that have a direct link to buying and selling flexibility in the market:

- **Aggregator**, who offer flexibility by preparing and submitting flexibility bids.
- **Flexibility procurers**, which, depending on the market, can include grid operator (**DSOs** or **TSOs**) and/or **BRPs**.

4.1.5. Market operation

The market operation step involves the flexibility marketplace operation by means of the appropriate market platform and abiding by the specific market rules. The market platform publishes flexibility needs, collects the submission of flexibility bids and their selection (or partial selection by elaborating a merit order list), as well as in the formalization of the contracts between flexibility buyers and sellers.

In this step, the main roles and their responsibilities are:

- **Flexibility Market Operator**, who facilitates the communication and coordination of all market processes. Other relevant actors are the flexibility procurers (**DSOs**, **TSOs**, **BRPs**) and the Aggregators.

4.1.6. Activation and settlement

Finally, the last step of the VC includes a set of relevant actions needed to activate the flexibility selected, to confirm that the flexibility activated is indeed activated, and to settle it according to the pre-specified settlement rules and contractual agreements, including the invoicing process.

In the flexibility activation process, the grid operator decides among the selected bids, if the flexibility should be activated and, therefore, the corresponding energy (up or down) provided. This is done by sending the activation signal to the Aggregators or flexibility providers, that can directly control the aggregated assets or forward the activation signals to the DER Managers responsible for the assets' operation.

To check if the request to increase or decrease consumption/production was fulfilled, the verification task is performed according to a pre-agreed baseline, computed according to a baseline calculation methodology and relying on monitoring the performance of the Aggregators or in the capability of the flexible assets in their control to providing the flexibility committed (additional information on baseline methodologies and metering is provided in D1.1 [71]).

Moreover, this step must ensure that the acquisition of flexibility to assist in grid operation procedures is done in a coordinated manner between TSOs and DSOs, depending on the coordination mechanisms in place.

After the settlement is done between the flexibility procurers and the Aggregators, the Aggregators must perform the settlement with the asset in their portfolios of flexibility assets, so that the added value for the provision of flexibility is also shared with the Consumers.

As a supporting activity, it is considered that relevant statistics may be computed to assess the flexibility market behaviour, the reliability of the flexibility committed and, regarding Aggregators participating in the flexibility provision, the analysis on the actor's behaviour and the impact of the flexibility activation on the grid condition.

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In this step, the main roles inside this step are:

- **Resource Aggregator**, that prepares the optimal bids based on their flexibility assets portfolio and flexibility requirements and settle with their aggregated Consumers the benefits from providing flexibility.
- **DER Manager**, that receives the flexibility activation signals to control the assets and deliver the committed flexibility.
- **Meter data collector**, that has access to metering and submetering data and provide them to the authorized parties that need them (DSOs, Aggregators, etc) to help in the flexibility delivery verification process.
- **DSOs** and **TSOs**, that manage their respective grids, and compute and inform about their flexibility needs, select the flexibility bids, decide their activation, verify the delivery, and settle the flexibility provision.
- **Billing agent**, responsible for the invoicing process.

4.1.7. Value chain and role model

To connect the VC with the proposed role model, the following diagram shows where each one of the VC phases are located and which roles will be essential to its operation:

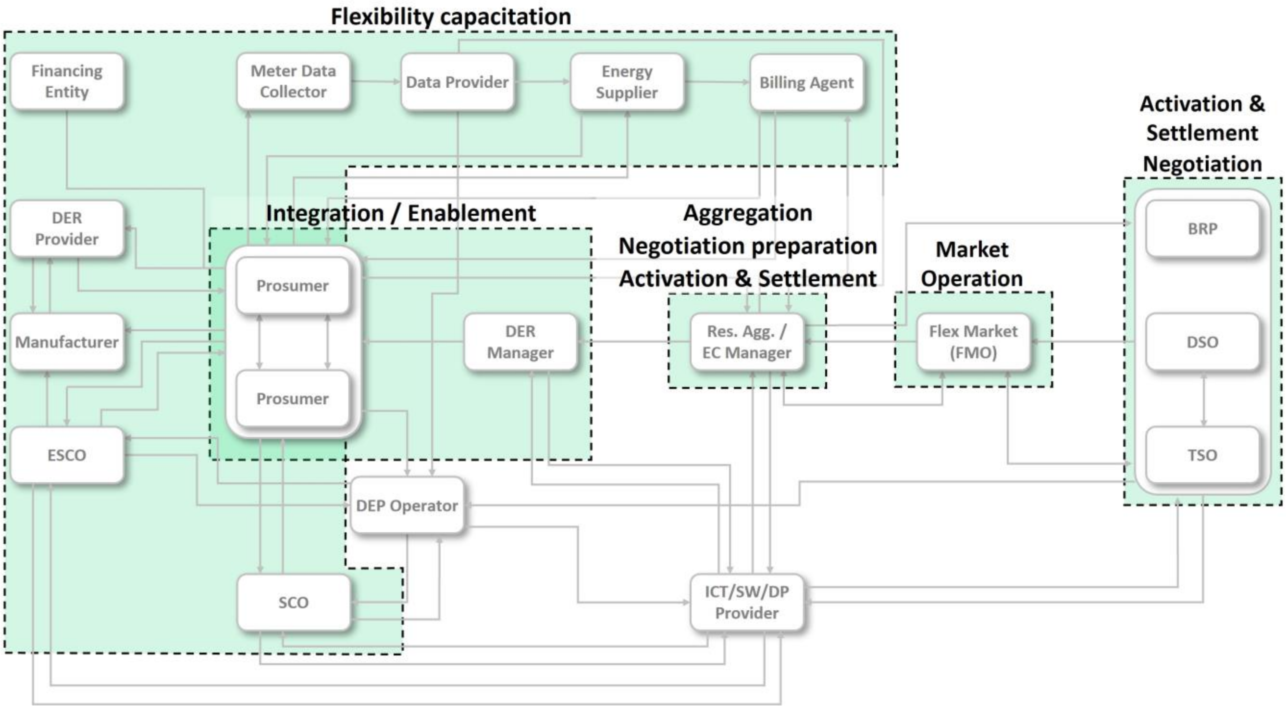

Figure 4.2 - Role Model mapping along the VC

4.1.8. Roadmap

The BeFlexible VC roadmap is meant to delineate the steps and actions necessary to operationalise, implement, and sustain the VC in real world applications.

The implementation of the VC starts with the deployment of the GDBN as a service. Next, in the onboarding step, stakeholders are invited to make their registration into the VC. Then, as members of the VC, those stakeholders can provide or subscribe to flexibility BMs. Since some of those stakeholders might already operate an own platform, it is necessary to guarantee a seamless link and data exchange between them and the GDBN. Once operational, the GDBN enables stakeholders to identify and match flexibility offers and requests from both Consumers/Prosumers and service providers. From their participation in the GDBN, stakeholders can create value and be paid for it, fostering a sustainable and mutually beneficial ecosystem. The last stage of the roadmap is centred on guarantying the scalability of the GDBN, so it adapts to a variable demand. The VC roadmap is depicted in Figure 4.3.

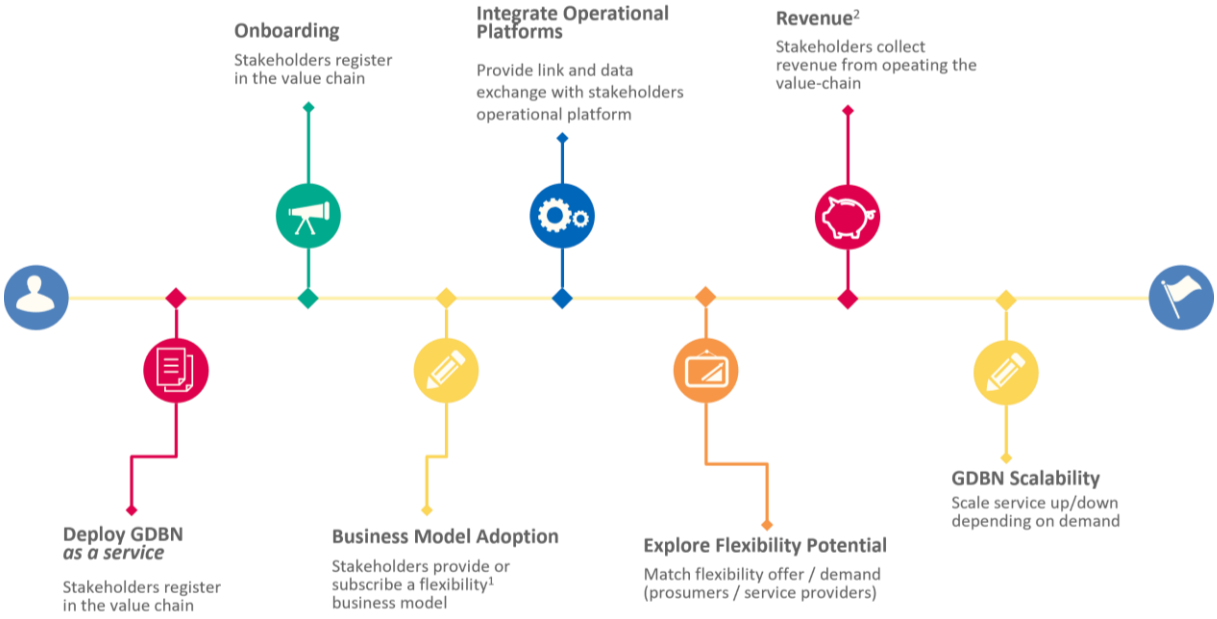

Figure 4.3 - VC roadmap

5. Architecture of the Grid Data and Business Network

The Grid Data and Business Network, from now on GDBN, is a digital platform to provide support to all activities in the Flexibility-centric VC described in Section 4. The conceptual design of the GDBN is depicted in Figure 5.1.

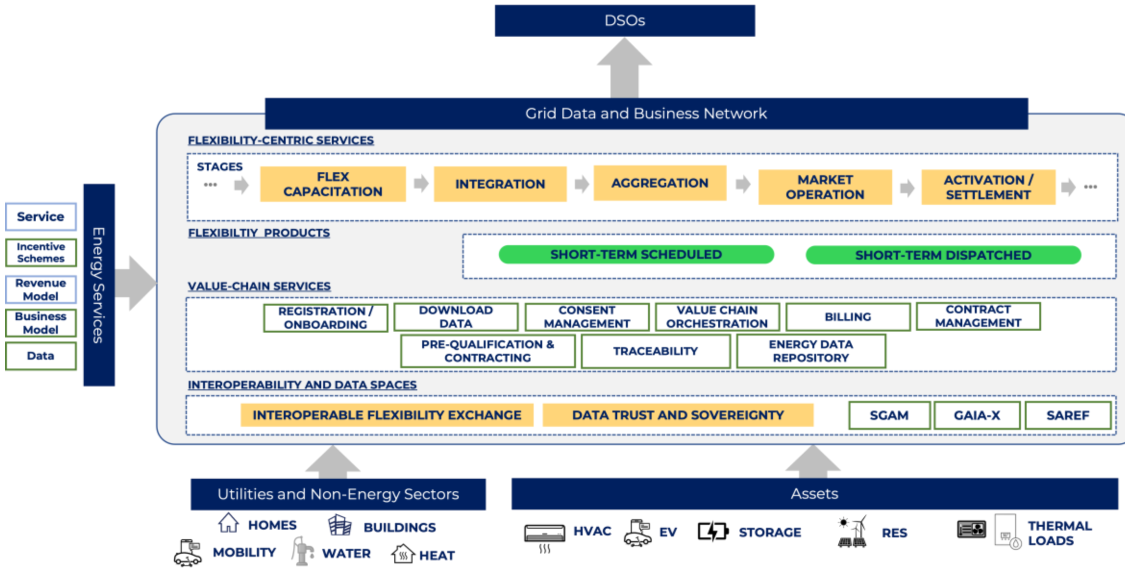

Figure 5.1 Conceptual Architecture for the GDBN

The GDBN architecture is composed by several logical modules concerning the adoption of the flexibility VC: the flexibility-centric services, hosting all the services that embody the different phases of the VC; the flexibility products, that characterize how the components of the flexibility-centric services module should behave in terms of the flexibility provision; the VC services, to support the basic features of the GDBN as an enabler of the VC (registration, data exchange, contracts management, etc); and the interoperability and data spaces module, to provide data interoperability and sovereignty for external services and actors interfacing with the GDBN.

To build on top of existing technologies and proposals, selected digital platforms and flexibility products are reviewed and summarized. Then, the processes for the flexibility exchange to be supported by the GDBN, the GDBN basic functionalities, the flexibility products to be considered in WP6 pilot demonstration, and the GDBN and basic and advanced services are described.

5.1. Digital Platforms review

This subsection presents a review of digital platforms related to the objectives of the GDBN. Depending on their purpose and functionalities, they can be divided into different categories, and several classification proposals can be found in the literature according to platform characteristics and main purpose. For instance, in [137], digital platforms are merely divided in Market Platforms and Aggregator Platforms. Meanwhile, in [138], they are split in Data Exchange Platforms, Flexibility Platforms and Aggregator Platforms. A more comprehensive classification is provided in [139], where eight categories are presented, including Market Platforms, TSO or DSO Operational Platforms, TSO/DSO Coordination Platforms, Market Facilitation

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Platforms (data exchange/data hub), Technology Platform (VPP or Microgrid Controller), Community Services Platforms, BRP/ Supplier Trading Platform and, at last, Energy Management Platforms.

For this work, the digital platform classification methodology used is the one proposed by ENTSO-E [140], that classifies the digital platforms designed to support the operation of power systems in the following categories [140]:

- Aggregator Platform:
    - Decentralized Assets;
    - Centralized Assets;
    - Decentralized and Centralized Assets;
- Flexibility Market Platform:
    - Operated by a Power Exchange;
    - Operated by a DSO;
    - Operated by a TSO;
    - Jointly operated by TSO-DSO;
    - Blockchain-operated;
    - Operated by a third-party;
- Grid Platform:
    - TSO-DSO physical interface (control system);
    - TSO grid;
- Data Exchange Platform:
    - Jointly operated by TSO-DSO;
    - Operated by a DSO;
    - Operated by a TSO;
    - Operated by a third-party.

The platforms reviewed in this document are listed in Table 5.1, where they are grouped according to the categories proposed by ENTSO-E and mapped to the different stages of the Flexibility VC they might potentially support. Grid platforms (i.e., TSO-DSO physical interface and TSO grid platforms) are not included in this review, as they are not considered to be within the scope of the current work.

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Table 5.1 - Reviewed platforms and their mapping along the flexibility-centric VC

Platforms		Flexibility Capacitation	Integration/ Enablement	Aggregation	Negotiation Preparation	Market Operation	Activation & Settlement
Aggregator Platforms	Tiko	X	X	X			
	Solmatch	X	X				
Flexibility Market Platforms	Piclo Flex				X	--[1]	--[1]
	Flexible Power				X[1]	--[1,2]	X
	Enedis platform				X	--[1]	--[1]
	OMIE platform				X	X	--[1]
	NODES				X	X	--[1]
	N-SIDE				X	X	--[1]
Data Exchange Platforms	SIORD						X
	Atrias					X	
GDBN		X	X	X			X

[1] – VC stage only partially supported by the platform

[2] – Support by Piclo Flex

For each one of those categories, a templated table is used to summarize the main characteristics of each platform. The template used for Aggregator Platforms is given in Table 5.2, in Table 5.3 for Flexibility Market Platforms and in Table 5.4 for Data Exchange Platforms.

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Table 5.2 - Table template to characterise Aggregator platforms

Characteristics	Summary
Platform type	• *(type of platform, according to the ENTSO-E proposal)*
Location	• *(country or list of countries where the platform is used)*
Sellers	• *(actors selling flexibility)*
Buyers	• *(actors buying flexibility)*
Services	• *(list of services supported by the platform)*
Resources/Assets	• *(resources being aggregated to provide flexibility)*
Pre-qualification	• *(information regarding pre-qualification tests the assets must endure)*
Bidding period	• *(periods available for flexibility suppliers to make offers)*
Negotiation & Market Operation	• *(information on how flexibility is negotiated)*
Activation & Settlement	• *(information on how flexibility is delivered, and transactions are settled)*
Proof of delivery	• *(how the provision of flexibility is verified, i.e., baseline)*
Remuneration	• *(how flexibility providers are remunerated)*

Table 5.3 - Table template to characterise flexibility market platforms

Characteristics	Summary
Platform type	• *(type of platform, according to the ENTSO-E proposal)*
Location	• *(country or list of countries where the platform is used)*
Market structure	• *(attributes of the flexibility market, e.g., one-sided market, two-sided market)*
Trading type	• *(how is processed trading within the flexibility market, e.g., auction based, continuous market)*
Price computation	• *(methodology employed to define prices, e.g., pay-as-bid, pay-as-clear)*
Market type	• *(market category, e.g., energy and/or reserve/capacity)*
Buyer	• *(actors buying flexibility)*
Sellers	• *(actors selling flexibility)*
Products/Services	• *(list of services supported by the platform)*
Resources/Assets	• *(resources being used to provide flexibility)*
Pre-qualification	• *(information regarding pre-qualification tests the assets must endure)*
Aggregation	• *(if and how assets' flexibility is aggregated)*
Bidding period	• *(periods available for flexibility suppliers to make offers)*
Negotiation & Market Operation	• *(information on how flexibility is negotiated)*
Activation & Settlement	• *(information on how flexibility is delivered, and transactions are settled)*
Proof of delivery	• *(how the provision of flexibility is verified, i.e., baseline)*
Remuneration	• *(how flexibility providers are remunerated)*
TSO-DSO coordination	• *(Description of TSO-DSO coordination mechanisms, when applicable)*

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Integration with other markets or platforms	• *(Interactions with pre-existing or new markets or platforms)*

Table 5.4 - Table template to characterise data exchange platforms

Characteristics	Summary
Type	• *(type of platform, according to the ENTSO-E proposal)*
Country	• *(country or list of countries where the platform is used)*
Operator/Ownership	• *(entity owning or operating the platform, e.g., DSO)*
Objective	• *(main goal for operating the platform)*
Data to be exchanged	• *(information exchanged)*
Data supplier	• *(actors who provide data)*
Data users	• *(actors who make use of the collected data)*
Assets	• *(assets used to exchange data and assets whose date is being exchanged)*
Other features	• *(other important features not included in the previous items)*

5.1.1. Tiko

Tiko is an Aggregator platform launched in Switzerland in 2014. It was developed with the goal of controlling and aggregating behind-the-meter assets, such as electric heating devices (heat pumps and boilers), EV chargers, and PV systems [141], as depicted in Figure 5.2. This way, Consumers benefit from having a higher level of control over their devices, thus optimizing self-consumption from PV panels, reducing peak consumption, increasing their comfort, and reducing energy bills [142]. Apart from these benefits obtained via implicit flexibility, Consumers who join Tiko can also enter a VPP and receive additional revenues by providing frequency regulation or by participating in intra-day and day-ahead markets [143]. Still, a full description of how that process is implemented was not obtained in the revised literature.

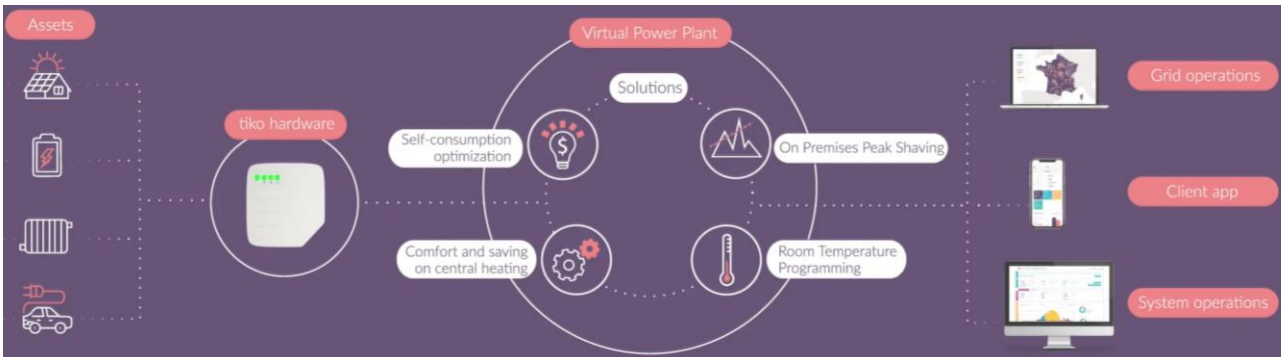

Figure 5.2 - Overview of the Tiko platform [142]

According to the most recent information found, Tiko is present in four other European countries, namely Austria, Belgium, France and Germany [137].

In the case of Switzerland, Tiko uses Consumers' flexibility to deliver balancing services for the local TSO. The settlement for trades is first done on the TSO balancing market between the Aggregator and the TSO, and

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then on Tiko's platform between the Aggregator and the Consumers providing flexibility. The TSO continuously acquires flexibility for the following week [141].

Regarding the hardware and software at Consumers' side, the Tiko's system is composed by four main parts (Figure 5.3). It includes actors and sensors, the gateway, Frontend and Backend, in addition to several other services [141], which are as follows:

- Actors and sensors – The K-Box is an essential device for controlling and measuring consumption from appliances such as heat pumps, air conditioning and EV charging stations. Measured data is redirected to the Backend to determine the state of the device and the control decision variables [141], [144]. The K-Box is equipped with relays used to control the devices in an on/off manner and shift electric consumption [145]. Consumers can also have sensors installed in their homes, such as temperature and humidity sensors [146]
- Gateway – The K-Box is connected to the M-box, to where it sends data though power line communication. The M-Box is an intermediate device that provides the Backend with data from the K-Box [141], [147].
- Backend – The main functionality of Backend is the algorithm that determines control actions for the connected devices. Control decisions are done by examining multiple parameters. Consumer comfort is guaranteed not to go beyond a specific limit [141].
- Frontend – The Frontend offers several functionalities to the Consumers. For instance, they can visualize their historical consumption patterns via a web or smartphone application, or they can activate the Eco-mode to reduce energy consumption. Consumers can also be alarmed when unusual energy consumption patterns are detected. Additionally, one Consumer can benchmark its energy consumption against other participants in the Tiko system [141].
- Other systems – Includes support service connected to the platform, such as rollout and installation planning tools, Consumer support portals, ERP systems, energy scheduling, capacity planning, and operation cockpits for primary and secondary control [141], [145].

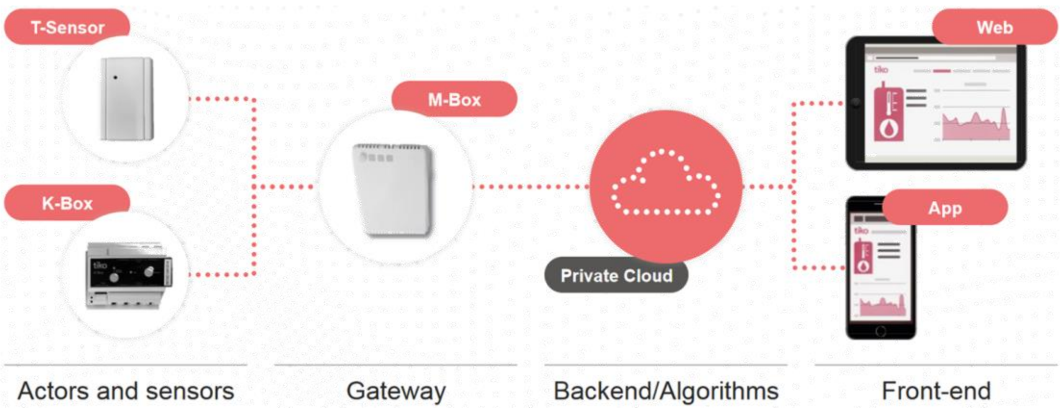

Figure 5.3 - Overview of the Tiko system [145]

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The website and mobile app provided by Tiko to the Consumers are not thoroughly described in the revised documentation, with only a few details made available (Figure 5.4). Still, it is possible to verify that they allow each Consumer to check the monetary savings achieved since they joined the platform, see, in real time, the energy being consumed from the grid or from their PV panels, the energy being transferred from/to the BESS and the energy being used for different purposes and by different devices (e.g., boilers, heaters, smart plugs…). If temperature sensors are installed, information on room temperature is also presented. Other additional features, such as Eco Mode (to further increase energy saving) and changing heating modes are also available on the website and app [148], [149].

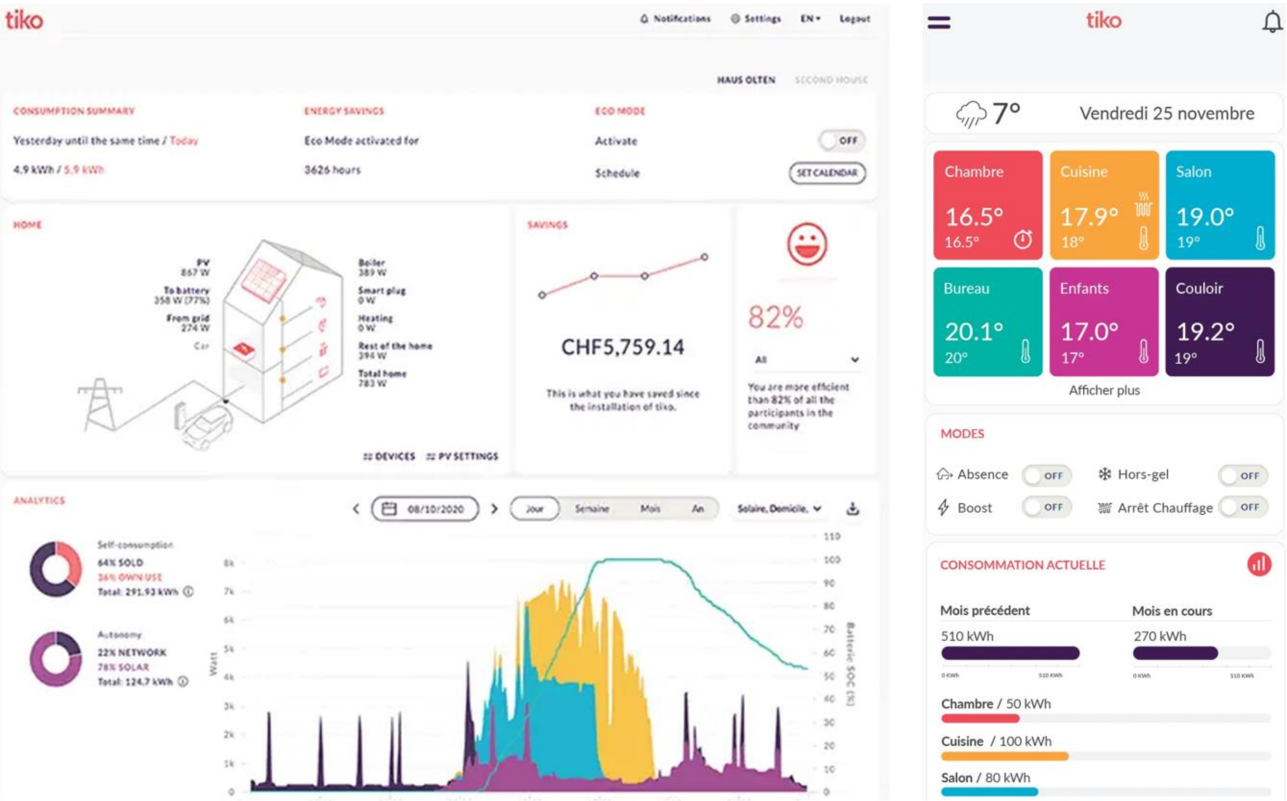

Figure 5.4 – Tiko website and mobile app [142]

The main value propositions offered by Tiko are an energy consumption analysis and a comparison with other users, energy savings, comfort, remote control and enhanced security related to abnormal consumption patterns and ensured by the alarming system, which, for instance, can help to detect device failure [145], [150]. Moreover, Tiko cooperates with utilities and vendors of heating devices. In doing so they strength the relation with customers, potentially increasing customer retention [145]. Additionally, utilities can benefit from the data provided by Tiko. Having close-to-real time consumption data allows Tiko to make a better identification and categorization of Consumers, improve forecasts and schedules. The collected consumption data enables analysis of the operation of many devices spread out all over the country in detail [145].

The main characteristics of Tiko are presented in Table 5.5.

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Table 5.5 - Main characteristics of the Tiko Platform

Characteristics	Summary
Platform type	• Aggregator Platform [137]
Location	• Switzerland, Austria, Belgium, France, Germany [137]
Sellers	• Aggregated domestic consumers and small/medium enterprises provide flexibility to Tiko [150] • Tiko provides flexibility to TSOs
Buyers	• TSOs (ancillary services market) [137] • DSOs [151]
Services	• Peak clipping [152] • Primary, secondary, and tertiary control (in Switzerland) [145]
Resources/Assets	• Electric loads (which can be delayed without impact on Consumers' comfort [150]) • Heat pumps, electric heaters, night storage heaters, water boilers, air conditioning, EV charging stations [141], [150] • Sensors and actuators are used to control assets [141], [150] • Backend algorithms determine control actions for the connected devices [141]
Pre-qualification	• Resources wanting to join the ancillary services market must pass pre-qualification tests defined by the TSO [145]
Bidding period	• TSO continuously buys flexibility for the following week [141]
Negotiation & Market Operation	• TSO's ancillary services market (outside Tiko's platform)
Activation & Settlement	• First, settlement between TSO and Aggregator is done on the TSO balancing market [141] • Next, settlement between the Aggregator and Consumers is done on Tiko's platform [141]
Proof of delivery	• Baseline is established using data from Smart Meters
Remuneration	• Payment from the TSO to the Aggregator [137] • Payment from the Aggregator to Consumers [137] • Pricing is based on market rules of TSO balancing services [137]

5.1.2. Solmatch

Solmatch is an initiative which began in 2020 and is promoted by a Spanish Retailer. Its purpose is to stimulate and facilitate the production and trade of solar power between Consumers in low voltage levels in urban areas. Here, a Consumer with a PV installation acts as "roofer", supplying energy to other Consumers, who are called "matchers "and must be within a 500-meter radius of a roofer. The PV panels are provided to the roofer via a Solar Power as a Service BM, meaning it is the Retailer who owns, installs and maintains the PV systems [137].

The main functionalities of Solmatch include feasibility studies, design, installation and maintenance of the PV plants and managing electricity supplied to households (solar power or grid power, depending on the availability) [137].

The platform settles transactions based on the agreed tariffs between the Retailer and roofers/matchers. The primary income for this Retailer comes from monthly fees paid by matchers and the margins obtained from the energy tariffs agreed with roofers and matchers. Roofers and matchers have a defined energy tariff contract with the Retailer. They agree on two different prices based on the source of the energy consumed: solar or from the grid [137].

Before signing up for this service, the platform helps Consumers to understand the benefits of being part of Solmatch and the different geo-localised communities they can join. Once members of a solar community, information on the best use of the service and environmental impact is provided through the web application to encourage responsible behaviour as part of the energy transition training [153], [154].

On a more technical side, Solmatch is described as providing a technological ecosystem that incorporates multi-cloud integration, geo-positioning, and data analytics for the exploitation of Consumers' intelligence, all with end-to-end integration between the stack of applications and services of the cloud ecosystem, and the different back-ends such as SAP [153].

The most relevant characteristics of Solmatch are presented in Table 5.6.

Table 5.6 - Main characteristics of the Solmatch Platform

Characteristics	Summary
Platform type	• Aggregator Platform [137]
Location	• Spain [137]
Sellers	• Consumers (roofers) [35]
Buyers	• Consumer (matchers) [35] • Retailer [137]
Services	• Settle transactions between the Retailer and roofers/matchers [137] • Help Consumers to understand the benefits of being part of Solmatch and choose a community to join [137] • Informe members on the best use of the service and on environmental impact to encourage new behaviours [137]
Resources/Assets	• PV panels [137] (provided by the retailer using an "as a Service" BM)
Pre-qualification	• N/A (Consumers are not providing flexibility)
Bidding period	• N/A (Consumers are not providing flexibility)
Negotiation & Market Operation	• N/A (Consumers are not providing flexibility)
Activation & Settlement	• N/A (Consumers are not providing flexibility)
Proof of delivery	• N/A (Consumers are not providing flexibility)
Remuneration	• Retailer's income comes from monthly fees paid by Consumers and the margins obtained from the energy tariffs agreed with roofers and matchers [137] • Roofers and matchers have unique contracts, agreeing on different prices for solar energy and energy from the grid [137]

5.1.3. Piclo Flex

Piclo, a software development company, created the Piclo Flex platform. It is defined as an independent end-to-end marketplace that assists the procurement, operation and dispatch of short and long-term flexibility [155]. It can support grid operators in obtaining flexibility and use it to solve local grid issues [156], enabling a more efficient usage of the existing infrastructure and reducing the need for reinforcements [137]. So far, it is available in five European countries, including the UK, Ireland, Portugal, Italy, and Lithuania, and also in the USA [155].

In short, Piclo Flex enables flexibility to be traded by offering grid operators a modularised service, which includes procurement with in-house transaction clearing, auction facilitation, flexibility requirement visibility, advertisement, asset/company pre-qualification and credential certification [138]. The platform is used to issue flexibility needs based on the demand location so that the DSO can see qualifying assets inside each zone. The resulting map of competitors enables the DSO to source flexibility with regard to specific locational, technical, and temporal requirements [137].

To use the Piclo Flex platform, an FSP company must start by completing a set of steps, described next. First, the FSPs will have to create a new account on the Piclo website. Here, they will have to provide several details, including [157]:

- Registered or legal name
- Registered number (Companies House number or registered charity number)
- Organisation website
- Organisation email (Use a shared email address e.g., 'flex@company.com')
- Country of registration

Then, the FSPs can login and start the qualification process, which consists of several step, including [158]:

- Company qualification
- Asset qualification
- Competition qualification

Once an FSP is registered on Piclo, the next step is to complete company qualification for each relevant DSO. DSOs might require FSPs to complete a dynamic procurement system application on Piclo Flex, a process also known as company qualification, where Piclo helps DSOs to pre-qualify FSPs before a competition/tender (i.e., flexibility market) opens. To complete company qualification, an FSP will be required to provide several details and supporting documentation. This process is split in 4 sections [158]:

- Organisation profile – The FSP has to provide company registration details such as registration number, VAT number and legal relationship with the assets.
- Organisation status – The FSP must answer questions related to its historic and current financial status.
- Auditing, insurance and legal – The FSP submits a copy of audited financial accounts covering at least the past 2 years, as well as multiple insurance documents.
- Declare and submit – The FSP confirms the information provided is accurate and submits it.

With this information, the DSO reviews the application and decides whether to approve or reject the application, informing the FSPs on the decision [158].

To qualify assets, the FSPs must upload their characteristics into the platform. That is done using a spreadsheet whose template can be found online (only available to those who register into Piclo Flex). This procedure, which is described next, is full detailed in [159]. When inputting a new asset into this template,

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first the FSP must defines its "Asset status" on sheet number 1, which influences how the rest of the spreadsheet is filled. Essentially, there are 5 statuses [159]:

- Planned assets – Assets that are either speculative or not yet formalized.
- In development – Assets that are in the process of being contracted, built, or installed.
- Operational – Assets ready to provide flexibility.
- Mothballed – Assets no longer providing flexibility, but that can be brought back online.
- Archived – Assets which are no longer needed can be removed or have their status changed to archived.

While "in development" and "operational" assets exist or have a clear development plan," planned assets" only exist theoretically or are speculative based on commercial development. Moreover, "planned assets" denote a plan that is specific to a certain competition or zone, they can represent the intention to develop one or several operational assets, and their existence might depend on the results of procurement [160]. That is, a "planned asset" can be directly archived if no contracts are won, meaning it will not even proceed to the "in development" stage [161]. The progress between asset statuses is pictured in Figure 5.5.

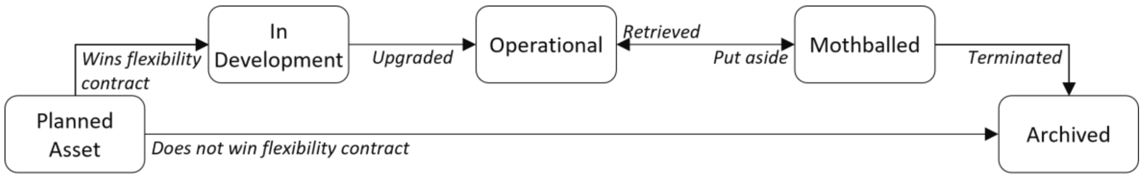

Figure 5.5 – Progress between asset statuses according to Piclo (based on [160], [161]

If the assets being added are "operational", "in development" or "mothballed", the FSP can move to sheet number 2, called "Operational and Developing Assets". In this sheet there are multiple data points to be filled out for each asset by the FSP. They are divided in 6 sections [159], and listed in Table 5.7.

Table 5.7 – Fields required to upload an "operational", "in development" or "mothballed" asset into Piclo Flex [159]

Section	Field	Description
Basic Details	**Asset Ref**	The reference you provide to uniquely identify the asset in the system.
	Asset Name	A human readable name used to identify the asset in the system.
	Asset Status	Describes the status of the asset to let you promote future assets as well as assets available now "in development" "operational" "mothballed"
	Asset Category	The general categorisation of the flex asset "storage" "energy efficiency" "demand side response" "interconnectors" "low carbon" "renewable" "thermal"
	Asset Type	Describes the specific technology type of the flex asset. "battery" "fuel cells" "liquid air" "compressed air" "pumped hydro" "vehicle to grid" "energy efficiency" "vehicle charging" "residential" "commercial" "industrial" "interconnector" "nuclear" "gas carbon capture and storage ccs" "biomass" "biomass chp" "hydro" "tidal" "wave" "offshore wind" "onshore wind" "advanced conversion technology act" "advanced conversion technology act chp" "anaerobic digestion" "anaerobic digestion chp" "biogas chp" "biofuel" "geothermal chp" "landfill gas" "sewage" "sewage chp" "solar pv" "waste" "waste chp" "combined cycle gas turbine

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		ccgt" "gas chp" "gas reciprocating engines" "open cycle gas turbine ocgt" "coal chp" "diesel reciprocating engines" "fuel oil" "coal" "gas" "diesel" "gas oil"
	Voltage Level	Voltage level at the point of connection to the network. "0.24" "0.40" "6.60" "11.00" "22.00" "33.00" "66.00" "132.00"…
	Country Code	Used to provide the approximate location
Flexibility Details	**active export capacity**	The flexible power capacity, in MW, that an asset can export to the network (+MW), either by discharging a storage asset, turning up export of a generation asset, or turning down the overall energy consumption of DSR asset.
	active import capacity	The flexible power capacity, in MW, that an asset can import from the network (-MW), either by charging a storage asset, turning down export of a generation asset, or turning up the overall energy consumption of DSR asset.
	reactive export capacity	The capacity, in MVAr, that an asset has to generate reactive power.
	reactive import capacity	The capacity, in MVAr, that an asset has to absorb reactive power.
Meter Details	**Point of Metering**	Describes where the asset is metered. "terminals" means behind the meter and "boundary" means at the network connection
	Meter Interval	The most granular metering frequency available.
	Metet ID Export	The unique identification of the export meter associated with this asset (e.g., MPAN). Leave blank if asset still in development.
	Metet ID Import	The unique identification of the import meter associated with this asset (e.g., MPAN). Leave blank if asset still in development.
	Supplier	Name of the energy supplier for this asset.
Technical Details	**Technical Response Time**	The minimum time required for the asset to respond to a utilisation message. If over 24 hours, prepend the duration with the number of days.
	Maximum Run Time	Maximum length of time that the asset can sustain capacity. If over 24 hours, prepend the duration with the number of days.
	Minimum Run Time	Minium length of time required to dispatch asset. If over 24 hours, prepend the duration with the number of days.
	Recovery Time	The time required by the asset to recover from one instruction until the next instruction can be actioned (assuming full utilisation). If over 24 hours, prepend the duration with the number of days.
Location Details	**Address**	Useful for helping the System Operator locate the asset. However, it is not required if a Meter ID is provided.
	Latitude	If provided, used to accurately locate the asset.
	Longitude	If provided, used to accurately locate the asset.

Otherwise, if the FSP wants to insert a “planned asset” they move to sheet number 3, called “Planned Assets”. Because “planned assets” are managed differently within Piclo Flex, the process to add them is also different. While “operational” and “in development” assets are added to the platform permanently, a “planned asset” can only be added when there is an active market on Piclo Flex and an FSP wants to add prospective assets into a live competition zone. A “planned asset” must always be related to a live competition and,

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consequently, an FSP cannot add a “planned asset” which is not associated to a specific competition. Once a competition is removed from Piclo Flex, each “planned asset” associated with it will no longer be visible on the map, however the FSP who created them can still see them in their existing asset download [162].

If a “planned asset” wins a flexibility contract it must be added to the “operational” and “in development” assets tab. It will be added as “in development” until the asset is “operational”, when the status should be updated once more [162]. Still, in the reviewed documentation about Piclo Flex it is not clear what happens if a “planned asset” wins a flexibility contract, but then its status never reaches “operational”. To upload a “planned asset”, not as many data points are required as to upload an “operational”, “in development” or “mothballed” asset [159], as seen in Table 5.8.

Table 5.8 – Fields required to upload a “planned asset” into Piclo Flex [159]

Section	Field	Description
Target Competition	**Target Competition**	Reference of the competition for which the FSP would like to qualify this asset
	System Operator Name	Name of the local System Operator
Basic Details	**Asset Ref**	A unique reference for this asset which will be used by the system
	Asset Name	A human readable name used to identify the asset in the system.
	Estimated Asset Count	Estimated number of assets for this “planned asset”.
	Asset Statues	Input future assets as “planned asset” or as “archived” to remove it from the system
	Asset Category	The general categorisation of the flex asset “storage” “energy efficiency” “demand side response” “interconnectors” “low carbon” “renewable” “thermal”
	Asset Type	Describes the specific technology type of the flex asset. "battery" "fuel cells" "liquid air" "compressed air" "pumped hydro" "vehicle to grid" "energy efficiency" "vehicle charging" "residential" "commercial" "industrial" "interconnector" "nuclear" "gas carbon capture and storage ccs" "biomass" "biomass chp" "hydro" "tidal" "wave" "offshore wind" "onshore wind" "advanced conversion technology act" "advanced conversion technology act chp" "anaerobic digestion" "anaerobic digestion chp" "biogas chp" "biofuel" "geothermal chp" "landfill gas" "sewage" "sewage chp" "solar pv" "waste" "waste chp" "combined cycle gas turbine ccgt" "gas chp" "gas reciprocating engines" "open cycle gas turbine ocgt" "coal chp" "diesel reciprocating engines" "fuel oil" "coal" "gas" "diesel" "gas oil"
	Voltage Level	Voltage level at the point of connection to the network. "0.24" "0.40" "6.60" "11.00" "22.00" "33.00" "66.00" "132.00"
Flexibility Details	**Flexibility Capacity Type**	The Planned Asset's capacity type. "active_import_capacity" "active_export_capacity" "reactive_import_capacity" "reactive_export_capacity"
	Capacity	The capacity of the Planned Asset in MW or MVAr unit
Technical Details	**Maximum Aggregate Technical Response Time**	The maximum time required for the Planned Asset to respond to a utilisation message. If over 24 hours, prepend the duration with the number of days.

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	Maximum Aggregate Run Time	Maximum length of time that any of the planned DERs can sustain flexibility capacity. If over 24 hours, prepend the duration with the number of days.
	Minimum Aggregate Run Time	Minimum length of time that any of the planned DERs can sustain flexibility capacity. If over 24 hours, prepend the duration with the number of days. Format: DD HH:mm:ss
	Maximum Aggregate Recovery Time	The maximum time required by any of the DERs to recover from one instruction until the next instruction can be actioned (assuming full utilisation). If over 24 hours, prepend the duration with the number of days. Format: DD HH:mm:ss

Besides using the described spreadsheets to upload assets, it is also possible to do this via APIs, which are described in 5.1.3.1. But it should be noted that, at this point, it is not clear which of the DSOs using Piclo Flex are already using these APIs, or which ones are still using spreadsheets.

Once the spreadsheets are completed, the FSPs upload them to the platform. Then, successfully created assets shall automatically appear in the dashboard, but they do not show as qualified until there is a live competition that those assets fall into. After the assets have been successfully uploaded, the FSP can view them on the dashboard map (Figure 5.6). The blue dot (above the green area) represents an asset which does not qualify for a live competition at that moment. Meanwhile the blue pin (inside the green area) represents an asset that is qualified for a live competition (i.e., allowed to participated in a flexibility market) [159].

To decide if an asset is qualified or not, there is an automatic qualification process completed by the platform based on the following criteria [159]:

- Geographic location: checks if the asset is within the boundaries of the competition.
- Voltage level: checks if the asset is connected to compatible voltage levels.
- Capacity: checks if the asset has compatible capacity for the need (e.g., “Active export” or “Reactive Import”).
- Date: checks if the asset is being uploaded before the qualification process deadline.
- Company qualification: checks if the FSP has been approved on the company qualification process.

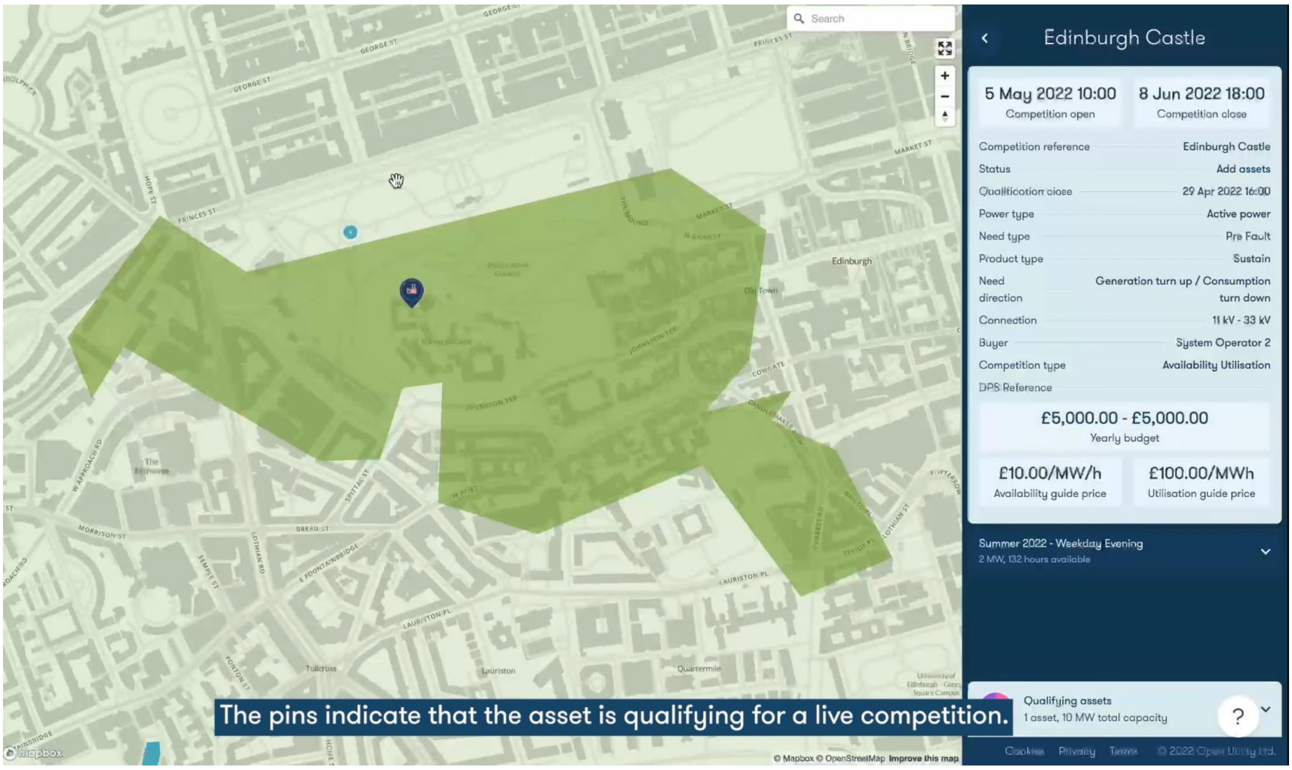

Figure 5.6 – View of qualifying and non-qualifying assets in a Piclo Flex competition [159]

By selecting a non-qualifying asset it is possible to see the reason why that asset is not qualified (e.g., the asset is too far away from any competition, or its voltage level is incompatible with any of the live competitions) [159].

A pre-qualification questionnaire (PQQ) is also mentioned in Piclo website, and its goal is to provide additional information about qualifying assets to the DSOs. Each DSO has its own QPP, thus the structure of this questionnaire is not standard and not described by Piclo. Still, it is possible to find an example of a PQQ in [163], which is the used by a British DSO (UKPN). Some of the information required on this PQQ includes:

- Company details
- Flexible asset details
  - Aggregated: Y/N
  - Type of connection: demand, generation, demand, and generation, mixed
  - Technology type (see Table 5.7)
- Baseline methodology: recent history baseline, last observation baseline, other (chosen and described by the FSP)
- Dispatch communication methodology: API, email

Further information about this exact PQQ is available in [164].

FSPs who completed the previous steps, i.e., company qualification and assets qualification, move on to the last qualification step, which is competition qualification. This stage is meant to ensure that the FSP intentions

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are known by the DSO. Hence, in this last step, all FSPs with assets which have been qualified must confirm entry or withdraw from each qualifying competition to complete the qualification process, and then be eligible to place bids. By confirming their entry into a competition, the FSPs are sending a signal to the DSO that they intend to bid. There are 4 statuses possible within competition qualification [165]:

- Entered: an FSP confirms they intend to bid into a competition
- Withdraw: an FSP is withdrawing from a competition.
- Unknown: this is the default status if neither of the above options are chosen.
- Ineligible: this is the state when the asset data is not complete, or the assets do not meet the required aggregate capacity.

The dashboard of Piclo Flex where competition statues are displayed is shown in Figure 5.7.

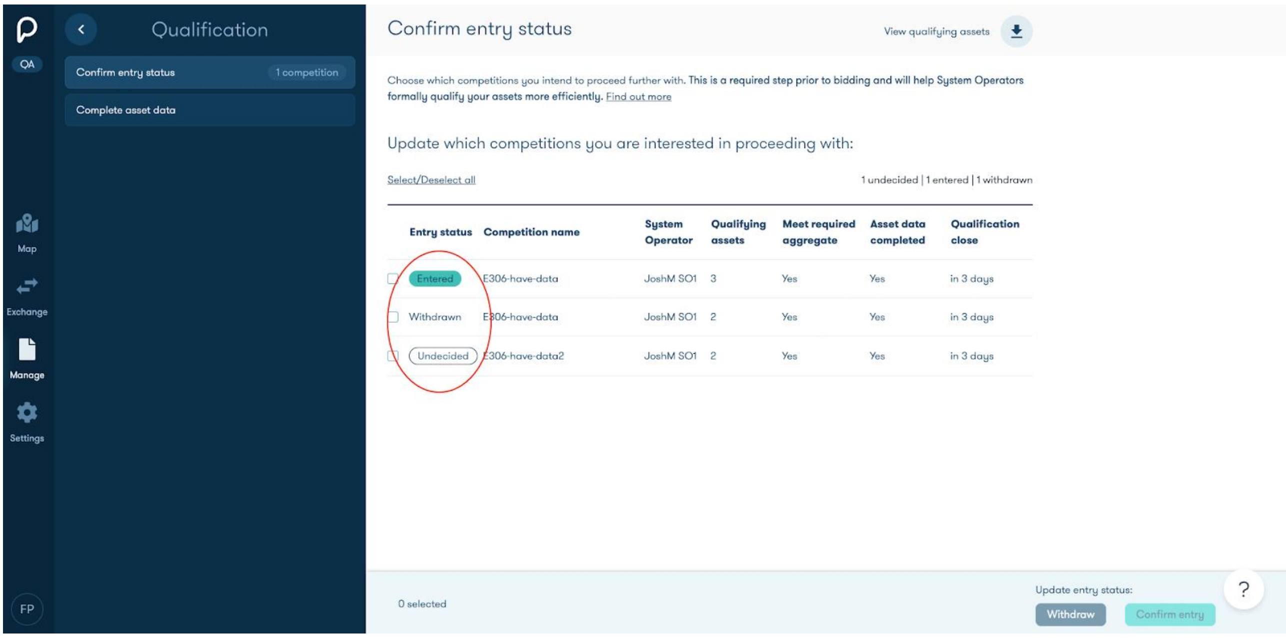

Figure 5.7 – Piclo Flex dashboard displaying competition entries statuses [165]

FSPs must confirm entry to, or withdraw from, a competition before the corresponding competition qualification ends. Besides, if they do not confirm entry to, or withdraw from, a competition, they will not be able to continue with the competition process. Once qualification is completed, FSPs who were accepted and had assets qualified can bid into the competitions they were qualified to [165]. This process is described next.

The data requested when submitting a bid includes [166]:

- Capacity (MW): Confirm the amount of MW the bid is for. This value cannot be above the lowest of either the qualified capacity value or the amount needed by the buyer.
- Maximum Runtime (D HH:MM:SS): Confirm the time that the submitted capacity can run for. This can be any value according to the technical capability of the asset(s) making up the bid.
- Availability (£/MW/h): A price for being available during the service window hours or pre-determined if price is fixed by DSOs. Dependent on type of competition.

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- Utilisation (£/MWh): A price for dispatching the capacity on receiving a dispatch notification or pre-determined if price is fixed by DSOs. Dependent on type of competition.
- Service (£/MW): A single, flat fee for providing the capacity submitted across the whole service window, or pre-determined if price is fixed by DSOs. Dependent on type of competition.

On a side note, all the competitions currently live on Piclo Flex are pay as bid. Moreover, bidding can be done via file or via APIs (still in development, according to the most recent information) [166].

Piclo offers DSOs the tools to show suggested pricing or 'pricing signals' for each competition to help FSPs on their pricing strategies. According to the strategies used by DSOs, there are different pricing signal data options [167]:

- Maximum and minimum budget (£) - these ranges are assigned per competition per year.
- Availability guide pricing (£/MW/h or £/MVAr/h) - used as a guide to help FSPs price availability bids.
- Utilisation guide price (£/MW/h or £/MVAr/h) - used as a guide to help FSPs price utilisation bids.
- Service fee (£/MW/h or £/MVAr/h) - annual fee paid for capacity as per the DSO's payment structure.

If pricing signals are provided by a DSO they can be seen on the map [167], as seen in Figure 5.8.

Figure 5.8 – Piclo Flex dashboard highlighting pricing signals of a competition [167]

Once the DSO has confirmed all bid results of a certain competition, Piclo Flex notifies all the participating FSPs. This message includes prompts to view the results (i.e., which bids were accepted and rejected). From this point onwards all the accepted bids are deemed as contractual obligations [168].

Regarding prices, in [169], [170] it is succinctly described how a DSO using Piclo Flex calculates a celling price for flexibility using a methodology and tool designed by Energy Networks Association (ENA). This ceiling price indicates the optimal deferral value where flexibility services are cheaper than traditional grid reinforcement and relies on many inputs including Customer Interruptions (CI), Customer Minutes Lost (CML), Weighted Average Cost of Capital (WACC), discount rates, losses value, carbon prices, cost per injury/fatality and inflation rates [171]. This ENA methodology, named ENA ONP CEM, is thoroughly described in [172], while the tool, implemented using a spreadsheet, is available in [173] and explained in [174]. Moreover, in [169],

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[170] it is summarized a methodology to guide FSPs on how to calculate their utilisation and availability bids based on the defined celling price. However, bidding bellow the celling price does not necessarily guarantee that the submission will be accepted and, conversely, bidding above the ceiling price doesn't mean the submission will be rejected, it just has a decreased likelihood of being accepted.

This completes the description on how FSPs can qualify and submit bids. Nonetheless, it is still important to describe how competitions work and how flexibility is required or defined.

Essentially, Piclo Flex supports 4 flexibility products [175]:

- Sustain - The DSO procures, ahead of time, a pre-agreed change in input or output over a defined period to prevent the network from going past its capacity.
- Secure - The DSO procures, ahead of time, the ability to access a pre-agreed change in FSP input or output based on network conditions close to real-time.
- Dynamic - The DSO procures, ahead of time, the ability of a FSP to change its output following a network issue.
- Restore - Following a loss of supply, the DSO instructs a FSP to either remain off supply, to reconnect with lower demand, or to reconnect and supply generation to support increased and faster load restoration under depleted network conditions.

The definition of these products changes among DSOs [167], as further clarified in Section 5.2, where flexibility products are reviewed.

When a DSO is creating a competition in this platform it must input the following information [176]:

- Power Type:
  - Active Power
  - Reactive Power
- Need Type:
  - Post Fault
  - Pre-Fault
  - Reinforcement Deferral
  - Compliance
  - Other
- Need Direction:
  - Deficit (Active Power)
  - Excess (Active Power)
  - Import (Reactive Power)
  - Export (Reactive Power)
- Product Type:

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- Sustain
- Secure
- Dynamic
- Restore

- Connection kV:
  - 0.24, 0.4, 6.6, 11, 22, 33, 66, 132
- Competition Type:
  - Availability & Utilisation
  - Utilisation
  - Service Fee
  - Capacity
- Fixed Price Competition:
  - True
  - False
- Public Holiday Handling:
  - Include
  - Exclude
- Boundaries: Bounding area of the competition
- Service windows: Allows the DSO to populate details of the flexibility service associated with the competition. Service windows are set within service periods for example a service period called 'Summer 2024' (from 1st April 2024 until 30th September 2024) can have a weekday morning window of 9:00 – 11:00 Monday - Friday and a weekday evening window 18:00 – 22:00. There is no limit to the number of service periods or service windows a competition can have.

Regarding the platform interface, the manner through which competitions are listed and presented in Piclo Flex is shown in Figure 5.9.

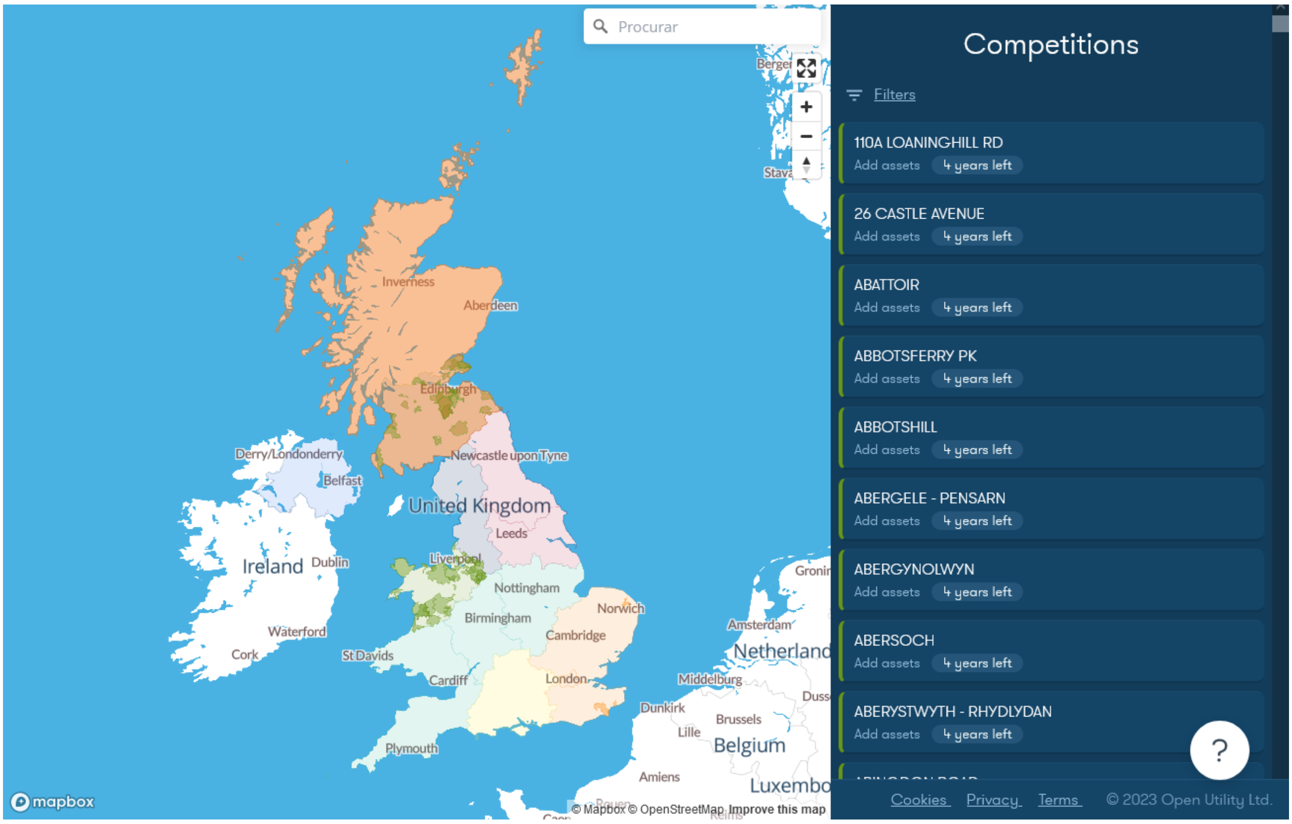

Figure 5.9 – Piclo Flex showing a list of competitions available in the UK [177]

After selecting one of those competitions, additional information is shown, as seen in Figure 5.10. For each competition, the following details are listed [176]:

- Competition reference
- Status (e.g., add assets, submit a bid)
- Qualification close
- Power type:
- Need Type:
- Product type
- Need direction
- Connection voltage level
- Buyer
- Competition type
- DPS reference

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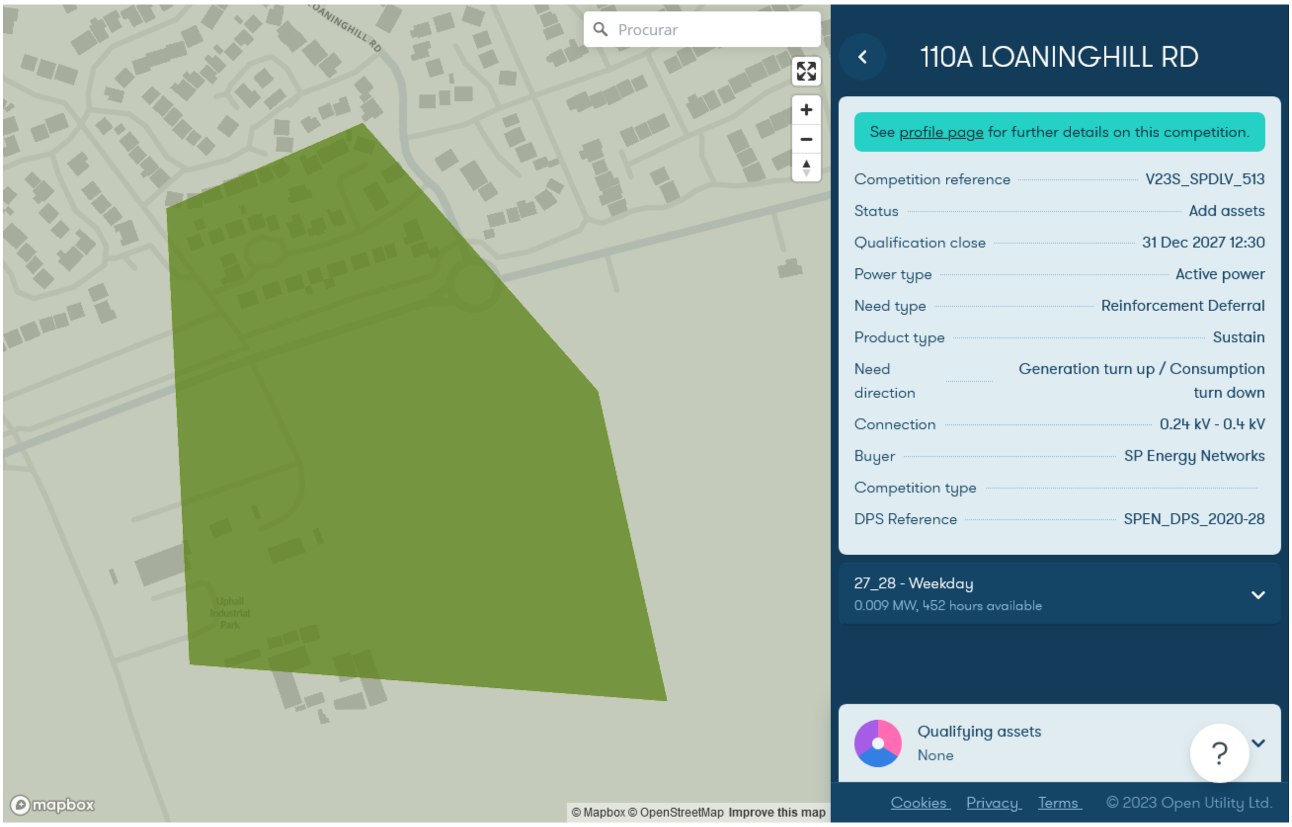

Figure 5.10 – List of details related to competitions available in the UK [177]

Beside these details, for each competition, it is also shown a list of all time periods when a competition requires flexibility (in the example displayed in Figure 5.10 there is only 1 service window (weekdays from 2027 to 2028), but in other competitions there are multiple time periods). For each service window, the following details are given, as seen in Figure 5.11:

- Contract start
- Contract end
- Time required
- Days required
- Estimated utilisation events
- Estimated utilisation duration/event
- Estimated hours utilisation
- Total need (MW)
- Minimum aggregated asset size
- Minimum run time

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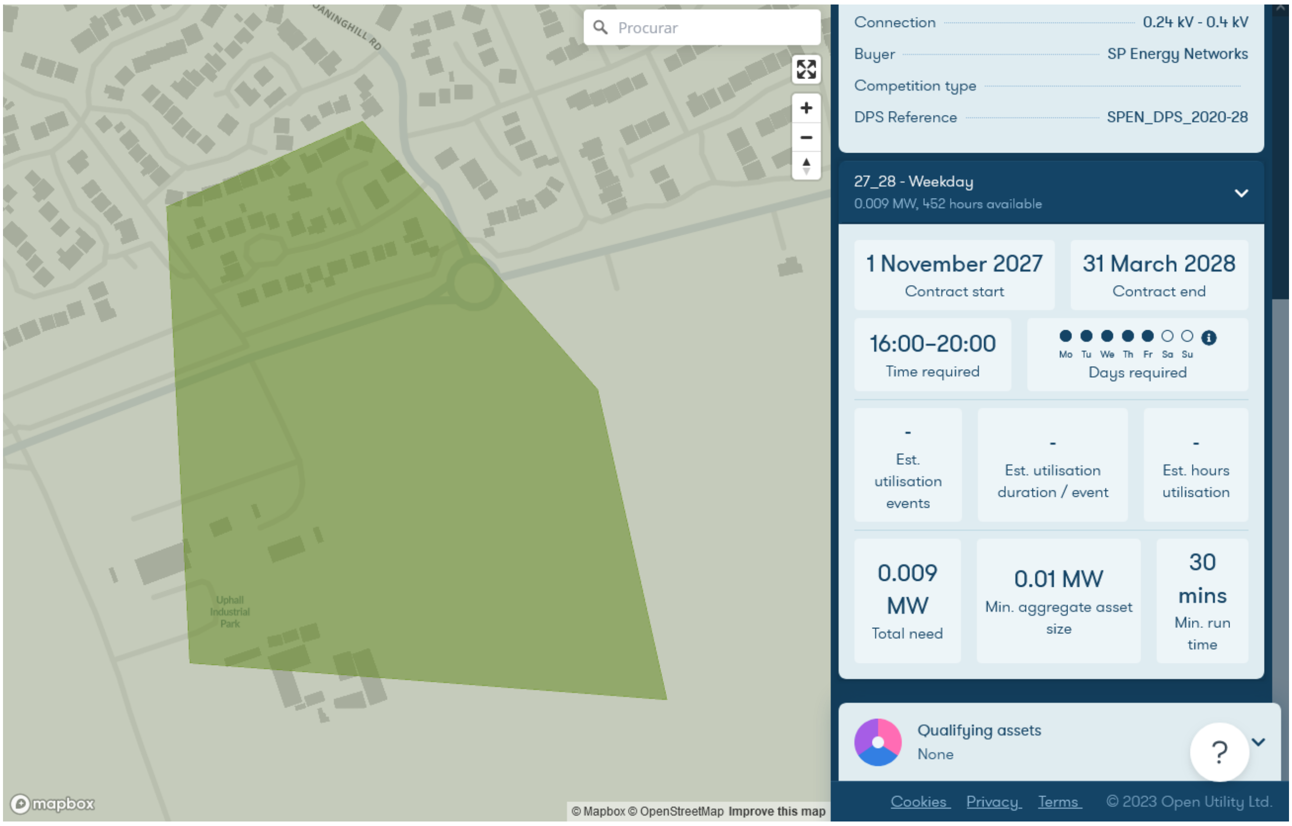

Figure 5.11 – Details of a specific service window of a competition in the UK [177]

Once a competition is closed, and assuming bids were received, the DSO chooses which bids to accept. This can be done either within the platform or through a procurement system owned by the DSO. Regarding activation and settlement, this is conducted by the DSO outside the Piclo Flex platform, with manual dispatch instruction and activation [138]. Still, and according to [164], settlement APIs can used to simplify the integration of metering and invoicing systems, but this seems to still be under development, and, at this point, it is not clear whether these APIs are already being used. Moreover, flexibility delivery is performed by the DSO in a manual validation process using meter data [132]. The baselines shall be defined using representative historical data and are provided by FSPs [163].

The main characteristics of Piclo Flex platform are summarized in Table 5.9.

Table 5.9 – Main characteristics of the Piclo Flex platform

Characteristics	Summary
Platform type	• Flexibility Market Platform [155]
Location	• UK, Ireland, Italy, Lithuania, Portugal, USA [155]
Market structure	• One-sided market (single buyer [137], [156])
Trading type	• Auction based [156]
Price computation	• Pay-as-bid [156]
Market type	• Energy and capacity [156]
Buyer	• DSOs [137]
Sellers	• Aggregators, DER Owners, large consumers, EV, and generators [137]

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Products/Services	• Congestion Management for DSOs (short-term and long-term [137], [156]) • Voltage control [137] • Observability over available flexibility [156] • Standardized: Sustain, Secure, Dynamic, Dispatch
Resources/Assets	• Batteries [137] • EV charging points [137] • Gas or diesel-powered generators, CHP systems, waste-to-power systems, wind farms [137] • Demand Side Response [137]
Pre-qualification	• Done by the DSO, using information stored in the platform [178]
Aggregation	• Aggregation is allowed [156]
Bidding period	• Tenders are organized with a lead-time of 6 months or more [137] • Contract duration can go from a few months to 4 years [137]
Negotiation & Market Operation	• Within-platform: sellers submit bids and the DSO chooses which to accept either within platform or through own procurement system [138]
Activation & Settlement	• According to [138], activation and settlement is conducted by the DSO off-platform • According to [138], manual dispatch instruction and activation by the DSO off-platform • According to [179], settlement APIs are used to simplify the integration between metering and invoicing systems
Proof of delivery	• Off-platform: DSO-led manual validation process using meter data [138] • Baseline is established using representative historical data [178]
Remuneration	• Dispatch payment (£/kWh) [137] • Availability payment (£/kW/h) [137] • Dispatch and availability payment (£/kWh + £/kW/h) [137]
TSO-DSO coordination	• TSO-DSO coordination is not considered [156]
Integration with other markets or platforms	• Runs separately from the existing electricity markets [137]

5.1.3.1. Piclo Flex API

By examining Piclo Flex APIs , described in [180], it was possible to obtain a more comprehensive understating of the data being exchange between the FSPs, the platform, and the DSOs. The gathered information is summarized next. For complete description of the APIs, readers are referred to [180].

The APIs are meant to enable software integration with the Piclo Flex platform, allowing participants to automate processes, reduce errors, and scale faster. Multiple APIs are already available for both FSPs and DSOs, with more resources still being developed. The main functionalities that have been implemented so far are depicted in Figure 5.12. Piclo Flex APIs follow REST API conventions and use JSON formatting [180].

To have access to Piclo Flex API, an FSP must contact the support service. An FSP who is found to be eligible is provided with the following content [180]:

- Provider ID - unique identifier for the FSP's organisation within Piclo Flex
- Client ID - identifier for a machine user created for the FSP's organisation
- API Key - secret key to authenticate this Client ID

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Once an FSP has access to the platform API, it can perform a set of actions, including creating/updating assets, submitting bids, and receiving dispatch instructions. Assets are divided in categories and types. An asset's category must always match a certain type, as represented in Table 5.10 [180]:

Table 5.10 – Assets categories and types [180]

Asset category	Asset Types
storage	battery, fuel_cells, liquid_air, compressed_air, pumped_hydro, vehicle_to_grid
energy_efficiency	energy_efficiency
demand_side_response	vehicle_charging, residential, commercial, industrial
interconnectors	interconnector
low_carbon	nuclear, gas_carbon_capture_and_storage_ccs
renewable	biomass, biomass_chp, hydro, tidal, wave, offshore_wind, onshore_wind, advanced_conversion_technology_act, advanced_conversion_technology_act_chp, anaerobic_digestion, anaerobic_digestion_chp, biogas_chp, biofuel, geothermal_chp, landfill_gas, sewage, sewage_chp, solar_pv, waste, waste_chp
thermal	combined_cycle_gas_turbine_ccgt, gas_chp, gas_reciprocating_engines, open_cycle_gas_turbine_ocgt, coal_chp, diesel_reciprocating_engines, fuel_oil, coal, gas, diesel, gas_oil

In a similar manner to what was described before, to create a new flex asset whose statues is either "in development", "operational", "mothballed", or "archived", the FSP must send the platform the information indicated in Table 5.11.

Table 5.11 – Create a new flex asset: request body schema [180]

Field	Description
provider (required)	string 7 characters ^[a-zA-Z0-9]{7}$ Your Flex Provider ID as provided by Piclo Flex.
ref (required)	string <text> [1 .. 36] characters ^[a-zA-Z0-9]{36}$ The reference you provide to uniquely identify the asset in the system.
name (required)	string <text> [1 .. 80] characters A human readable name used to identify the asset in the system.
status (required)	string Enum: "in_development" "operational" "mothballed" "archived" Describes the status of the asset to let you promote future assets as well as assets available now.
asset_category (required)	string Enum: "storage" "energy_efficiency" "demand_side_response" "interconnectors" "low_carbon" "renewable" "thermal" The general categorisation of the flex asset.
asset_type (required)	string Enum: "battery" "fuel_cells" "liquid_air" "compressed_air" "pumped_hydro" "vehicle_to_grid" "energy_efficiency" "vehicle_charging" "residential" "commercial" "industrial" "interconnector" "nuclear" "gas_carbon_capture_and_storage_ccs" "biomass" "biomass_chp" "hydro" "tidal" "wave" "offshore_wind" "onshore_wind" "advanced_conversion_technology_act"

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	"advanced_conversion_technology_act_chp" "anaerobic_digestion" "anaerobic_digestion_chp" "biogas_chp" "biofuel" "geothermal_chp" "landfill_gas" "sewage" "sewage_chp" "solar_pv" "waste" "waste_chp" "combined_cycle_gas_turbine_ccgt" "gas_chp" "gas_reciprocating_engines" "open_cycle_gas_turbine_ocgt" "coal_chp" "diesel_reciprocating_engines" "fuel_oil" "coal" "gas" "diesel" "gas_oil" Describes the specific technology type of the flex asset.
voltage_level (required)	string Enum: "0.24" "0.40" "6.60" "11.00" "22.00" "33.00" "66.00" "132.00" Voltage level at the point of connection to the network.
country_code	string <iso-3166-1> ISO 3166-1 Designation of the country the asset is located in.
connection_status	string or null Enum: "planned" "submitted" "accepted" "energised" Describes the status of the asset's connection with the network.
operational_date	string or null <date> YYYY-mm-dd The date from which the flex asset was operational.
connection_type	string Enum: "long_term_parallel" "short_term_parallel" "timed" "flexible" "standby" "other" "n/a" "" Describes the type of connection the asset has with the network.
connection_current	string Enum: "<=16_a" ">16_a" "n/a" "" Describes the current per phase of the asset's connection with the network, either below or above 16 A. Specify 'N/A' for planned assets where this is not yet known.
erec_compliance	string <text> <= 200 characters Describes the compliance status of the asset's connection, in accordance with the approriate Engineering Recommendation for its size and type. Specify 'N/A' for planned assets where this is not yet known.
active_export_capacity	string or null^[0-9]{1,15}(\.[0-9]{1,20})?$ The flex asset's maximum flexible capacity for exporting active power to the grid.
active_import_capacity	string or null^[0-9]{1,15}(\.[0-9]{1,20})?$ The flex asset's maximum flexible capacity for importing active power from the grid.
reactive_export_capacity	string or null^[0-9]{1,15}(\.[0-9]{1,20})?$ The flex asset's maximum flexible capacity for exporting reactive power to the grid (lead).
reactive_import_capacity	string or null^[0-9]{1,15}(\.[0-9]{1,20})?$ The flex asset's maximum flexible capacity for importing reactive power from the grid (lag).
max_import_capacity	string or null^[0-9]{1,15}(\.[0-9]{1,20})?$ The maximum import capacity the asset can draw down from the network.
max_export_capacity	string or null^[0-9]{1,15}(\.[0-9]{1,20})?$ The maximum export capacity the asset can provide the network.
response_time	string or null^([1-9])?([0-1][0-9]|2[0-3]):[0-5][0-9]:[0-5][0-9]$ The minimum time required for the asset to respond to a utilisation message. If over 24 hours, prepend the duration with the number of days.

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<table>
<tr><td>max_runtime</td><td>string or null^([1-9])?([0-1][0-9]|2[0-3]):[0-5][0-9]:[0-5][0-9]$
Maximum length of time that the asset can sustain capacity. If over 24 hours, prepend the duration with the number of days.</td></tr>
<tr><td>min_runtime</td><td>string or null^([1-9])?([0-1][0-9]|2[0-3]):[0-5][0-9]:[0-5][0-9]$
Minium length of time required to dispatch asset. If over 24 hours, prepend the duration with the number of days.</td></tr>
<tr><td>recovery_time</td><td>string or null^([1-9])?([0-1][0-9]|2[0-3]):[0-5][0-9]:[0-5][0-9]$
The time required by the asset to recover from one instruction until the next instruction can be actioned (assuming full utilisation). If over 24 hours, prepend the duration with the number of days.</td></tr>
<tr><td>metering_point</td><td>string
Enum: "" "boundary" "terminals"
Describes where the asset is metered.</td></tr>
<tr><td>meter_interval</td><td>string
Enum: "" "ss" "mm" "hh"
The most granular metering frequency available.</td></tr>
<tr><td>supplier</td><td>string <text> <= 80 characters
Name of the energy supplier for this asset.</td></tr>
<tr><td>address</td><td>string <text> <= 200 characters
Used to provide the approximate location. Either a 'meter_id' or an 'address' value must be provided.</td></tr>
<tr><td>latitude (required)</td><td>number [-90 .. 90]
If provided, used to accurately locate the asset.</td></tr>
<tr><td>longitude (required)</td><td>number [-180 .. 180]
If provided, used to accurately locate the asset.</td></tr>
<tr><td>export_meter_id</td><td>string <text> [13 .. 30] characters
The unique identification (MPAN) of the export meter associated with this asset. Leave blank if asset still in development.</td></tr>
<tr><td>import_meter_id</td><td>string <text> [13 .. 30] characters
The unique identification (MPAN) of the import meter associated with this asset. Leave blank if asset still in development.</td></tr>
</table>

After sending this information, the FSP receives a response from the platform. If something is wrong the FSP receives an error code (400 invalid input). If the creation of the asset is successful the FSP receives a message which, besides including the same information provided by the FSP, also includes an ID assigned by Piclo Flex for the new asset. After creating assets, FSP are able to retrieve them, update them or find them by ID [180].

It is also possible to create planned assets using the APIs [180]. For that, the FSP must provide Piclo Flex the information specified in Table 5.12.

Table 5.12 – Create a new planned asset: request body schema [180]

Field	Description
provider (required)	string 7 characters ^[a-zA-Z0-9]{7}$ Your Flex Provider ID as provided by Piclo Flex.
reference (required)	string <text> [1 .. 36] characters ^[a-zA-Z0-9]{36}$ The reference you provide to uniquely identify the asset in the system.
name (required)	string <text> [1 .. 80] characters A human readable name used to identify the asset in the system.
capacity_type (required)	string Enum: "active_import_capacity" "active_export_capacity" "reactive_import_capacity" "reactive_export_capacity" The Planned Asset's capacity type.
capacity_value (required)	string^[0-9]{1,15}(\.[0-9]{1,20})?$ The capacity of the Planned Asset in MW or MVAr unit
competition_reference (required)	string <text> <= 40 characters ^[a-zA-Z0-9]{40}$ The System Operator defined unique identifier for a competition.
estimated_asset_count (required)	integer <= 5 characters [1 .. 10000] Estimated number of assets for this Planned Asset.
voltage_level (required)	string Enum: "0.24" "0.40" "6.60" "11.00" "22.00" "33.00" "66.00" "132.00" Voltage level at the point of connection to the network.
asset_type (required)	string Enum: "battery" "fuel_cells" "liquid_air" "compressed_air" "pumped_hydro" "vehicle_to_grid" "energy_efficiency" "vehicle_charging" "residential" "commercial" "industrial" "interconnector" "nuclear" "gas_carbon_capture_and_storage_ccs" "biomass" "biomass_chp" "hydro" "tidal" "wave" "offshore_wind" "onshore_wind" "advanced_conversion_technology_act" "advanced_conversion_technology_act_chp" "anaerobic_digestion" "anaerobic_digestion_chp" "biogas_chp" "biofuel" "geothermal_chp" "landfill_gas" "sewage" "sewage_chp" "solar_pv" "waste" "waste_chp" "combined_cycle_gas_turbine_ccgt" "gas_chp" "gas_reciprocating_engines" "open_cycle_gas_turbine_ocgt" "coal_chp" "diesel_reciprocating_engines" "fuel_oil" "coal" "gas" "diesel" "gas_oil" Describes the specific technology type of the flex asset.
maximum_response_time	string or null^([1-9])?([0-1][0-9]|2[0-3]):[0-5][0-9]:[0-5][0-9]$ The maximum time required for the Planned Asset to respond to a utilisation message. If over 24 hours, prepend the duration with the number of days. Format: DD HH:mm:ss
maximum_runtime	string or null^([1-9])?([0-1][0-9]|2[0-3]):[0-5][0-9]:[0-5][0-9]$ Maximum length of time that any of the planned DERs can sustain flexibility capacity. If over 24 hours, prepend the duration with the number of days. Format: DD HH:mm:ss
minimum_runtime	string or null^([1-9])?([0-1][0-9]|2[0-3]):[0-5][0-9]:[0-5][0-9]$ Minimum length of time that any of the planned DERs can sustain flexibility capacity. If over 24 hours, prepend the duration with the number of days. Format: DD HH:mm:ss
maximum_recovery_time	string or null^([1-9])?([0-1][0-9]|2[0-3]):[0-5][0-9]:[0-5][0-9]$

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	The maximum time required by any of the DERs to recover from one instruction until the next instruction can be actioned (assuming full utilisation). If over 24 hours, prepend the duration with the number of days. Format: DD HH:mm:ss
operator_name (required)	string <= 80 characters Enum: "Electricity North West" "NIE Networks" "Scottish and Southern Electricity Networks" "SP Energy Networks" "UK Power Networks" "Western Power Distribution" Name of the System Operator for whom the Competition belongs.

Once all the qualification procedures described before are completed and the assets are created, the FSPs can place bids using the APIs. This enables FSPs to handle bid submission and to create a ballot to bid into the competitions it is qualified for. A ballot is a representation of a group of bids that an FSP submitted for a given competition. All bids should be submitted together for a competition, covering all service windows this FSPs wishes to bid into. If the FSP wants to re-submit a bid for a specific service window, it needs to include all the other bids for that competition in the request as well, and only the last submitted ballot will be considered [180].

Bedsides, all rates corresponding to the service window's parent competition type must be supplied. For instance, for a service window which belongs to an "Availability and Utilisation" competition, both an availability and utilisation rate must be supplied, while a service fee rate shall not be indicated [180].

When submitting a ballot for a competition, if no assets are explicitly specified, all the FSP's assets (including planned assets) that qualify for the specified competition are included in the service window bids. Otherwise, the FSP can opt to specify precisely which assets to submit in a ballot. Assets are associated at the ballot level, that is, this set of assets are for all bids in the ballot [180].

If a competition already has a ballot submitted against it with a different set of assets, submitting a ballot will not be allowed. I this case, if the FSP wishes to re-submit a ballot, it must use the same set of assets stated in the previous ballot. At last, by submitting a ballot, the FSP agrees to adhere to the DSO rules for this competition [180]. To create a ballot using the API the FSP must provide Piclo Flex the information specified in Table 5.13.

Table 5.13 – Create a ballot: request body schema [180]

Field	Description
competitionId (required)	string <text> ^[a-zA-Z0-9]{7,12}$ Internally-generated unique identifier for the Competition to bid into.
bids (required)	string <text> [1 .. 36] characters ^[a-zA-Z0-9]{36}$ The reference you provide to uniquely identify the asset in the system.
• **service_window_id** (required)	string <text> ^[a-zA-Z0-9]{7,12}$ The service window that this Bid is for
• **capacity** (required)	string <decimal (5 d.p.)> ^[0-9]{1,9}(\.[0-9]{1,5})?$ Offered Capacity in MW/MVar. This should be equal to or less than the required need of the service window.
• **max_runtime** (required)	string <duration> ^(?:[0-9]{1,8}?T)?([01]?[0-9]|2[0-3]):[0-5][0-9]:[0-5][0-9]$

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	Maximum length of time that you can make the Bid capacity available for. Format: DDTHH:mm:ss
• **rates** (required)	Array of objects (OfferPost) non-empty [items] Offered Rate for this Bid.
○ **type** (required)	string Enum: "utilisation" "availability" "service_fee" The type of service for which the Rate is being offered. Supply values for corresponding Competition type only - for example, supply utilisation only for Utilisation Competition type.
○ **value** (required)	string <currency - decimal (2 d.p.)> ^[0-9]{1,8}?[.][0-9]{0,2}$ Value of the Rate Offer in (£/MW/h) for the corresponding competition type service windows.
assets	object (FPBallotAssetsPost) Optionally specify which Assets you wish to bid with. If none are passed, all qualified Assets for this Competition will be used in this Ballot.
• **flex**	Array of strings <text> non-empty Your Flex Assets associated with this Ballot.
• **planned**	Array of strings <text> non-empty Your Planned Assets associated with this Ballot.

Figure 5.12 is a sequence diagram which intends to show the interaction between FSPs and the platform and between the platform and DSOs using the API. Still, it should be noted that not all the APIs available might be presented in this diagram, since some are still undergoing development. Hence, the author refer the readers to [180] in order to obtain a more comprehensive description of the API and to check potential updates and added functionalities.

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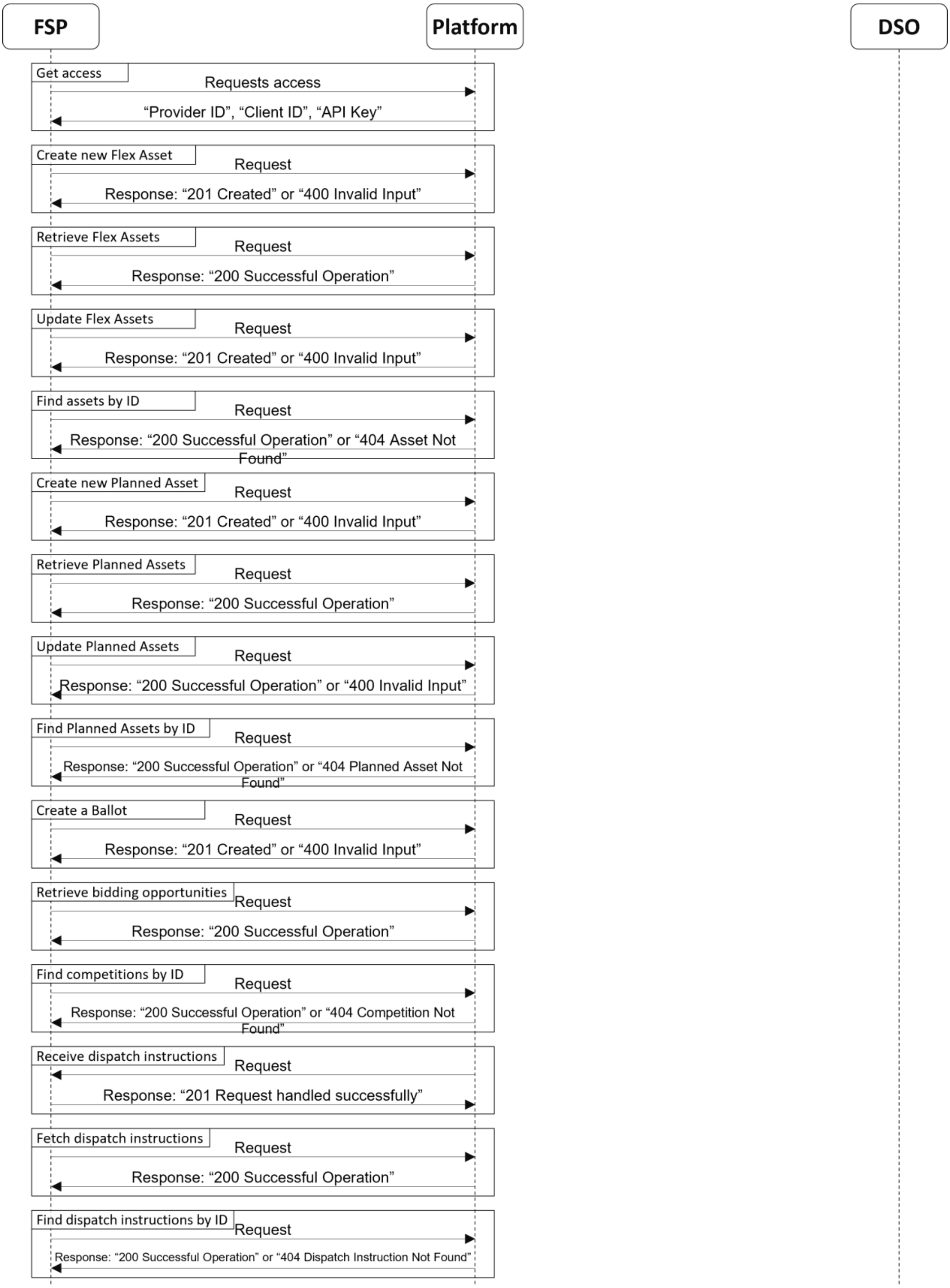
FSP
Platform
DSO
Get access
Requests access
"Provider ID", "Client ID", "API Key"
Create new Flex Asset
Request
Response: "201 Created" or "400 Invalid Input"
Retrieve Flex Assets
Request
Response: "200 Successful Operation"
Update Flex Assets
Request
Response: "201 Created" or "400 Invalid Input"
Find assets by ID
Request
Response: "200 Successful Operation" or "404 Asset Not Found"
Create new Planned Asset
Request
Response: "201 Created" or "400 Invalid Input"
Retrieve Planned Assets
Request
Response: "200 Successful Operation"
Update Planned Assets
Request
Response: "200 Successful Operation" or "400 Invalid Input"
Find Planned Assets by ID
Request
Response: "200 Successful Operation" or "404 Planned Asset Not Found"
Create a Ballot
Request
Response: "201 Created" or "400 Invalid Input"
Retrieve bidding opportunities
Request
Response: "200 Successful Operation"
Find competitions by ID
Request
Response: "200 Successful Operation" or "404 Competition Not Found"
Receive dispatch instructions
Request
Response: "201 Request handled successfully"
Fetch dispatch instructions
Request
Response: "200 Successful Operation"
Find dispatch instructions by ID
Request
Response: "200 Successful Operation" or "404 Dispatch Instruction Not Found"

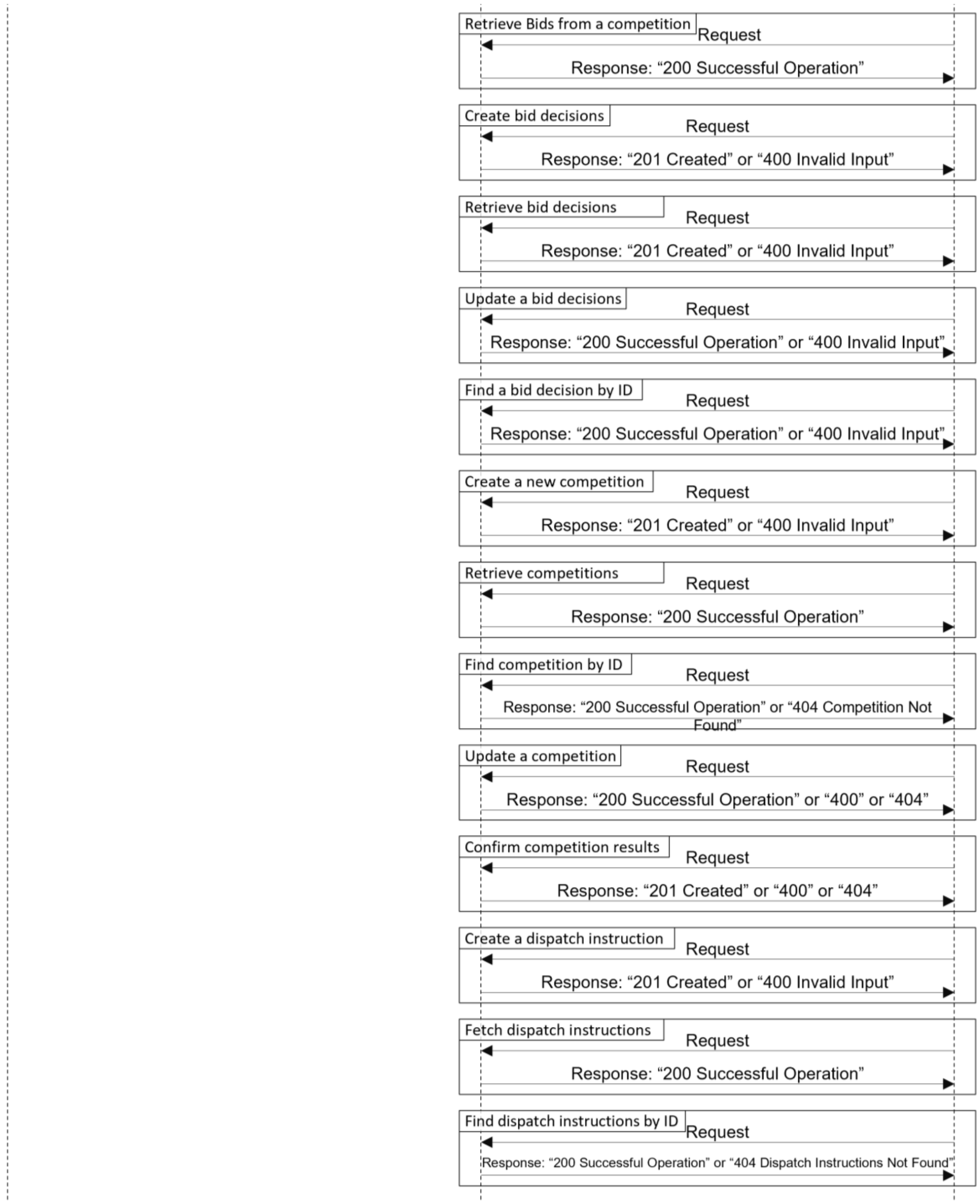

Figure 5.12 - Piclo Flex sequence diagram (based on [180])

5.1.4. Flexible Power

Flexible Power emerges from a joint initiative between several British DSOs. Its objective is to offer a single point of information concerning flexibility needs, allowing FSPs to view flexibility locations, requirement data and procurement notices issued by DSOs [181]. The developers of Flexible Power created an end to end process to deal with the procurement and operation of flexibility [182], as seen in Figure 5.13.

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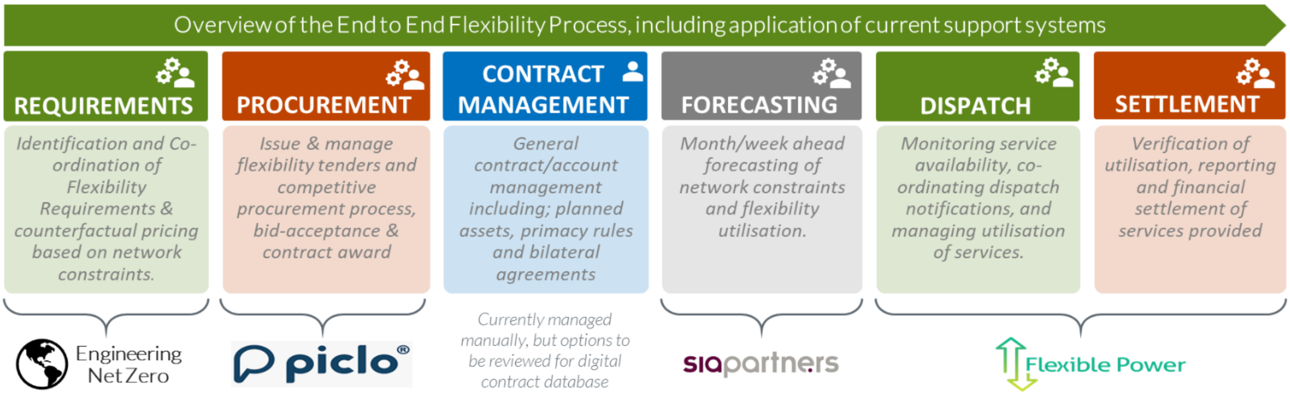

Figure 5.13 – Overview of the implemented end to end flexibility process [182]

The grid flexibility requirements are set using a modelling tool which takes inputs such as historical load, load growth, number of new EV connecting to the grid, etc [183]. These requirements are sent to the DSO, who use the Piclo Flex platform to procure flexibility (as already described in subsection 5.1.3) [184]. After the procurement process is over, contracts are issued, with their management still being done manually and outside the platform. Then, monthly forecasts of the likelihood of utilisation of the contracted assets are issued. This helps FSPs to understand how often the DSOs will use their assets in the upcoming months. Finally, dispatch and settlement are completed through the Flexible Power platform. This includes issuing start and stop signals, verifying flexibility provision, generating performance and financial reports and sending invoices [183]. The usage of Piclo Flex platform follows the methodology previously described in subsection 5.1.3 [184]. First, the DSOs require FSPs to answer a set of specific questions, related to, for instance, their financial position. Next, each FSP is also asked to characterize its flexible assets so that the DSOs can assess if they are suitable to satisfy the service requirements [185]. Having this information, the DSOs evaluate the technical and locational details to confirm suitability for the individual zones and, if approved, qualified assets can be used to submit bids [184]. All FSPs who meet the requirement criteria are invited to bid and, following the assessment of their bids, contracts are granted to successful FSPs [184].

To decide on whether to procure flexibility or not, the DSOs evaluate investment solutions by means of a comparative assessment approach. This means that they determine the value of flexibility (i.e., the amount of money they would spend on flexibility services) based on a like-for-like comparison with a counterfactual solution, such as a grid reinforcement, in the same scenario, considering both its cost and value [184]. As a result, it is possible to, for instance, get an equitable comparison between a 45 year reinforcement scheme and a 3 year flexibility contract [184]. The procedure used is similar to the one described in Piclo Flex, being based on the same ENA ONP CEM methodology and tool, which is described in [186] and available in [187].

Once DSOs receive bids, these are assessed to confirm that they could technically help in managing the identified constraints. The risks associated with using flexibility are evaluated and, if responses are greater than the requested capacity DSOs consider the most cost-efficient mix of tender responses. For each bid that is submitted, DSOs assess [184]:

- The overall value of the service offered against the annual ceiling cost (budget).
- The technical parameters.
- Competing bids.

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The bid assessment criteria of SPEN is detailed in [188], where it is stated how different solutions are assessed to identify the most suitable and least costly option. If flexibility is deemed as a technically viable solution, the value of such service will depend on the cost of the alternative solution [188].

This bid assessment criteria follows the steps described next. First, an annual ceiling cost (budget) is calculated for each constraint management zone. This value is based on the cost of alternative solutions. Next, it is analysed to what degree each bid meets the necessary requirements, such as capacity, service window, run time. At last, and after the above tests are applied, bids will be ordered by price offered, with the lower prices being selected first. DSOs might accept a higher bid from a FSP that is able to meet all requirements, compared to a lower bid where only some requirements are met [188].

The dispatch methodology follows the steps provided next [184]:

- Operability: first, the FSPs which can best meet the requirements are identified.
- Reliability: reliable FSPs are prioritized over those who failed to meet scheduled requirements in the past, but new FSPs are not ignored in favour of more experienced FSP, so that they all get an opportunity to develop a reliability score.
- Price: usually, DSOs procure the most cost-effective flexibility services. After operability and reliability are assessed, cheaper services are given priority, and when multiple FSPs offer the same price, it is guaranteed a fair level approach.

Since Flexible Power uses Piclo Flex to procure flexibility, it accepts the same 4 products: sustain, secure, dynamic and restore [189].

In the sustain product the dispatch schedule is agreed with the FSPs long before the service being needed. Consequently, this service does not have to be made available within a service window and wait for a dispatch instruction from the platform. A utilisation fee is paid for the entire scheduled dispatch delivered. For the secure service both an arming fee and a utilisation fee are paid. The first is paid for the window confirmed in advance as being the time services are expected to be required, while the second is paid for the service scheduled ahead of time or dispatched in real-time following an instruction. Meanwhile, in the dynamic service both an availability and a utilisation fee are paid. The first is paid for the availability accepted a week ahead and the second is paid for the duration of a utilisation event following a dispatch instruction. In this case the availability fee is low because the time of a fault is unknown and therefore the service window needs to cover all risk hours. The utilisation Fee is expected to be higher than that paid for sustain and secure services due to the chances of dispatch being smaller. At last, in the restore service only a utilisation fee is paid. The probability of dispatch is low and depends on the grid experiencing or being at risk of a loss of supply during the contracted service window. Since no availability fee is given the Utilisation Fee is expected to be high [189]. A summary of these 4 products is given in Table 5.14.

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Table 5.14 - Services provided by SPEN on the Flexible Power platform

	Sustain	Secure	Dynamic	Restore
Purpose	• Manage grid peak load and preventively reduce it [190]	• Manage grid peak load and preventively reduce it [190]	• Support the grid in the case of faults [190]	• Help with restoration after uncommon faults [190]
Use Case	• Scheduled [190]	• Pre-fault [190]	• Post-fault [190]	• Post-fault power grid restoration [190]
Utilisation fee (£/MWh)	• Yes [189]	• Yes [189]	• Yes [189]	• Yes [189]
Arming fee (£/MW/h)	• No [189]	• Yes [189]	• No [189]	• No [189]
Availability fee (£/MW/h)	• No [189]	• No [189]	• Yes [189]	• No [189]
Availability declarations	• Week-ahead [190]	• Week-ahead [190]	• Week-ahead [190]	• Week-ahead [190]
Availability acceptance	• Week-ahead [190]	• Week-ahead [190]	• Week-ahead [190]	• Week-ahead [190]
Dispatch Notice	• Fixed within contract and notice sent 15 min ahead of requirements [190]	• Fixed week-ahead on acceptance of availability and notice sent 15 min ahead of requirements [190]	• Sent 15 min ahead of requirements [190]	• Sent 15 min ahead of requirements [190]

Fees are paid depending on delivery of the contracted services and all dispatch events are validated using metering data. If contracted services are not provided, in part or in full, an adjustment may apply to these fees, as described in [191]. This situation is exemplified in Figure 5.14, where it is shown, for the dynamic service, how the percentage of the utilisation fee varies with the percentage of flexibility delivered.

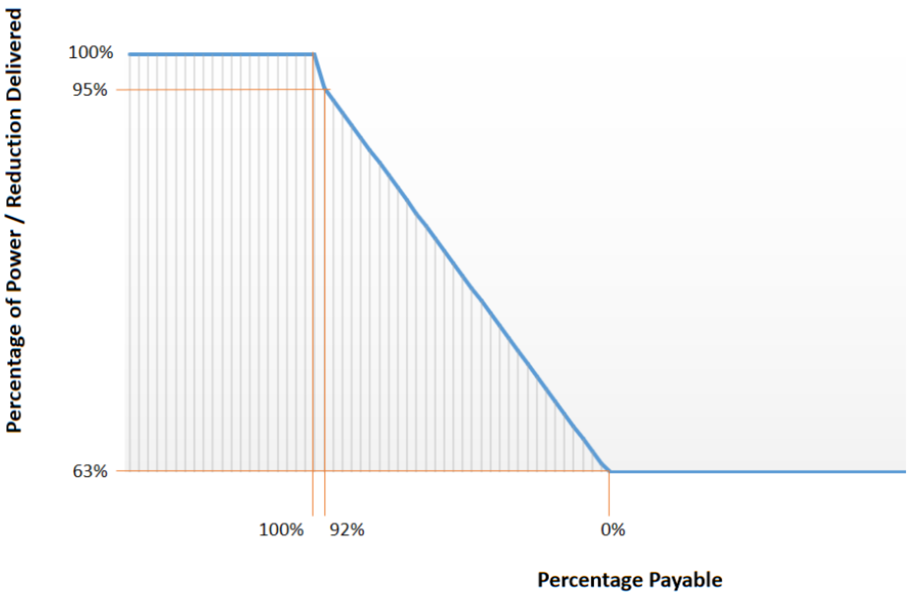

Figure 5.14 – % of utilisation fee received depending on % of flexibility provided [192]

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In order to receive requests from Flexible Power to turn their assets on or off, it is required to establish communication using APIs [193], which can also be used to send meter readings [194]. After dispatch and flexibility delivery, FSPs are invoiced an earning statement [195].

The main characteristics of the Flexible Power platform are summarized in Table 5.15.

Table 5.15 - Main characteristics of the Flexible Power platform

Characteristics	Summary
Platform type	• Flexibility Market Platform [181]
Location	• UK [181]
Market structure	• One-sided market (single buyer)
Trading type	• Auction based (like Piclo Flex)
Price computation	• Pay-as-bid (like Piclo Flex)
Market type	• Energy and capacity (like Piclo Flex)
Buyer	• DSOs [181]
Sellers	• “Anyone” connected to the grid [182]
Products/Services	• Pre-fault: ○ Sustain: pre-fault (intact system), scheduled support [183], [184] ○ Secure: pre-fault (intact system), dispatched support [183], [184] • Post fault: ○ Dynamic: post-fault system support [183], [184] ○ Restore: post-fault restoration [183], [184]
Resources/Assets	• Demand Side Response [184] • Batteries [184] • Electric Vehicles [184] • CHP [184]
Pre-qualification	• Yes, divided in two parts (providers pre-qualification and assets pre-qualification) [184], [185]
Aggregation	• Aggregation is allowed [194]
Bidding period	• Over a period of approximately 12 months [196] • Contract duration up to 4 years [196]
Negotiation & Market Operation	• Within Flexible Power platform [183] • After receiving bids, the FSPs which best meet the requirements are identified [184] • Reliable FSPs are prioritized those who failed to meet scheduled requirements in the past [184] • After assessing operability and reliability, cheaper services prioritized [184]
Activation & Settlement	• Within platform: Flexible Power automatically schedules a dispatch signal [183] • Performance and financial reports are generated (14 days to verify accuracy) [183] • Invoices generation[183]
Proof of delivery	• Baseline is based on historical data [197], [198] • 1 minute resolution or half-hour resolution [199]
Remuneration	• Utilisation fee (£/MWh) [189] • Arming fee (£/MW/h) [189] • Availability fee (£/MW/h) [189] (depends on the product)
TSO-DSO coordination	• No information regarding TSO-DSO coordination

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Integration with other markets or platforms	• Flexible Power makes use of the Piclo Flex platform for flexibility procurement[183] • Runs separately from other electricity markets

5.1.5. Enedis platform

Enedis, a French DSO responsible for supplying 95% of the country's territory [200], created a platform to assist them in the acquisition of flexibility through market-based procurement processes [201]. The goal is to facilitate the connection of Consumers, promote the integration of RES into the grid and optimise planning and operation on the distribution network [201].

The Enedis Request For Information (RFI) platform, as it is called, has multiple objectives, such as [202]:

- Inform the DSO about the available flexibly and the existing services through the registration of FSPs on a single site.
- Give FSPs a preview of the areas of interest for the DSO.
- Develop the local knowledge on flexibility: promote flexibility to opportunities areas Consumers and local communities.

The first flexibility tender was launched in 2020 [200]. The end-to-end flexibility procurement process is divided in 6 steps, as seen in Figure 5.15.

Figure 5.15 - Overview of the end-to-end flexibility process used by Enedis [200]

After identifying flexibility needs [200], Enedis publishes them in their platform, thus creating a potential market call [203]. The platform has a dashboard where it presents a map with the potential, ongoing and ended tenders/market calls, as in Figure 5.16. This allows FSPs to verify their eligibility by checking if their connection points are within the listed sites of a potential market [204].

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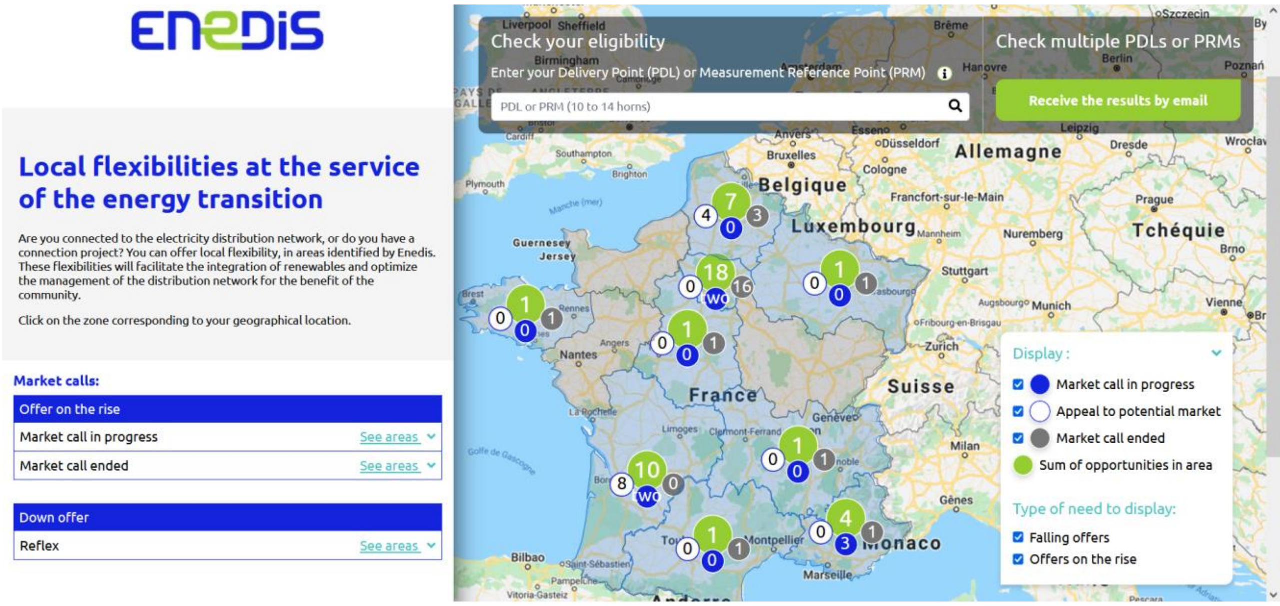

Figure 5.16 – Potential, available and ended market calls (05/06/2023) [203]

In case there is an adequate number of interested FSPs, Enedis opens a flexibility tender [204]. Here, products do not follow a standardized definition (like in Piclo Flex and Flexible Power). Instead, several uses are described [200]:

- Smart Connection Offers (SCO) to connect Consumers and Producers to the MV grid faster and at lower cost
- Promoting the development of RES by optimising grid planning under the Regional Renewable Energies Connection Master Plans (S3REnR)
- Flexibility to defer investments
- Flexibility to enhance work planning
- Flexibility as an alternative to power resupply resources before or following an incident

Their main characteristics and contractual principles and summarized in Table 5.16.

Table 5.16 - Uses cases summary [200]

	Smart Connection Offers	Optimisation of investments	Defer investments	Enhance work planning	Incident management
Flexibility value	Connection cost and reduction of the delay for the consumer	Maximum value for society of 250M€ by 2035 (alternative to investments)	Maximum value for society from 0 to 24k€/MW/year (Investment postponement)	Maximum value for society from 0 to 20k€/MWh (must be compared with the alternative usual solutions, such as generators)	
Importance of the location	Important for all use cases				
Sources of flexibility	MV sites to be connected	Producers, storage, electric vehicles, demand response, with active or reactive power for voltage congestions			

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Duration of activation and occurrence	Depends on the case	0.06% of limitations	Between 0 and a few hours per year, depending on the case	During the work	A few hours per year (low occurrences
Contractual principles	Bilateral contract	Competitive process according to the defined call for flexibility process and in compliance with the existing rules enforced			
Remuneration principles	Remuneration included in the connection offer	Contract with guaranteed availability Minimum size of the offer: 500 kVA (obligation of result) Guaranteed availability, remunerated with a fixed part, with associated penalties			Framework contracts without guaranteed availability: variable part depending on activation

For each flexibility tender, Enedis defines the following parameters [205]:

- Eligibility zone
- Capacity per predefined period
- Full activation time
- Activation duration
- Neutralisation duration between activation (in hours)
- Maximum injection ramp
- Notification period

Generally, these flexibility products have an availability/capacity (€/kw) and a utilization/activation component (€/kWh) [205]. They can be acquired using 1 of 2 market types to acquire these products: with capacity reservation and without capacity reservation [206]. Thus, availability/capacity fees and/or utilization/activation fees are considered [204]. Regarding timespans, long-term tenders are organised. The procurement periods can vary from 5 to 44 months ahead of flexibility delivery. Procurement is done for an entire year and, as already seen, flexibility is required for predefined periods of the year [205]. So far, tenders have been issued in 2020, 2021, 2022, 2023 and 2024.

When using the RFI platform, after the FSP selects a region, the map zooms in and all the market calls within that region are presented, as in Figure 5.17. By selecting one of the ongoing tenders, the FSP is shown its details, including start and end dates (e.g., November 1st and December 31th), type of contract (e.g., no capacity reserve), type of remuneration, products expected by Enedis in power and duration (e.g., 1MW for 30 minutes) and the activation periods (e.g., time period between 10:00h and 13:00h, from January to March and from November to December), as depicted in the example in Figure 5.18.

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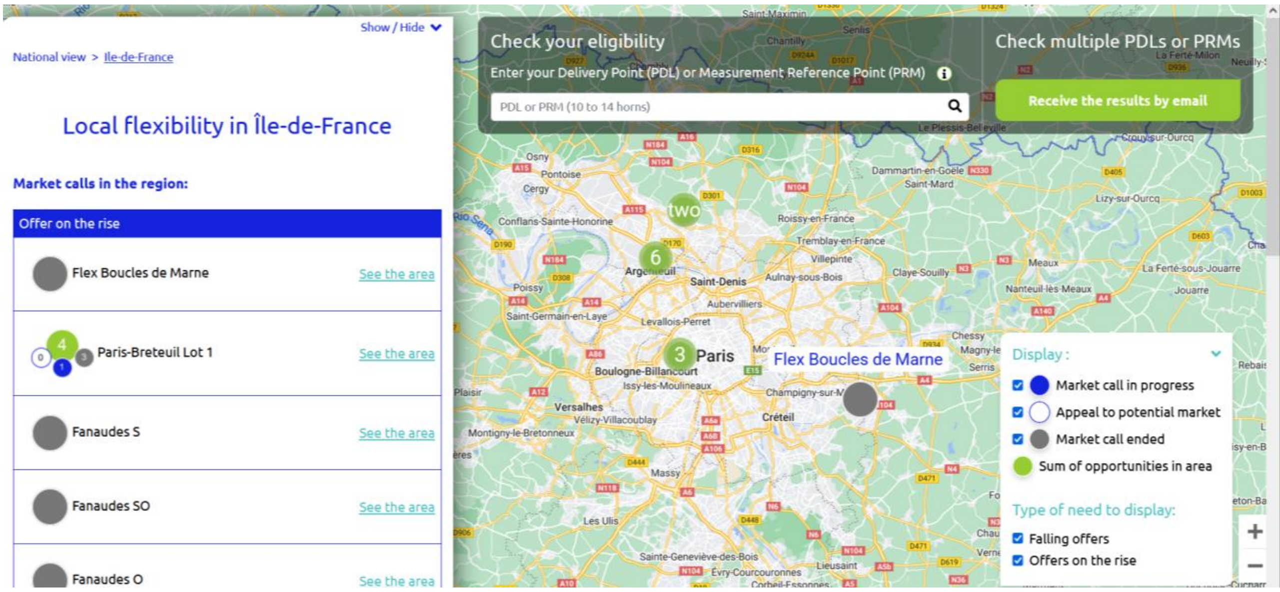

Figure 5.17 - Available market calls (Île-de-France, 05/06/2023) [203]

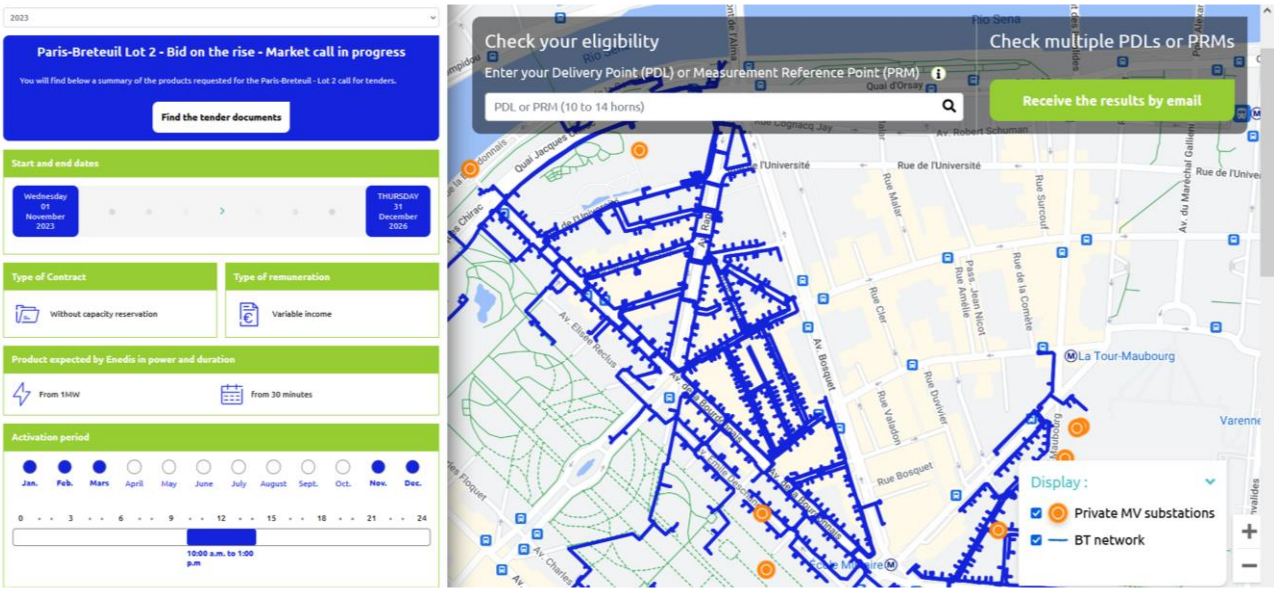

Figure 5.18 – Example of an available market call (Île-de-France, 05/06/2023) [203]

Besides providing a map and details on flexibility opportunities, Enedis' platform has other functionalities [202], for instance:

- "Check your eligibility" – a module for market players to test their eligibility based on their metering point ID. Results are immediate.
- "State your interest on a local flexibility opportunity zone" – any party can describe any potential offer, which can be of interest for the DSO in case of competitive tendering, based on its characteristics (full activation time, capacity, duration, etc).
- "Aggregation checkbox" – a checkbox, available in the formulary, which grants Enedis permission to forward the Consumer's contact details and technical data to Aggregators.

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Once the bidding period is over, Enedis proceeds to bid selection. Here criteria can depend on economic and/or technical characteristics of the offers. For energy products, bid evaluation is only base based on prices, but for availability products, their evaluation depends on the purpose of the flexibility service. Usually, when the service is the alleviation of congestions, the evaluation is solely based on price but, when voltage-related constraints limit the effectiveness of flexibility sources, sensitivity factors per flexibility asset connection point are employed in the selection of offers [205].

After bids are selected, contracts are signed between Enedis and the selected FSPs. Usually, these agreements have a length of 1, 2 or 3 years [207], [208]. During the contract duration, communication and flexibility activation tests might be carried out by Enedis [209].

Price caps are enforced in the selection of offers, but they are not published in advance. They are based on the difference between the effectiveness of flexibility (the reduction of lost loads, valued as Value Of Lost Load (VOLL)) and the effectiveness of traditional investment (the annualised cost of the best alternative network expansion plus its effectiveness on VOLL and losses). The employed pricing mechanism is pay-as-bid for both availability and activation [205].

So far, the activation of a flexibility service is accomplished via email or phone call to the FSP, but Enedis is working on implementing API activation. Typically, there is no pre-announcement for activation of a contract. If the flexibility product aims at reliability enhancement (e.g., for outage management), the notification period can even be as low as 0 minutes for delivery 30 minutes later. The measurement and settlement period are 30 minutes. A baseline is employed for the settlement. Different baseline methodologies are proposed by Enedis depending on the type of flexibility facility (demand response, production units or mixed) and their size. The FSP can set a different baseline method for each type of facility (demand response in its portfolio. If a facility is also providing services to the TSO, then the same baseline procedure must be used for both cases [205].

Remuneration is monthly for both availability and activation. Remuneration of availability is done after the activation period and subject to successful delivery. Reduced remuneration and/or penalties are applied when flexibility is partially delivered, resulting, in very extreme cases, in the FSPs paying the DSO. There is no compensation for over-delivery [205].

Regarding TSO/DSO coordination, according to the survey results Enedis and the TSO are not expecting operational security issues in the upstream network resulting from the activation of flexibility for the time being, owing to its relatively low volume in this early phase of development of local flexibility. As a result, for now, they do not anticipate noticeable system imbalances [205].

The main characteristics of the Enedis' platform are summarized in Table 5.17.

Table 5.17 - Main characteristics of the Enedis platform

Characteristics	Summary
Platform type	• Flexibility Market Platform [200]
Location	• France [200]
Market structure	• One-sided market [200]
Trading type	• Auction based [210]
Price computation	• Pay-as-bid (for both availability and activation components) [205]

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	• Price caps (propensity to pay) are imposed in the selection of offers, but they are not published beforehand.
Market type	• Energy and capacity [204]
Buyer	• DSO [200]
Sellers	• Consumers (aggregated) [204]
Products/Services	• Congestion management for DSO (short term) [156] • Support distribution grid planning (long term) [156] • Balancing for TSO (long term) [156]
Resources/Assets	• Power plants, demand response, EV, storage (hot water tanks, hydrogen) [200]
Pre-qualification	• FSPs can access their eligibility through the Enedis website [205] • To submit and offer, an FSP must provide a list of their portfolio's assets, where technical characteristics are screened out by Enedis [205] • If a portfolio includes non-eligible sites, Enedis either disqualifies the offer or asks for a resubmission [205] • Upon acceptance of an offer, two pre-qualification tests are undertaken: a test of communication between Enedis and the FSPs and a test of flexibility activation [205]
Aggregation	• Consumers participate in this platform through an Aggregator [200] • Minimum bid size considered is 500 kVA [200]
Bidding period	• Procurement is done for an entire future year and flexibility is required for certain predefined periods (e.g., for month 3 to month 6, every day between 18:00 and 21:00 and between 22:00 and 24:00) [205]
Negotiation & Market Operation	• For energy products, the assessment of offers is exclusively based on prices [205] • For availability products, the assessment of offers depends on the purpose of the flexibility service. o When the service is the alleviation of power congestions, the evaluation of offers is solely based on price. o Nonetheless, when voltage-related constraints limit the effectiveness of flexibility sources, sensitivity factors per flexibility asset connection point are employed in the selection of offers [205]
Activation & Settlement	• The activation of flexibility is done via email or phone call by the DSO to the FSPs [205] • Enedis is working on implementing API activation soon [205]
Proof of delivery	• Different baseline methodologies are proposed according to the type of asset [204]: o Recent observation: Used for generation sites, the baseline is defined as the average power produced during a certain time before activation (in this case the 10 minutes prior to it) [204] o k-nearest neighbours: Used for production and consumption sites, the baseline is calculated as the average profile over k days during which the profile is the closest to the day of activation [204] o Panel method: Used for consumption sites, this method sets the baseline by comparison to a reference panel of non-flexible consumers with similar characteristics to the ones offering flexibility [204]
Remuneration	• Reservation and activation payments [204]
TSO-DSO coordination	• TSO-DSO coordination model to share a flexibility pool (under demonstration) [210]
Integration with other markets or platforms	• Assets participating in other markets through a different legal representative cannot be declared by the FSPs under the penalty of being rejected [205]

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5.1.6. OMIE platform

The Iberian Electricity Market Operator (OMIE) is creating its own local flexibility market platform [211], which is based on the work done in the IREMEL [212] and DRES2Market [213] projects. At the time this document was written, this platform was still in the development phase, being used, for instance, in some demonstrators of the OneNet project [214]. Nevertheless, since this is not yet a commercial platform, i.e., deployed and used at a large-scale environment, the available information and documentation is rather limited, especially when compared to some of the previous digital platforms.

The OMIE digital platform is used by DSOs and FSPs, with OMIE acting as market operator for the local flexibility market. This local market trades multiple products in two main markets and four submarkets [215]:

- Long-term market, divided in:
    - Long-term active power availability submarket (LT-P-A): The DSO procures active power flexibility in terms of availability from FSPs connected to the distribution grid. The FSPs inside the procurement zone submit availability bids to the local auction marketplace [216].
    - Long-term active power availability and activation submarket (LT-P-A-E): Analogous to the LT-P-A submarket, but the bids submitted by the FSPs include both availability and activation offers. This submarket is meant for cases in which the need for flexibility can be forecasted long in advance. Therefore, the activation of the FSPs can be scheduled long in advance with high reliability [216].
- Short-term market, divided in:
    - Day-ahead availability-optional and activation submarket (ST-P-E): Represents a day-ahead local mechanism in which the DSO can procure active power flexibility from FSPs connected to the distribution grid. Active power is procured and remunerated. However, the submarket structure leaves open the possibility to also remunerate availability in some cases. The peculiarity of this submarket relies on the fact that it is composed of two different time procedures. If the market operator receives the request for flexibility before 2 p.m., the auction opens at 2 p.m. Else, the auction opens at the next hour. Although all the FSPs in the relevant procurement zone can take part, the participation of the FSPs that have been cleared in the LT-P-A is mandatory. These FSPs can bid a different amount and price in the short-term submarket. However, the ST-P-E auction is characterised by a reserve price established by DSOs (maximum price accepted by the algorithm in the auction process) that cannot be surpassed and is related to the long-term matching price [216].
    - Real-time activation submarket (RT-P-E): Represents a local mechanism that occurs on the same day of the delivery in which the DSO procures active power flexibility from FSPs connected to the distribution grid. In this market, active power activation is procured and remunerated. Participation in the RT-P-E submarket is open to all qualified FSPs, and there is no link with the long-term submarkets (LT-P-A and LT-P-A-E).

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An overview of these markets is given in Figure 5.19, along with some of the existing submarkets (day-ahead energy market, intraday energy market, common congestion management market, and balancing energy market) [215].

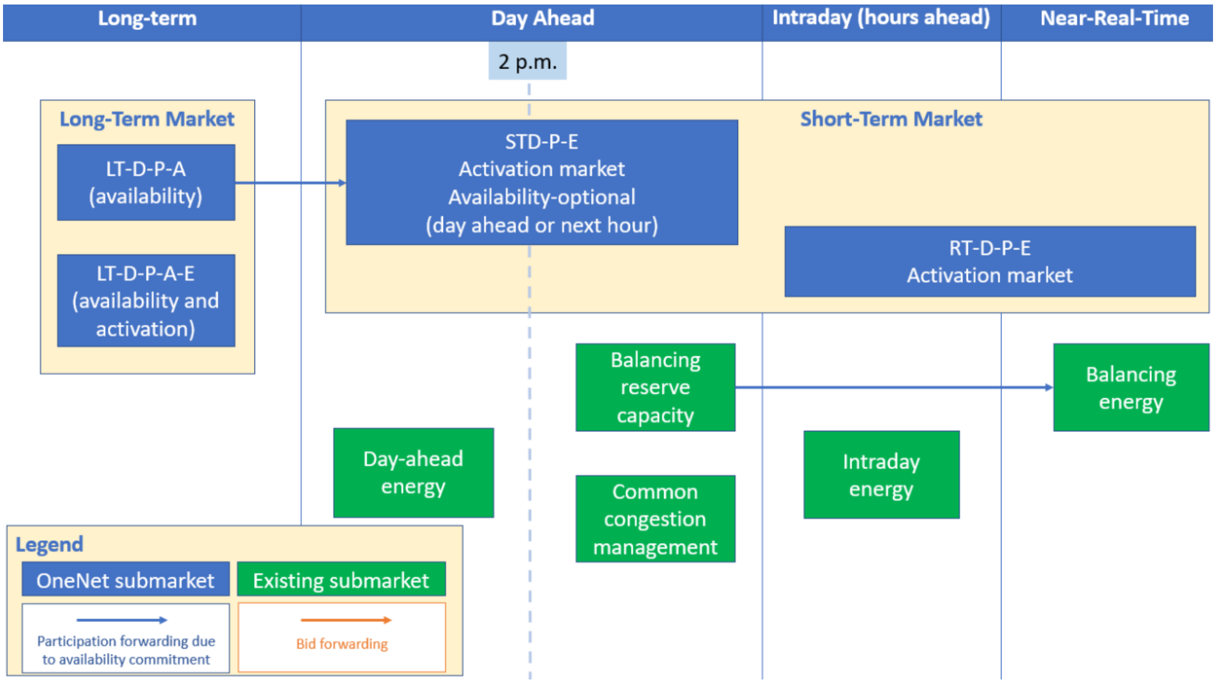

Figure 5.19 – Market architecture overview [215]

The new submarkets are decentralized, and event based, that is, if needed, the DSO asks OMIE to open a call in a specific grid area to procure flexibility. Depending on the considered submarket, it might procure active power availability, activation, or both [215].

In the case of the long-term availability product (LT-P-A), it is a local mechanism for DSOs to procures active power flexibility in terms of availability from FSPs connected to the distribution grid. The FSPs belonging to the procurement zone compete by submitting activation and availability bids to the local marketplace. In this case, the FSPs get the compromise to be available, but the activation is not granted. Meanwhile, in the case of the long-term agreed activation product (LT-P-A-E), in its market, both availability and activation terms are settled and not to be renegotiated anymore. This market is planned for buying flexibility in those cases in which the need for flexibility can be forecasted long in advance. Therefore, the activation of FSPs can be planned long in advance with a high reliability [215].

For both of these long-term submarkets, market sessions are requested by the DSO, who selects a zone, delivery period, flexibility being procured, among other parameters, necessary to create a market session [215], as shown in Figure 5.20.

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Figure 5.20 – Preliminary screen for the market session request [215]

Once a new market session starts, FSPs are informed, and the pre-qualification and qualification processes take place, as shown in Figure 5.21. After these processes are concluded, resources able to join the market session are notified and bidding takes place, followed by the market-clearing and the communication of results [215].

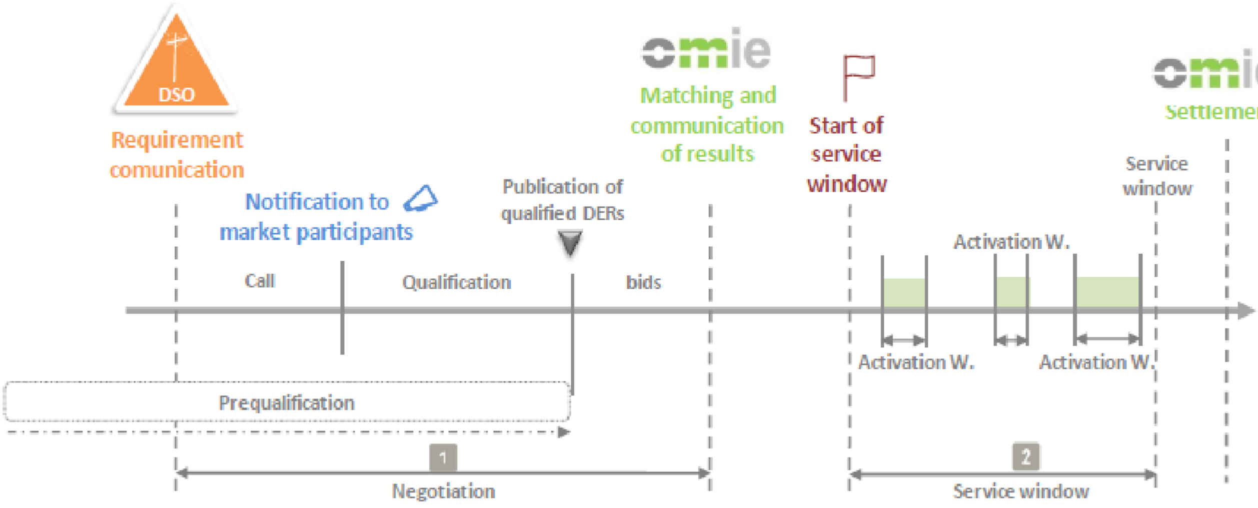

Figure 5.21 – Market session steps for long-term products [215]

In a Spanish demo where this framework was used, several phases were followed to ensure that flexibility product can be delivered when (and if) activation takes place. These are divided in pre-qualification and qualification, both market and technical. Pre-qualification takes place when an FSP requests to have resources pre-qualified and it is performed by both DSO and market operator. The DSO conducts a technical pre-qualification and the market operator a market pre-qualification. The qualification process takes place for a specific market session. Among the pre-qualified FSPs, DSO and market operator conduct a final check to verify that resources/FSPs can join a certain market session. It should be noted that pre-qualification can still happen and be concluded after a market session is requested by the DSO, but this overlap of processes is only possible in long-term markets because they are open for a long period [215].

The service window is defined as the period when the flexibility product is being delivered and it should not be confused with the activation window. The service window can include the time of the availability procured by the DSO from a certain FSP. Within a service window, activation might or might not happen [215].

Once the service window is over, the market operator proceeds with settlement. Based on metering data, the market operator compares the flexibility provided by the each FSP with the agreed baseline. In case of partial delivery by the FSP, the market operator applies a correction factor to the final payment [215].

Meanwhile, for short-term, the Short-Term P activation submarket (ST-P-E) correspond to a day-ahead local mechanism in which the DSO can procure active power flexibility from the FSPs connected to the distribution grid. Here, active power activation is procured and remunerated, and the possibility to also remunerate availability is left open. The uniqueness of this submarket is on the fact that it is composed of two different time procedures. If the market operator receives the request for flexibility before 2 p.m., the auction opens at 2 pm. Else, the auction opens at the subsequent hour. Even though all the FSPs in the relevant procurement area can participate in the associated auction, if there are FSPs that have been cleared in the Long-term active power availability submarket (LT-P-A), their participation is obligatory, but they might bid a different amount and price in the short-term submarket [215].

The Real-Time P activation submarket (RT-P-E) represents a local mechanism that occurs on the same day of the delivery in which the DSO procures active power flexibility. Participation in the RT-P-E submarket is open to all qualified FSPs and there is no connection with the two long-term submarkets [215].

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In the mentioned Spanish demo, only the long-term P availability submarket (LT-P-A) and short-term P activation submarket (ST-P-E) directly interact. This interaction is because the FSPs cleared in the long-term availability market are required to participate in the short-term market. In any case, the FSPs can submit new bids or change the activation bid [215].

From the proposed timeline, illustrated in Figure 5.22, it can be concluded that the market processes for short-term are very similar to the ones for long-term submarkets. The sessions are also called by the DSO in a similar way to the long-term markets, and FSPs/resources must be pre-qualified. One difference is that the pre-qualification for a possible participant must be concluded before the market session is requested by DSO due to the short-term nature of the process [215].

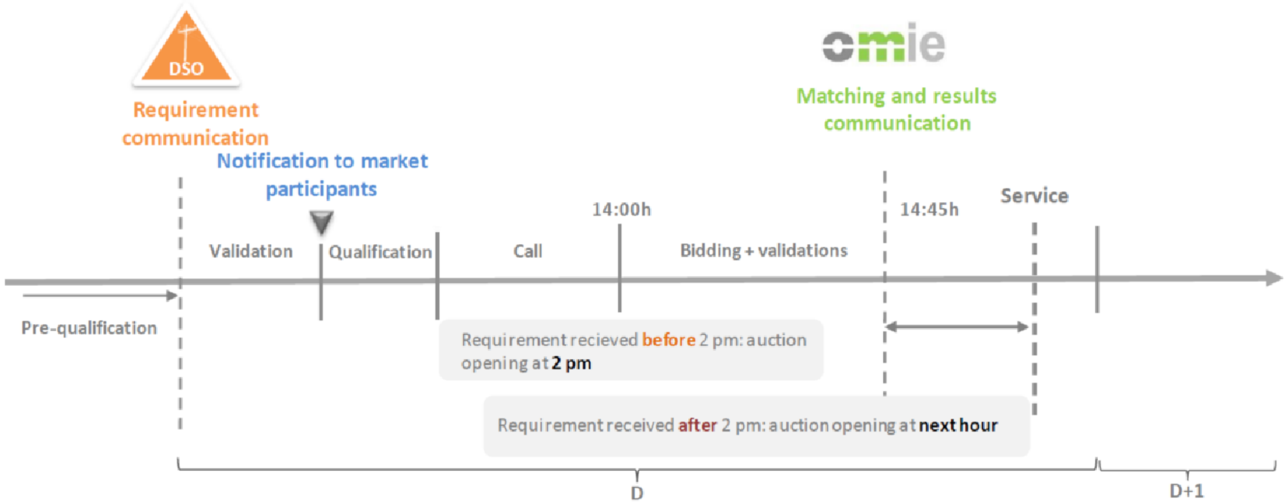

Figure 5.22 – Short-term submarket processes [215]

The main characteristics of the OMIE platform are summarized in Table 5.18.

Table 5.18 - Main characteristics of the OMIE platform

Characteristics	Summary
Platform type	• Flexibility Market Platform [215]
Location	• Spain [137] (possibly Portugal as well, since OMIE is common to the two countries)
Market structure	• Two-sided market [137]
Trading type	• Periodic closed gate auction [156]
Price computation	• Pay-as-clear [217]
Market type	• Energy (kWh) and power (kW) [215]
Buyer	• DSOs [215]
Sellers	• Aggregators, consumers, and generation asset owners [137]
Products/Services	• Congestion management for DSO (short term) [156], [217] • Support distribution grid planning (long term) [156], [217]
Resources/Assets	• DER connected to the distribution grid [215]
Pre-qualification	• Pre-qualification takes place when an FSP requests to have resources pre-qualified [215] • Performed by DSO and market operator [215] • Divided in market and technical pre-qualification and qualification [215]

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Aggregation	• DER can be aggregated [215]
Bidding period	• Long-term: lasts form 1 year to 1 week [215] • Short-term: hours [217]
Negotiation & Market Operation	• DSO requests OMIE to start tender [215] • DSO specifies needs [215] • Considers 4 submarkets [215]: ○ Long-term active power availability submarket ○ Long-term active power availability and activation submarket ○ Day-ahead availability-optional and activation submarket ○ Real-time activation submarket
Activation & Settlement	• DSOs monitor network conditions in real time and send activation signals to DERs [215] • Takes place close to real-time and in real-time [215]
Proof of delivery	• Baseline agreed between DSOs and FSPs [217] • In some demos, the agreed methodology consists of taking as a baseline the consumption/generation of the FSPs on the week prior to the delivery of each of the demo markets [215]
Remuneration	• Availability and activation payments [215]
TSO-DSO coordination	• TSO-DSO coordination is considered (but not yet described) [215]
Integration with other markets or platforms	• Exist in parallel with day-ahead energy market, intraday energy market, common congestion management market, and balancing energy market [215]

5.1.7. NODES platform

NODES is described as an independent marketplace where decentralised flexibility and energy can be traded [218]. It is in operation since 2018 and has been used across different countries, including Germany, Norway, Sweden, and the UK. Moreover, it is also involved in the EUniversal project, with pilots in Germany, Poland, and Portugal [141] The main goal of NODES is to increase the value of flexibility for FSPs and reduce costs for DSOs, while allowing flexibility not used locally by the DSOs to be sold to TSOs and/or BRPs to solve imbalance issues [219].

The structure of the NODES marketplace and the main roles involved is presented in Figure 5.23. A Consumer or a Prosumer can sign a flexibility contract with an independent Aggregator. These Aggregators, along with BRPs and microgrids, can sell flexibility in a centralised flexibility market which operates in parallel to the wholesale and reserve markets [219]. As it stands, NODES sells flexibility to DSOs, TSOs, and BRPs [141].

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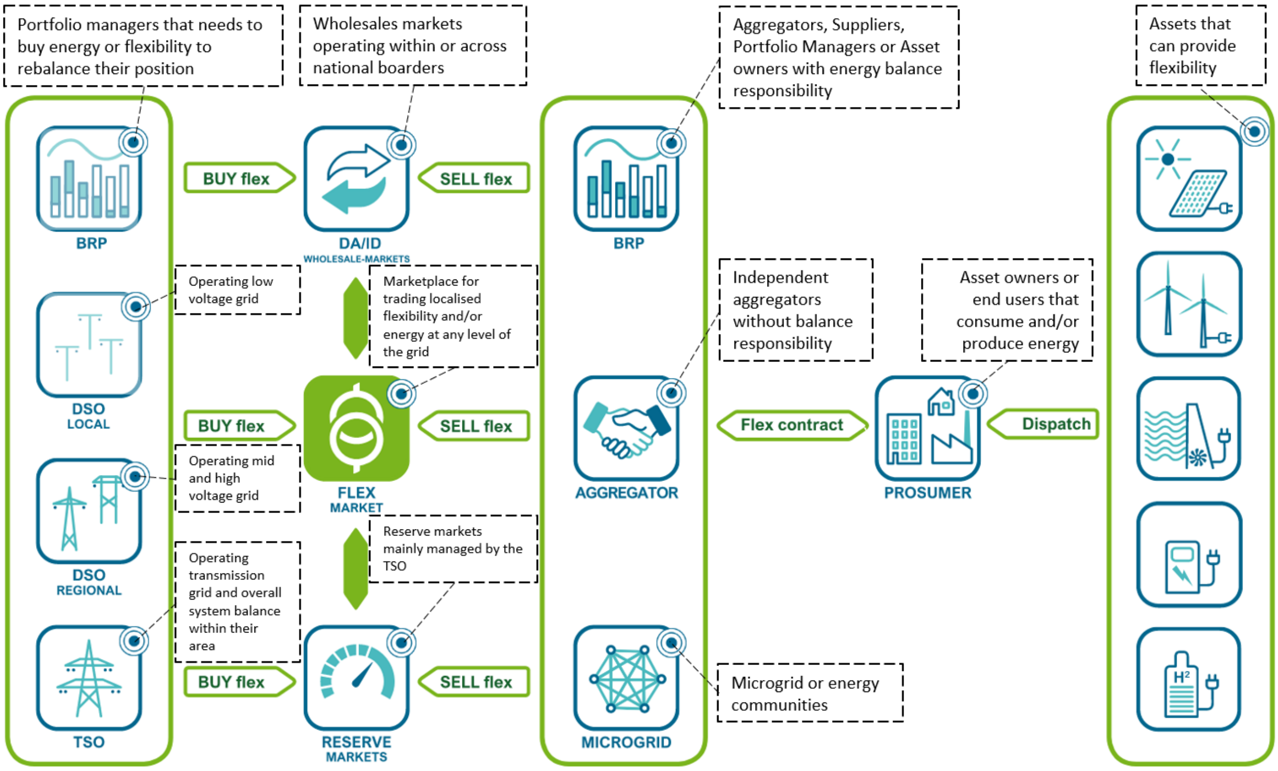

Figure 5.23 - NODES market design [220]

This marketplace offers long-term (LongFlex) and short-term flexibility (ShortFlex) [141].

In LongFlex a SO (a DSO or a TSO) makes availability payments to secure the access to flexibility over a certain period to ensure system security and stability [141]. According to the agreements, in a LongFlex contract between an FSP and a system operator, the FSP commits to always submit ShortFlex according to the contract details allowing the SOs to activate the reserved flexibility if needed. If the reserved flexibility is not activated by the SOs the offer in the ShortFlex market stays available, enabling other buyers to activate the available flexibility, therefore ensuring the most effective use for all market participants [221].

ShortFlex can be obtained to solve grid congestion [141]. FSPs can offer their assets where several technologies compete against each other on a level playing field and where flexibility can be purchased by the SOs to tackle immediate needs [221].

The NODES trading timeline, presented in Figure 5.24, includes an early period of trading of availability products. This first stage typically lasts from years ahead until opening of the day-ahead auction. Afterwards, in the intraday market, which in most European countries starts only after the day-ahead market is closed, BRPs can rebalance their portfolios continuously until gate closure. Meanwhile, the TSO has various products outside the current intraday market which it can use to manage congestions [219].

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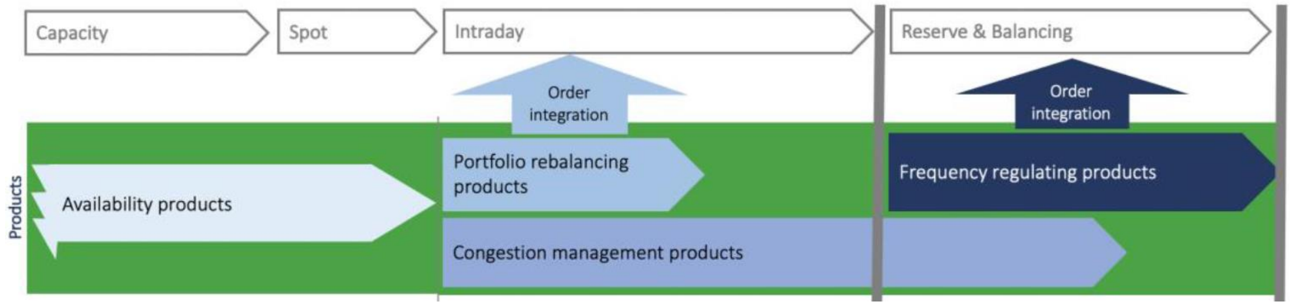

Figure 5.24 - NODES trading timeline [219]

According to [156] the interfaces between NODES and the existing markets are not yet available.

Regarding the functionalities of the digital platform, it hosts the registration and pre-qualification of assets [138]. For that, and after completing their registration on the NODES portal, FSPs must fill in a pre-qualification questionnaire required by NODES and the SO. Only pre-qualified FSPs will receive invitations to tender [222]. In some cases, physical testing of the assets is required prior to their approval. Regarding matching of offers/bids, this platform facilitates centralised matching without the direct involvement of the DSOs or TSOs, unlike other platform where those entities can filter and select offers themselves (such as Piclo Flex). Concerning price formation, NODES platform runs internal auctions through a continuously clearing market format. Dispatch instructions are given automatically by the platform operator, though this process is not comprehensibly described in the revised literature. At last, validation and settlement are based on metering data collected on a minute-by-minute basis. After validating delivery, penalties are imposed when discrepancies in the offered and actually delivered flexibility are identified [138].

Those penalties, which are fully described in [223], impact the sum received by the FSPs in the following manner. The sum to be received by a FSP is [223]:

- Sum to receive = traded quantity × price × payment percentage.

The term payment percentage is a factor which varies from 0 to 100% and is related to the delivery percentage in the following manner and as depicted in Figure 5.25 [223]:

- A delivery percentage between 82% and 100% is remunerated with 100% payment.
- For each delivery percentage below 82% the payment percentage is decreased by 2%.
- Delivery above 100% is remunerated at 100% payment.

There is no other punishment for partial or non-delivery except the reduction in payment percentage [223].

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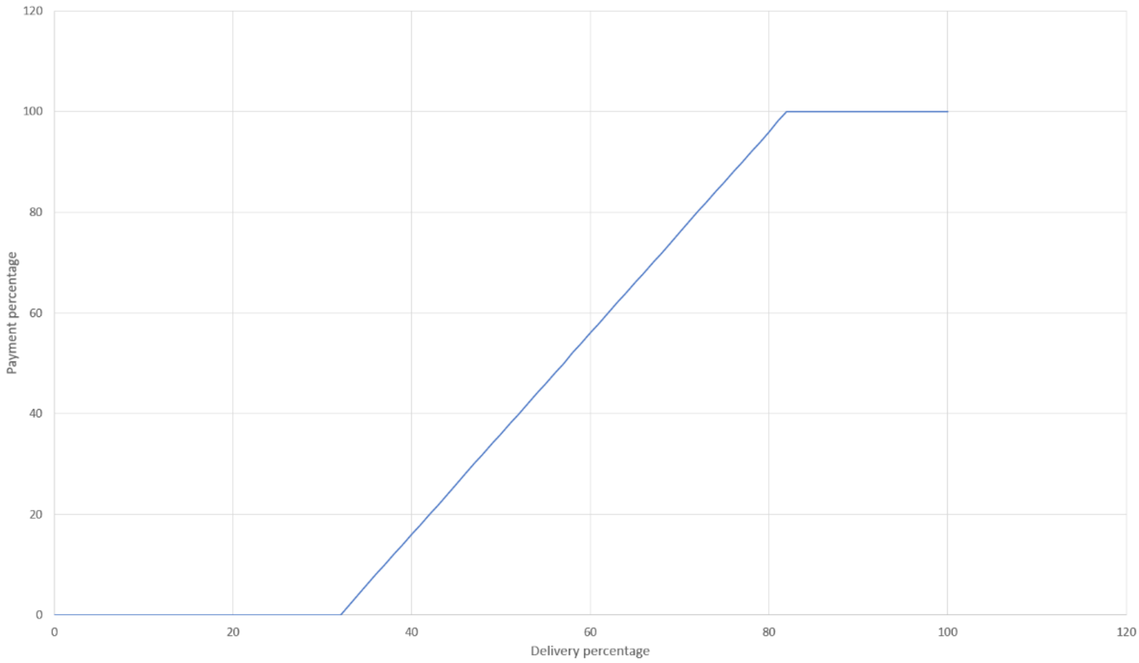

Figure 5.25 - Payment percentage and corresponding delivery percentage [223]

Regarding the advantages provides by this platform, Figure 5.26 illustrates that the existing intraday, day-ahead, and balancing markets are not geographically granular enough for the DSO to tackle local congestions and other grid issues. In NODES, all flexibility assets are tagged with their location (using meter-ID and GPS coordinates or postal code), meaning that all the flexibility within a certain grid location can be aggregated into one or more offers in the NODES platform. SOs are free to decide how granular they want the offers, that is, how large those grid locations should be. Afterwards flexibility buyers define their willingness to pay for activation of flexibility at a particular grid location and give this information to NODES via an API. Flexibility is made available by the FSPs, and these offers are feed into NODES via another API. For the activation of flexibility, the FSPs will need to have a BM with the asset owners in place and technology that makes it possible to control those assets. For most of the time, flexibility is not needed locally at its grid location, or it is needed only a few hours a year. Nevertheless, flexibility within a certain location can still be valuable for the rest of the system, either for balancing purposes for the TSO or in the intraday market for the BRP, because NODES has an interface that makes flexibility available for these markets [219].

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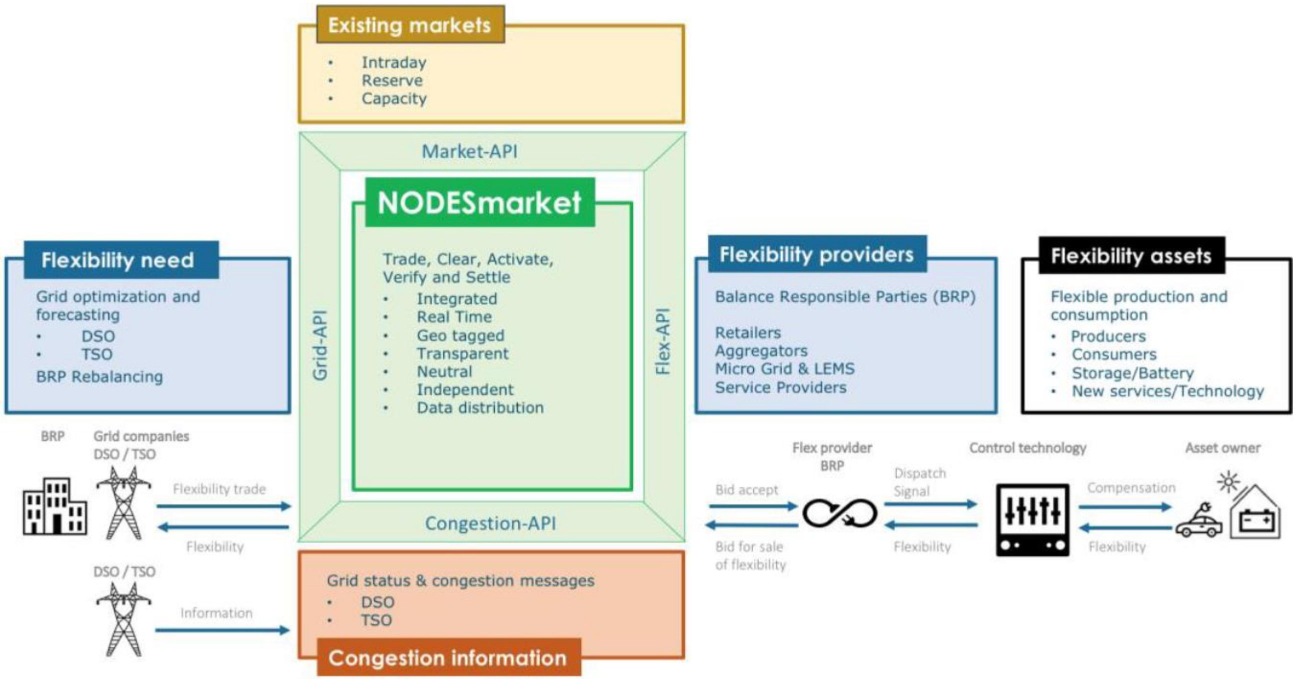

Figure 5.26 - NODES marketplace model [219]

The main characteristics of the NODES platform are summarized in Table 5.19.

Table 5.19 - Main characteristics of the NODES platform

Characteristics	Summary
Platform type	• Flexibility Market Platform [137]
Location	• UK, Norway, Sweden [138], Germany, Poland, and Portugal [221]
Market structure	• Two-sided market [137]
Trading type	• Continuous market [156]
Price computation	• Pay-as-bid [156]
Market type	• Energy [156]
Buyer	• DSOs, TSOs and BRPs [137]
Sellers	• BRPs, Aggregators (prosumers, active demand-supply) and microgrids [137]
Products/Services	• LongFlex (Availability) and ShortFlex (Activation) [137] • Congestion management [156] • Balancing (mFRR and RR) [137]
Resources/Assets	• Generators, Consumers, Storage [138]
Pre-qualification	• Platform verifies assets to qualify [138]
Aggregation	• Aggregators and BRPs are accepted [138]
Bidding period	• Timeframe depends on region and market [137] • No direct contact between DSOs and FSPs [138] • Orders are automatically matched or picked from an order book and activated by the buyer [137]
Negotiation & Market Operation	• Market operator matches when a request is greater than or equal to an offer [138] • Filters based on buyers' preferences can be applied before matching on price [156]
Activation & Settlement	• Within-platform [138]

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	• NODES sends trade confirmations that FSPs convert to activation signals [138] • FSPs are responsible for activation [138] • Settlement conducted monthly with performance-based penalty methodology [138]
Proof of delivery	• Within-platform [138] • Flexibility delivery is validated using baseline measurement methodology and metering data [138]
Remuneration	• Availability (€/MW/h) [138] • Activation (€/MWh) [138]
TSO-DSO coordination	• Available on request [156]
Integration with other markets or platforms	• Interface between NODES and the existing electricity markets is not yet possible [156] • Ongoing tests with different providers and TSO operating procedures [137]

5.1.8. N-SIDE platform

N-SIDE is a Belgian company which developed a local market platform. It can be operated in two ways, either as a local flexibility market or as an optimal bid selector for market participants In both cases the goal is to facilitate the link between FSPs and DSOs' bids through an auction-based mechanism accounting for grid constraints. Moreover, the platform can concentrate the liquidity of the market with a closed-gate mechanism, before clearing it by maximizing social welfare. Its main features include [221]:

- Impartiality, by presenting a neutral market where network companies and FSPs can win contracts for services.
- Useful for reserve and/or energy by offering auctions for reserve and utilization over multiple time horizons.
- Allows participants to share price signals.
- Market participants influence the clearing through price sensitive orders.
- Several pricing rules can be used while clearing auctions: pay-as-clear and pay-as-bid.
- By accessing grid data, the market clearing process can guarantee that reserved and activated contracts respect grid constraints.
- Can include a TSO/DSO coordinated flexibility procurement mechanism to guarantee that TSO contracts are not having a negative impact on distribution grids.
- It can admit switching possibilities of the grid to select the best grid configuration to adopt while clearing the market to further increase social welfare.

The end-to-end flexibility process implemented by the N-SIDE platform, pictured in Figure 5.27, respects the following steps [221]:

- Registration and Pre-qualification: Different resources can qualify for participation in the flexibility market. FSPs can request qualification when their assets comply with the requirements defined by the DSO and FMO. If the pre-qualification is successful, the FSPs can then make offers on the flexibility market. In this phase, the DSO also registers on the market platform as a buyer and defines grid areas to determine the locations of flexibility potential.

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- Bidding and Selection: Grid utilisation and the identification of potential grid issues take place on this phase. This is followed by bid and baseline submission and evaluation. The DSO forecasts grid issues and determine flexibility needs and then the qualified FSPs submit their bids. When those bids are matched, flexibility is used to fulfil the DSO's requirements.
- Delivery and Monitoring: This phase is related to bid activation and the monitoring of delivery. After bids are paired on the flexibility market, a trade confirmation and activation signal are sent to the FSPs. The proof of delivery is based on metering data. Together with the baseline, this forms the basis for settlement.
- Settlement: At last, when the services are delivered, based on respective baselines for the specific offers, and active metering systems, it is calculated how much the DSO needs to pay to the FSPs for the flexibility delivery.

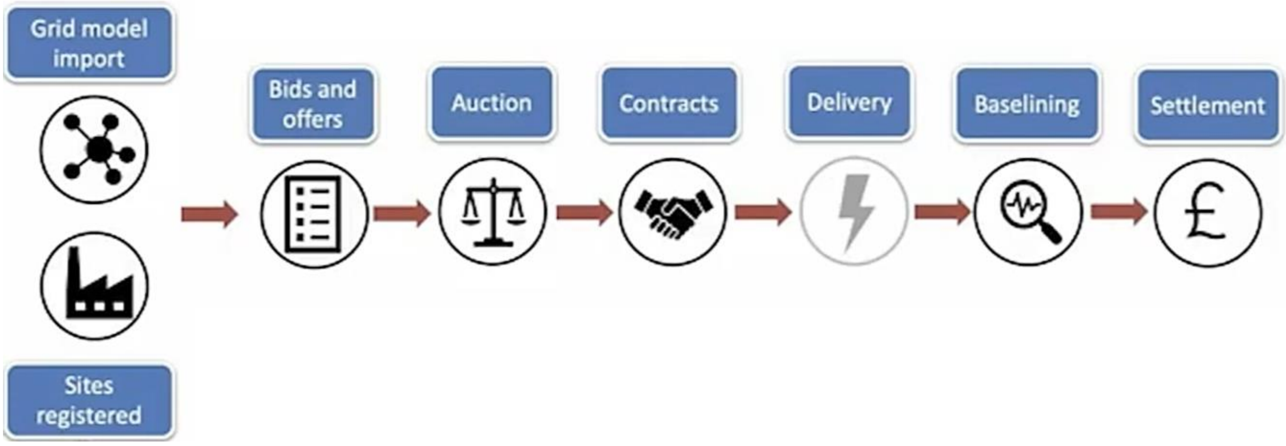

Figure 5.27 – Overview of the end-to-end flexibility process used by N-SIDE [224]

Regarding the timeline of the flexibility market, the bidding period for long-term flexibility lasts 1 week, starting 3 weeks before and closing 2 weeks before activation. This allows FSPs to place long term flexibility offers for active and reactive power after the DSO identifies grid constraints. Then, the market operator matches the offers, which once validated by the DSO, are reserved for later activation [221].

In the meantime, in the short-term market there will be reserved offers derived from the long-term market and potential new offers, submitted in the short-term market. This short-term flexibility market is open for 48 hours, being open 72 hours before and closed 24 hours before activation. It matches the needs expressed by the DSO with the offers presented by the FSPs in an iterative process [221].

The main characteristics of the N-SIDE platform are summarized in Table 5.20.

Table 5.20 - Main characteristics of the N-SIDE platform

Characteristics	Summary
Platform type	• Flexibility Market Platform [221]
Location	• Belgium, United Kingdom [225] and Portugal [221]
Market structure	• (not available)
Trading type	• (not available)

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Price computation	• Pay-as-bid or pay-as-clear [221]
Market type	• Energy and reserve [221]
Buyer	• DSOs [221]
Sellers	• Aggregators [221]
Products/Services	• Voltage control and predictive voltage control [221] • Congestion management and predictive congestion management [221]
Resources/Assets	• Generation assets [224] • Flexible demand [224] • Storage units [224] • EV chargers [224]
Pre-qualification	• Potential FSPs can ask for qualification when their assets meet requirements defined by the DSO and/or the FMO [221]
Aggregation	• Accepted [226]
Bidding period	• Long term flexibility [221]: ○ Market opens 3 weeks before and closes 2 weeks before flexibility activation ○ Market opens 3 years before and closes 2 years before flexibility activation • Short term flexibility: market opens 72 hours before and closes 24 hours before flexibility activation [221]
Negotiation & Market Operation	• (not available)
Activation & Settlement	• After flexibility is delivered, it is calculated how much the DSO has to pay to the FSPs [221]
Proof of delivery	• Based on metering data [221]
Remuneration	• Availability fee (€/MW/h and €/MVAr/h) [221] • Activation fee (€/MW and €/MVAr) [221]
TSO-DSO coordination	• Can include TSO/DSO coordination to ensure TSO contracts do not impact distribution grids [221]
Integration with other markets or platforms	• EPEX SPOT [225] • IEX [227]

5.1.9. SIORD

In 2019, Spanish DSOs united to develop the Sistema de Información de los Operadores de Redes de Distribución (SIORD). For now, the main purpose of SIORD is to be a common platform to exchange real-time data between DSOs and Significant Grid Users (USRs), thus unifying, simplifying, and minimising the cost of sharing information and monitoring grids and DERs [228], [229]. Moreover, with undergoing upgrades, it is expected to support the deployment of flexibility at distribution level by facilitating the communication with the new flexibility market operators [230].

A first version of the SIORD platform (SIORD v1) was available by February 2023, which included activation and monitoring/metering processes (Figure 5.28). However, to deploy flexibility at distribution grid level, it is necessary to implement information exchange processes between DSOs, market operators, Aggregators and DERs. In this setting, SIORD can be a unique communication link between all those actors, minimizing operating costs. The new version (SIORD v2) is also expected to cover interoperability processes related to pre-qualification stage and the forecast of flexibility needs and their schedule (Figure 5.28). SIORD v2 is being developed to be a single communication port between all the DSOs and Aggregators not only to activate

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units, but also to support the entire flexibility-centric VC. The SIORD platform, and some of its issues, are to be addressed at several projects, including the BeFlexible project [230].

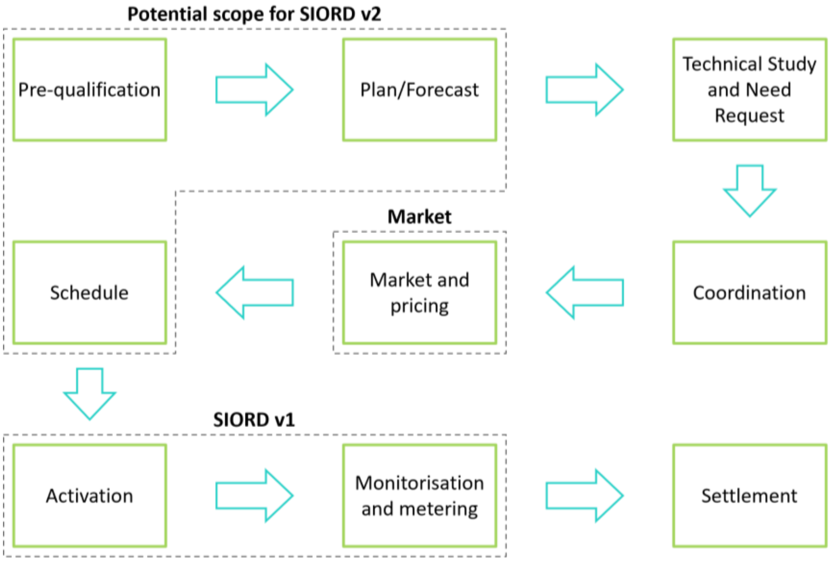

Figure 5.28 - Stages for the implementation of flexibility at distribution grids [230]

To explain the context leading to the creation of this platform, as of 2021 there were around 63,000 registered generators in Spain and over 27,000,000 Consumers. This means that the involvement of only 1% of these Consumers would lead to a total of 270,000 participants needing to communicate with DSOs and market operators [231]. Additionally, there are more than 300 different DSOs in Spain. Altogether, this creates the need to exchange a very large amount of data between Generation and Demand Control Centres (CC-GDs) and those DSOs. This situation is depicted in Figure 5.29, where it is pictured how a high volume of connections would be required, making a point-to-point approach for data exchange unfeasible. SIORD addresses this issue by using a common source of information for all agents, thus facilitating data transfer and promoting the participation in flexibility services and supporting new flexibility markets [231].

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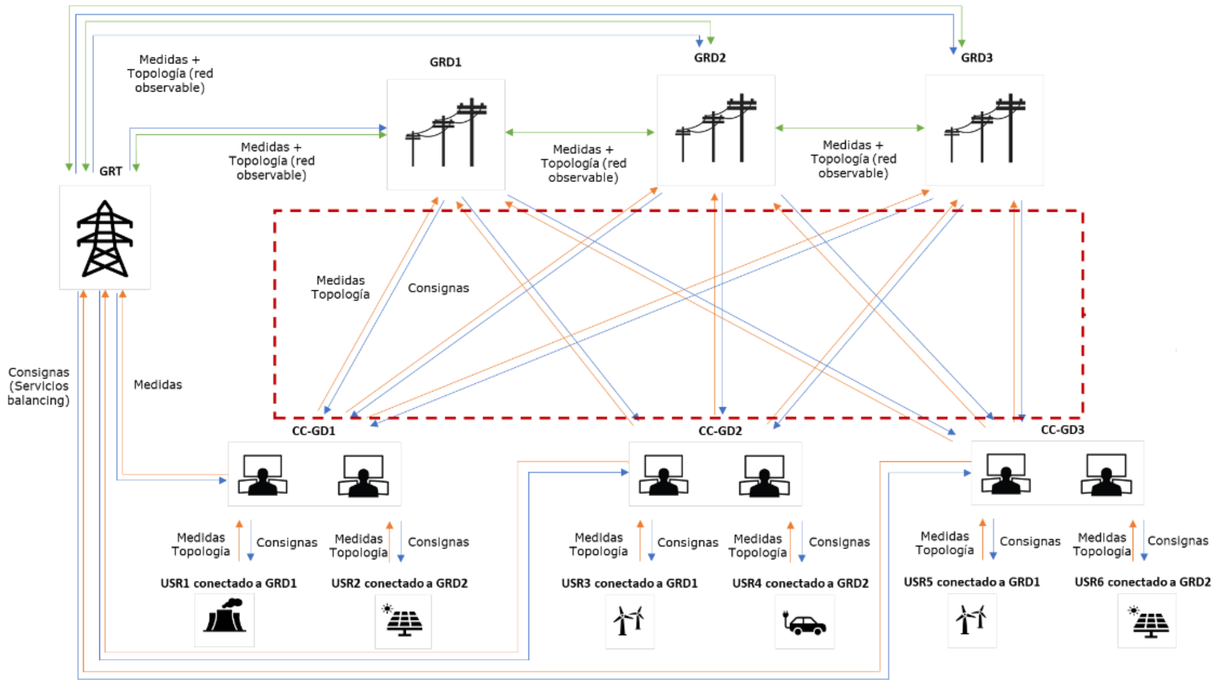

Figure 5.29 - Current data exchange architecture [232]

Under these circumstances, SIORD establishes a single communication channel between CC-GDs and DSOs to streamline real-time information exchange [228], as portrayed in Figure 5.30. On the CC-GDs' side, SIORD can be used to send real time data to the DSOs. On the USRs and CC-GDs' side, they have a cheaper option to send required real-time data. Besides that, the process of commissioning new USRs can be simplified as the TSO no longer has to be directly involved, meaning these procedures can now be handled between CC-GDs and DSOs only, and not between CC-GDs, DSOs and TSOs. On the DSOs' side, SIORD is useful for collecting monitoring data, essential to manage bidirectional power flows, also enabling to connect a higher share of DERs. It also improves grid observability. On the TSOs' side, as earlier mentioned, SIORD increases the amount of small USRs that can be monitored in real-time. At last, security of supply increases, as this new link with the DSO decentralizes the prevailing real-time communication flow with the TSO [230].

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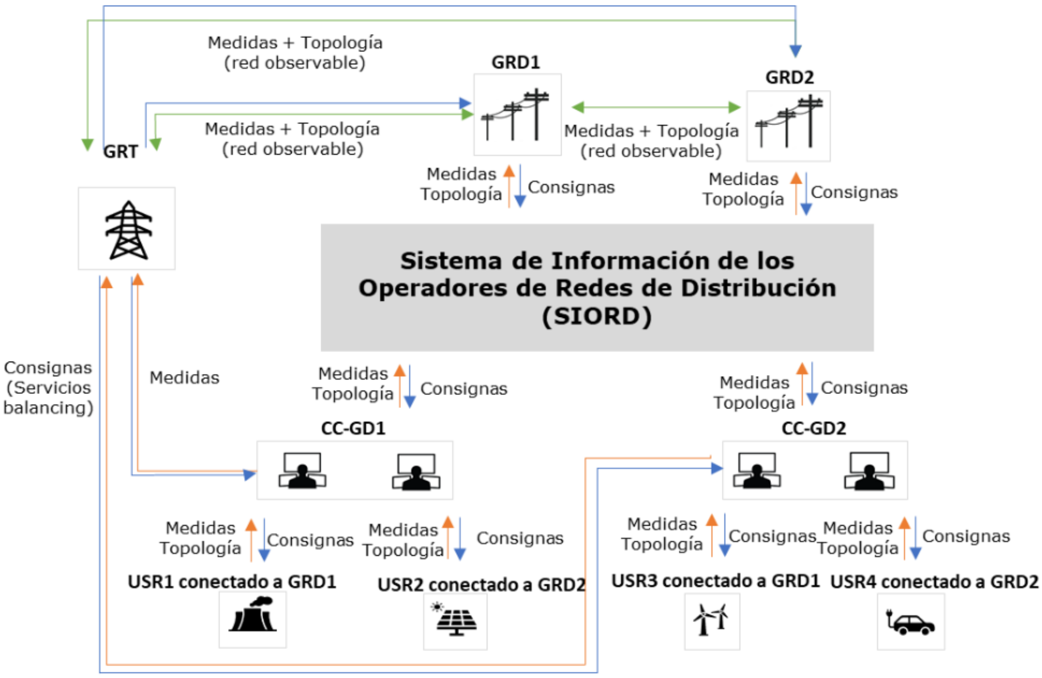

Figure 5.30 - Future model for data exchange using SIORD [232]

The methodology followed for the design of SIORD is focused on simplicity, avoiding the creation of an overly complex system, thereby establishing a flexible and easy-to-manage platform. The system stores records of all the activity (communication logs), allowing for full traceability of the information passing through. The platform stores the transmitted information to ensure the interconnection operation, and a historical record of the transmitted information is not stored [228].

Moreover, SIORD has an administration console for performing activities such as platform monitoring, alert management, configuration, connectivity management, logs, etc. This architecture allows for its scalability to adapt to future needs as the number of USRs connected via CC-GDs keep growing, thus increasing the amount of data flowing through the platform, which must continue to provide real-time services. The confidentiality of the received information is maintained, and it can only be used for functions established in accordance with applicable regulations. Real-time data from USR is to remain confidential [228].

When Producers and CC-GDs provide information to DSOs, this information can be also sent to TSOs. As such, even if TSOs do not have an active participation in this platform, the technical requirements for information exchange between TSO-DSO have been considered in the elaboration of SIORD [228].

The main characteristics of SIORD are the following [228], [232]:

- Be a common, simple, and standard solution connecting all DSOs within the Spanish territory.
- Each CC-GD has a common communication link with all DSOs, regardless of the network to which the Consumers attached to each CC-GD are connected.
- It is a platform managed by DSOs, within the bounds of their responsibilities.
- Each DSO has a common communications link with the CC-GDs.
- Each DSO has access to the information corresponding to its area of competence, complying with the current regulations.

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- Accepts different communication protocols and open to bond with all CC-GDs.
- Confidential information can only be accessed by the DSO to which the USR is connected.
- Does not store or process the information, it is just a way of communicating and exchanging data.
- Offers opportunities for the creation and development of new flexibility markets, with the participation of Consumers and grid operators.

From a more technical perspective, SIORD has been developed in standard modules to easily scale the number of USR at a low cost. Its architecture is based in "containers" (dockers) on orchestration cluster services (Kubernetes) and its communication network can support many different communication protocols (IEC, 60870, ICCP, OPC, Modbus) in order to allow the connection of all types of CC-GDs and USRs [230].

The implementation of SIORD involves a long and complex process, which is structured into multiple phases, as seen in Figure 5.31. Its design requires significant coordination efforts due to the large number of parties involved [228].

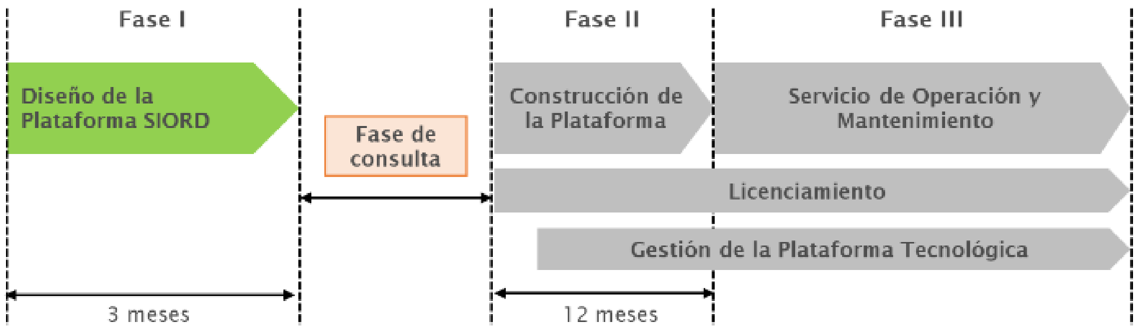

Figure 5.31 - Stages of development of SIORD (green: phases completed by 2021) [228]

According to the most recent information available, in 2021, Spanish DSOs proposed the subsequent development phases for the platform [228]:

- Phase I – Drafting of SIORD platform design specifications for consideration by the parties involved.
- Consultation Phase – The outcome of the consultation should lead to the final design specifications of the platform.
- Phase II – Creation/implementation of the platform.
- Phase III – Operation and maintenance of the platform.

There are several anticipated uses for SIORD in the future, for instance, the platform might be able to provide real-time measurements to Consumers and small/medium Producers that can be used for supervision and control of their installations, meaning that Consumers/Producers who choose to communicate via SIORD might avoid the installation of additional equipment in their installations. Furthermore, for small Producers with no obligation to send real-time information, SIORD might be a viable solution to have this information available in real time for their installation. This would make SIORD the source of real-time data on small generation and for the entire national territory. Moreover, in Spain, SIORD might help to aggregate data at municipal, zonal, county, provincial or autonomous community level. This data could be of great value to administrations and/or interest groups, for example, to show in real time the savings in CO_2 emissions due to the RES installed in a certain territory. At last, authorised third parties might be able to view and connect

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to SIORD to exploit data in line with existing regulations [228], a possibility which can help to link several sectors and unlock value for all actors, including Consumers.

The logical architecture of SIORD, which is thoroughly described in [233], is summarized in Figure 5.32.

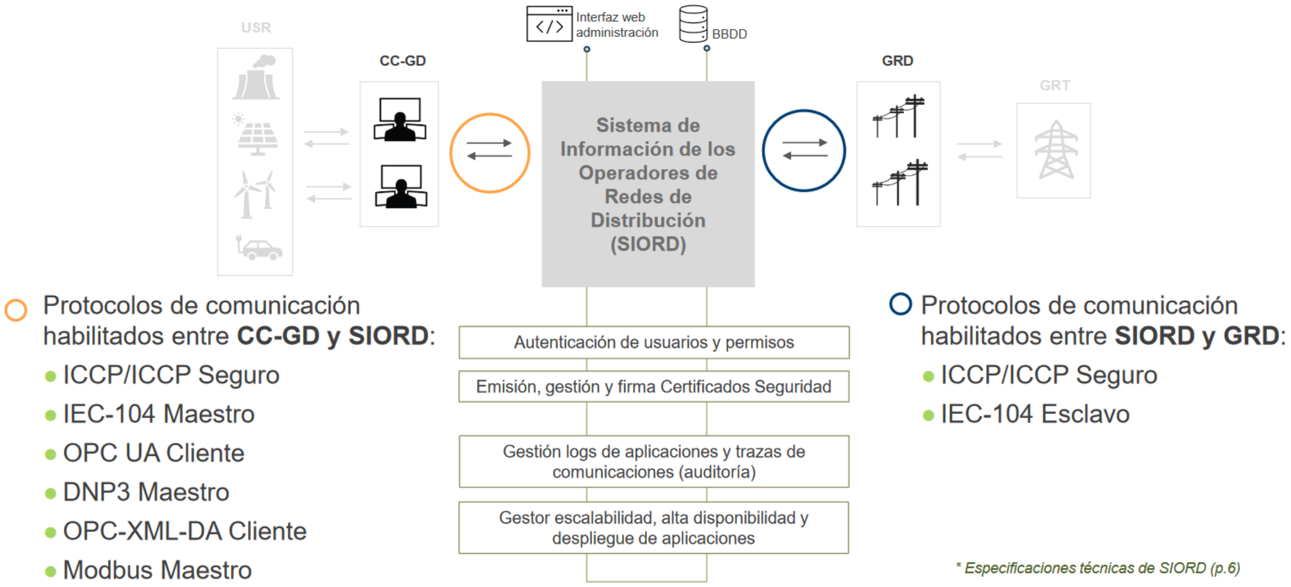

Figure 5.32 - Logical architecture of SIORD [228]

An overview of the SIORD data model is given next (for a complete description the readers are referred to [233]). The SIORD data model provides unique identifiers to all data exchanged through different protocols among different systems. The identifier for each signal is unique, and there cannot be two different signals with the same identifier [233]. The data model (States and measurements module) of SIORD for generation units over 1 MW is given in Table 5.21. The remaining data models, including states and measurements module for generation ≤ 1 MW, signals from generation modules providing secondary frequency control, states and measurements of demand installations, etc, are given in [233].

Table 5.21 - States and measurements module for generation > 1MW

SIORD identifier	Description	Unit
ESTADO_CONEXION_IDENTIFICADOR_USR	Connection status of the installation to the distribution or transmission network	N/A
P_ACTIVA_PROD_IDENTIFICADOR_USR	Active power produced by the entire installation, excluding the self-consumption of the generation units.	MW
P_REACTIVA_PROD_IDENTIFICADOR_USR	Reactive power produced/absorbed by the entire installation, excluding the self-consumption of the generation units	MVAr
TENSION_BARRAS_IDENTIFICADOR_USR	Voltage measurement at the central busbars	kV
P_MAX_PROD_IDENTIFICADOR_USR	Maximum power that can be produced under current conditions	MW
PROD_H1_IDENTIFICADOR_USR	Expected hourly production in hour h+1 with hourly update	MWh
P_ACTIVA_CONSUM_IDENTIFICADOR_USR	Active power consumed by the self-consumption or cogeneration installation, excluding consumption associated exclusively with the generation units	MW
P_REACT_CONSUM_IDENTIFICADOR_USR	Reactive power consumed by the self-consumption or cogeneration installation, excluding consumption associated exclusively with the	MVAr

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	generation units.	

Some concerns are mentioned about SIORD. For instance, in local flexibility markets, a DSO buys flexibility provided by Aggregators. As a result, it might not be fair that the DSO is responsible for managing access to data which is required by Aggregators to provide services to that same DSO. In other words, having the DSO as a buyer of flexibility and a provider of data raises some concerns regarding impartiality. It must be ensured that data access is done in a fair and non-discriminatory manner. One solution that is proposed is to separate the management of Consumers' data and the physical management of the grid. The DSO would still be responsible for maintaining and operating the distribution grid, but an independent operator would manage the data and provide it, in a harmonized format, to Retailers and Aggregators [234].

The main characteristics of SIORD are summarised in Table 5.22.

Table 5.22 - Main characteristics of the SIORD data exchange platform

Characteristics	Summary
Type	• Data Exchange Platform
Country	• Spain [228]
Operator/Ownership	• DSOs [231]
Objective	• Connect all DSOs and CC-GD under a single platform [232] • Activate flexible units [230] • Simplify and minimise costs of data and instructions exchange in power systems [228]
Data to be exchanged	• Real-time distribution grid data [232] • DER data (small generators, BESS, EV chargers) [232]
Data supplier	• DSOs [231] (smart meters [228])
Data users	• Aggregators, Retailers, Consumers, public administration [231] • Flexibility markets [230]
Assets	• DERs, ESS, EV Charging Points, Heat Pumps, smart meters [228]
Other features	• Information on CO_2 savings [228] • Accept different communication protocols [232] • Confidentiality (data only accessible to the DSO to which a Consumer is connected) [232] • Does not permanently store or process the information, it is just exchanges data [232]

5.1.10. Atrias

Atrias is a data exchange platform [138] created as the result of a joint initiative between the five largest Belgian DSOs [235]. The objective was to develop a platform to facilitate data exchange among the participants of energy markets [236], and also to enable market access to DERs [237].

In this context, the platform is used to gather, structure and exchange data between different actors, performing operations and calculations on the behalf of the DSOs and facilitating the access of new actors to the energy market [237]. The data to be exchanged in the platform includes master data, metering data, grid fee data, infeed data, settlement volumes and energy supply contract data [238].

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Furthermore, this platform supports processes related to the metering point administrator including all market processes from creation to decommissioning of an accounting point (including moves, change of supplier, end of supply, change of grid), grid fee billing, infeed collection and provisional allocation [238].

In mid-2020, Atrias introduced a new communications standard (MIG6) ready to include recent technologies, such as smart meters and DERs, making demand management opportunities accessible [239]. The new MIG6 was intended to further simplify the existing market processes and to increase the efficiency and Consumer friendly services such as switching and prepayment. Although Belgium provided a negative business case on the rollout of smart meters, also included market processes supporting smart meters and the corresponding data exchange [235].

To clarify the benefits of this platform, in Belgium, where DSOs oversee the installation, reading, and maintenance of energy meters, each DSO must make the collected data available through their personal portal. The validated data received from the meters is used for billing and is made available to Retailers through a web portal, used to bill the Consumers [235]. However, without Atrias' platform, each DSO uses its own access register with its own information and technology, making interactions between market participants more complex. For example, if a Consumer desires to switch Retailer, the new Retailer must send the required data through the portal to the right DSO to modify the access registry (master data). But with this platform, information exchange becomes uniform. This new approach, compared to the current situation, both depicted in Figure 5.33, lowers the barrier for a party to request information from the DSO and be able to offer its services. For instance, once a new Aggregator is recognised by the DSO, it can request information about its Consumers directly through the Atrias platform [235].

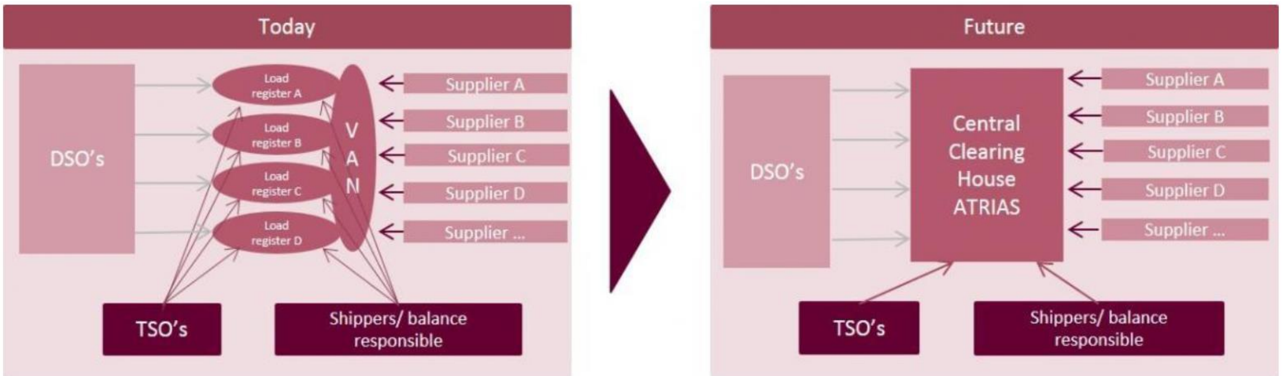

Figure 5.33 - Before and after the implementation of Atrias [235]

The main characteristics of the Atrias platform are given in Table 5.23.

Table 5.23 –Main characteristics of the Atrias data exchange platform

Characteristics	Summary
Type	• Data Exchange Platform
Country	• Belgium [235]
Operator	• Atrias (private company) [238]
Objective	• Facilitate data exchange between energy market participants [236] • Enable market access to DERs [237]
Data to be exchanged	• Master data [238]

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	• Metering data [238] • Grid fee data [238] • Infeed data [238] • Settlement volumes [238] • Energy supply contract data [238]
Data supplier	• DSOs [235]
Data users	• All energy market actors (emphasis on Aggregators and ESCo) [235]
Assets	• Smart meters, DERs, EV charging stations [235]
Other features	• N/A

5.2. Flexibility products review

This subsection presents a review of flexibility products. It starts by describing the products proposed by the Energy Networks Association (ENA), which are being used by platforms like Piclo Flex and Flexible Power in several countries. Afterwards, the products/services defined and/or tested in several European projects are detailed. The objective of this review is to support the proposal of standardized flexibility products for the BeFlexible project.

5.2.1. ENA

ENA, an entity which represents British and Irish DSOs and TSOs, proposed a standard definition and parameters for four active power products [175], [240], [241]:

- Sustain – The DSO procures, ahead of time, a pre-agreed change in consumption/production over a defined period to prevent the grid from going beyond its capacity. Thus, this product is used to deal with ongoing requirements to reduce peak demand. Dispatch is scheduled well in advance for a fixed fee, and providers are made aware of the times they are expected to provide flexibility when the contract is signed.
- Secure – The DSO procures, ahead of time, a pre-agreed change in consumption/production based on grid conditions closer to real-time than in Sustain. This product is used to predictively acquire flexibility in pre-fault scenarios, such as managing peak demand on the network. Usually a utilisation fee is paid, but availability fees might be available. The timing of dispatch varies between DSOs, but providers are still notified at the procurement and contract stages of the expected windows of availability and utilisation.
- Dynamic – The DSO procures, ahead of time, an agreed change in consumption/production during a network abnormity or fault conditions, such as maintenance work. This means this product is used for corrective (post-fault) scenarios. Typically, it is dispatched at short notice, with a low availability payment and high utilisation payment.
- Restore – Following a loss of supply, the DSO instructs a provider to either remain off supply, or to reconnect with a lower demand, or to reconnect and supply generation to accelerate grid restoration. This product supports the DSO in post-fault scenarios caused by equipment failure. It is typically dispatched at short notice with low availability payments and high utilisation payments.

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The main characteristics of these products, as originally defined by ENA, are given in Table 5.24. Since its publication, this proposal was adopted by several British DSOs and, more recently, by the Portuguese DSO. However, each DSO made several adaptions to the initial characteristics of those products, meaning that the same product, when procured by different DSOs, can have different requirements, timings, and payments. For that reason, the characteristics of these products, as defined by each DSO, are provided in Table 5.25. It should be noted that some DSOs do not yet provide a complete description of the products they are using, in some cases because they are still taking the first steps in the procurement of Consumer-side flexibility.

Table 5.24 – Characterization of flexibility products according to ENA

Source	Product	Use case / Network constraint	Risk to network	Utilisation certainty	Minimum capacity	Minimum utilisation duration capability	Minimum utilisation	Maximum ramping period	Availability agreement period	Utilisation notification period	Ref.
ENA	Sustain	Scheduled forecast overload	Low	High	0 – 50 kW	30 min	15 – 30 min	N/A	N/A	Scheduled in advance	[240]
	Secure (scheduled)	Pre-Fault / Peak shaving	Medium	High				N/A	Contract stage	Contract stage	
	Secure (dispatched)							< 15 min	Week ahead	Real time	
	Dynamic	Network abnormality / Planned outage	High	Low				< 15 min	Contract stage (if applicable)	Real time	
	Restore	Network abnormality /	High	Low				< 15 min	Contract stage (if applicable)	Real time	

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Table 5.25 – Characterization of flexibility products as implemented by each DSO

Source	Product	Use case / Network constraint	Procurement timescale	Minimum capacity	Payment structure	Availability agreement period	Utilisation notification period	Dispatch mechanism	Maximum ramping period	Ref.
SSEN (UK)	Sustain	Risk of the grid going past capacity	Annual / Season	50 kW	Utilisation	Pre-determined	Notice sent 1 month ahead	API call / Phone call / Email	30 min	[242], [243]
	Secure	Grid resilience compromised	Annual / Season		Availability + Utilisation	Month ahead	Notice sent 1 week ahead	API call / Phone call / Email	30 min	
	Dynamic	Pre-fault / Planned maintenance	Annual / Season		Availability + Utilisation	Week ahead	Notice sent 1 day ahead	API call / Phone call / Email	3 min	
	Restore	Supply restoration	Annual / Season		Utilisation	No availability	Notice sent 2 min ahead	API call / Phone call / Email	3 min	
	Emergency	——	Annual / Season		Utilisation (with a fixed rate)	No availability	Notice sent 15 min ahead	API call / Phone call / Email	——	
UKPN (UK)	Sustain	Firm, dispatchable service	Annual / Season	10 kW	Fixed service payment (£/MW/year)	Years or months ahead (specified in tender)	Scheduled on dispatch (months ahead)	Scheduled at contract awarded	——	[244], [245]
	Secure	Non-firm dispatchable service	Annual / Season		Availability (£/MW/h) + Utilisation (£/MWh)	Years or months ahead (specified in tender)	Day ahead dispatch	Email /API	——	
	Dynamic	Enduring peak reduction	Annual / Season		Utilisation (£/MWh)	No availability	Day ahead dispatch	Email /API	——	
ENWL (UK)	Sustain	Scheduled forecast overload	Twice a year (Spring and Autumn)	50 kW	Utilisation	Pre-determined	Scheduled in advance	API call / Phone call / Email	N/A	

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	Secure	Pre-fault / Peak shaving	Twice a year		Availability + Utilisation	Months ahead (contract stage)	1 week in advance	API call / Phone call / Email	< 15 min	
	Dynamic	Grid anomaly / Planned outage	Twice a year		Availability + Utilisation	Months ahead (contract stage)	Real time	API call / Phone call / Email	< 2 min	
	Restore	Grid anomaly	Twice a year		Utilisation	Months ahead (contract stage)	Real time	API call / Phone call / Email	< 2 min	
SPEN (UK)	Sustain	Scheduled	Annual / Season	50 kW	——	Week ahead	Day ahead	API call	30 min	[175], [184], [190]
	Secure	Pre-fault	Annual / Season		——	Week ahead	Day ahead	API call	30 min	
	Dynamic	Post-fault	Annual / Season		——	Week ahead	Real time	API call	3 min	
	Restore	Post-fault network restoration	Annual / Season		——	Week ahead	Real time	API call	3 min	
E-Redes (Portugal)	Sustain	——	Season	Depends on voltage level: 2 kW (LV) 50 kW (MV) 200 kW (HV)	——	——	Instruction sent with at least 12 h in advance	——	——	[246], [247]
	Secure	——	Season		——	——	Notice sent 15 min ahead of requirements	——	——	
	Dynamic	——	Season		——	——	Notice sent 15 min ahead of requirements	——	——	
	Restore	——	Season		——	——	Notice sent 15 min ahead of	——	——	

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Where the requirements for product specification are [175]:

- Use case / Network constrain: Describes the situation that leads to the procurement of the product.
- Procurement timescale: Refers to the timeframe for which a flexibility product is procured/acquired.
- Minimum capacity: The minimum flexible capacity a FSP can make available to the DSO, and which can be made up of aggregated and non-aggregated assets.
- Minimum utilisation duration capability: The minimum amount of time a FSP must be able to continuously hold their contracted flexible capacity.
- Minimum utilisation: The minimum amount of time a DSO will require the provision of a product from a FSP following a utilisation instruction.
- Maximum ramping period: The maximum allowed time for a provider to reach their contracted flexible capacity once a utilisation instruction has been issued.
- Availability agreement period: Indicates how long before dispatch will flexibility providers agree on being available for the provision of a product.
- Utilisation notification period: Indicates how soon flexibility providers will receive instructions to activate their flexible assets.
- Payment structure: Indicates how flexibility providers (Aggregators and/or Consumers) are rewarded for the provision of a product.
- Dispatch mechanism: Refers to the process used to send out dispatch instructions to flexibility providers and/or their assets.

Regarding this divergence in products characterization, starting with the Sustain product (Table 5.26), the revised DSOs seem to be mostly aligned on its interpretation and characterisation. The DSO procures this product in advance according to a pre-agreed schedule and the FSPs are made aware of the periods when they are expected to provide flexibility [240].

Table 5.26 – Sustain product [240]

Parameter	DSO Interpretation
Use case / Network constraint	Pre-fault
Procurement timescale	Annual / Season
Payment structure	Utilisation
Availability agreement period	Pre-determined
Utilisation instruction	Scheduled contract stage
Dispatch mechanism	Scheduled / Self-dispatch

Regarding the Secure product (Table 5.27), the DSOs are not so well aligned in its description. For instance, the availability agreement period differs between DSOs, with some securing availability at the year ahead, while others only secure it at the week ahead. Agreeing on availability at the year-ahead can increase revenues for FSPs and give the DSO confidence in contractual availability. But committing to availability so

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far in advance may limit the FSPs' ability to engage in other market opportunities (i.e., the provision of other products). Additionally, there is also divergence in the timing of the utilisation instructions, which can go from real time to week ahead [240].

Table 5.27 –Secure product [240]

Parameter	DSO Interpretation
Use case / Network constraint	Pre-fault / Planned outage
Procurement timescale	Annual / Season
Payment structure	Availability + Utilisation
Availability agreement period	Week-ahead / 2 weeks ahead / Year ahead
Utilisation instruction	Real time / Within day / Week ahead
Dispatch mechanism	API call / Phone call / Email

In the Dynamic product (Table 5.28), there is a certain disagreement towards its definition, with certain DSOs using it as a close to real-time supplement for the pre-fault products (Secure and Sustain). These same DSOs only pay for the utilisation of flexibility, unlike the majority (which pay for availability and utilisation). Similarly to the Secure product, there is also disagreement on the timing of the utilisation instructions, now ranging from day ahead to real time [240].

Table 5.28 – Dynamic product [240]

Parameter	DSO Interpretation
Use case / Network constraint	Network abnormality / Post-fault
Procurement timescale	Annual / Season
Payment structure	Availability + Utilisation / Utilisation only
Availability agreement period	No availability / Week-ahead / 2 weeks ahead
Utilisation instruction	Real time / Within day / Day ahead
Dispatch mechanism	API call / Phone call / Email

At last, in the Restore product (Table 5.29), DSOs also seem aligned in its definition. The product it is procured in advance as a utilisation only product operated in post fault situations to support grid restoration [240].

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Table 5.29 – Restore product [240]

Parameter	DSO Interpretation
Use case / Network constraint	Post fault
Procurement timescale	Annual / Season
Payment structure	Utilisation only
Availability agreement period	N/A
Utilisation instruction	Real time
Dispatch mechanism	API call / Phone call / Email

5.2.2. OneNet

In the OneNet project, products are divided into frequency control products and non-frequency control products. Frequency control includes six products with the following definitions [248]:

- Inertia – Based on active energy, with very fast activation time (close to real-time) and used for reducing power system oscillations.
- Frequency Containment Reserve (FCR) – Based on active power reserves available to contain system frequency after the occurrence of an imbalance. Requires a relatively fast response (full activation time below 30 seconds).
- Fast Following Response (FFR) – Based on the delivery of a rapid active power increase or decrease by generation or load in a time frame of 2 seconds or less, to correct a supply-demand imbalance and assist in managing system frequency. Until recently there was no need for FFR as a market product in Europe because the inertia in hydro and gas power plants would be able to address these needs. The integration of more RES lacking "natural" inertia causes the need for fast responses from new sources.
- automatic Frequency Restoration Reserve (aFRR) – Based on the active power reserves available to restore frequency to its nominal value and, for a synchronous area consisting of more than one LFC area, to restore power balance to the scheduled value always that the activation takes place automatically.
- manual Frequency Restoration Reserve (mFFR) – Based on the active power reserves available to restore frequency to its nominal value and, for a synchronous area consisting of more than one LFC area, to restore power balance to the scheduled value always that the activation takes place manually.
- Replacement Reserve (RR) – Based on the active power reserves available to restore or support the required level of FFR to be prepared for additional system imbalances including generation reserves. Can have a long full activation time (over 30 minutes).

Non-frequency control products include [248]:

- Corrective local active product – Reacting with active power to an unexpected incident that requires correction in less than 1 hour (i.e., full activation time should be under 1 hour). This product includes information about the location of the flexibility.

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- Predictive short term local active product – Reacting with active power to a forecasted system need within the operational planning timeframe. Therefore, activation can be planned, which reduces the pressure on the full activation period and, as a result, increases liquidity. The product can be acquired as a capacity only (to be combined with an energy product), an energy product or a capacity and energy product. The procurement of this product would happen at least once a month (i.e., the duration of the product is under 1 month) to increase the liquidity in the market. This product will include information about the location of the flexibility.
- Predictive long-term local active product – Used to mitigate and/or delay the need for traditional grid reinforcements using active energy. This product can contract capacity (together with energy or alone with the acquisition of the energy left to the following procurement process). The duration of the product could extend over a long period (can cover multiple years). Activation can be planned (scheduled delivery) or done at the request of the SO (this could require a separate procurement process if the initial product is a capacity only product). This product includes information about the location of the flexibility.
- Corrective local reactive product – Used to react with reactive power to an unexpected incident that requires correction in less than 1 hour. This product includes information about the location of the flexibility.
- Predictive short term local reactive product – Used to react using reactive power to a forecasted system need within the operational planning timeframe. Therefore, activation can be planned which reduces the pressure on the full activation period and, as a result, increases liquidity. The product can be acquired as a capacity only (to be combined with a reactive power product), a reactive power product or a capacity and reactive power product. The procurement of this product happens at least once a month (i.e., the duration of the product is under 1 month) to increase the liquidity in the market. This product includes information about the location of the flexibility.
- Predictive long-term local reactive product – Used to mitigate and/or delay the need for additional grid reinforcements using reactive power. This product includes activated reactive power or reserved reactive power (together with the potential for activating the reactive power or alone with the reactive power being procured in the following procurement process). The duration of the product extends over a long period (can cover multiple years). Activation can be planned (scheduled delivery) or done at the request of the SO (this could require a separate procurement process if the initial product only include a reserve of reactive power). This product includes information about the location of the flexibility.

The main characteristics of these non-frequency control products are summarized in Table 5.30.

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Table 5.30 – OneNet non-frequency control products attributes [217], [248]

Attributes	Active power products			Reactive power products		
	Corrective local active product	Predictive short-term local active product	Predictive long-term local active product	Corrective local reactive product	Predictive short term local reactive product	Predictive long-term local reactive product
Capacity / Energy	Energy	Energy and optional capacity	Energy and optional capacity	Capacity, Energy, or both	Capacity, Energy, or both	Capacity, Energy, or both
Maximum full activation time (FAT)	< 60 min	< 60 min	24 h	< 60 min	< 60 min	24 h
Minimum delivery period	Multiple of 15 min up to 1 h	Multiple of 15 min up to 1 h	Multiple of 15 min up to 1 h	Multiple of 15 min up to 1 h	Multiple of 15 min up to 1 h	Multiple of 15 min up to 1 h
Maximum deactivation period	Defined in terms and conditions for FSPs	Defined in terms and conditions for FSPs	Defined in terms and conditions for FSPs	Defined in terms and conditions for FSPs	Defined in terms and conditions for FSPs	Defined in terms and conditions for FSPs
Maximum recovery period	Defined in terms and conditions for FSPs	Defined in terms and conditions for FSPs	Defined in terms and conditions for FSPs	Defined in terms and conditions for FSPs	Defined in terms and conditions for FSPs	Defined in terms and conditions for FSPs
Required mode of activation	Automatic or manual (if compliant with FAT)	Automatic / Manual	Automatic / Manual	Automatic or manual (if compliant with FAT)	Automatic / Manual	Automatic / Manual
Minimum quantity	TSO: 1 MW DSO: 0.01 MW	TSO: 1 MW DSO: 0.01 MW	TSO: 1 MW DSO: 0.01 MW	0.01 or 0.1 MVar	0.01 or 0.1 MVar	0.01 or 0.1 MVar
Divisibility	Divisible and indivisible bids are allowed	Divisible and indivisible bids are allowed	Divisible and indivisible bids are allowed	Divisible and indivisible bids are allowed	Divisible and indivisible bids are allowed	Divisible and indivisible bids are allowed
Granularity	TSO: 1 MW DSO: 0.01 MW	TSO: 1 MW DSO: 0.01 MW	TSO: 1 MW DSO: 0.01 MW	0.01 MVar	0.01 MVar	0.01 MVar
Availability price	No	If required, in €/MW	Yes, in €/MWh	If required, in €/MVar	If required, in €/MVar	If required, in €/MVar
Activation price	Yes, in €/MWh	Yes, in €/MWh	If required, in €/MWh	Yes, in €/MVarh	Yes, in €/MVarh	Yes, in €/MVarh
Symmetric / Asymmetric	No symmetry required	No symmetry required	No symmetry required	No symmetry required	No symmetry required	No symmetry required
Aggregation	Allowed	Allowed	Allowed	Allowed	Allowed	Allowed

Where the requirements for product specification are [248]:

- Capacity / Energy – Determines whether the product accounts for the possible acquisition of capacity (MW) or energy (MWh)

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- Maximum full activation time (FAT) – Maximum admissible time period between the SO activation request and the corresponding full delivery of the concerned product.
- Minimum delivery period – Minimum period of delivery during which the service provider delivers the full requested change of power in-feed to, or the full requested change of withdrawals from the system.
- Maximum deactivation period – Maximum period for ramping from full delivery to a set (pre-agreed) point, or full withdrawal back to a set point.
- Maximum recovery period – Maximum duration between the end of the deactivation period and the following activation.
- Required mode of activation – The mode of activation of bids, i.e., manual, or automatic. Automatic
- activation is done automatically during the validity period (with little or no direct human control), whereas a manual activation is done at the SO's request.
- Minimum quantity – Minimum amount of power for one bid.
- Divisibility – The possibility for a SO to use only part of the bids, either in terms of power activation or time duration.
- Granularity – The smallest increment in volume of a bid.
- Availability price – Price for keeping the flexibility available (mostly expressed in €/MW/hour)
- Activation price – Price for the flexibility delivered (mostly expressed in € /MWh)
- Symmetric / Asymmetric – This attribute determines whether only symmetric products or also asymmetric products are allowed. For a symmetric product upward and downward volumes must be equal. For asymmetric products, upward and regulation volumes can be different. Two cases of asymmetric product are:
    - when either upward or downward regulation volume is set equal to zero (i.e., the product only covers downward or upwards offers).
    - When there is a rule linked upwards and downwards offers (e.g., upwards adjustment is 2/3 of downward adjustments)
- Aggregation – Determines whether a grouped offering of power by covering several units via an Aggregator is allowed.

Figure 5.34 illustrates the interaction between some of the time related requirements when activation takes place.

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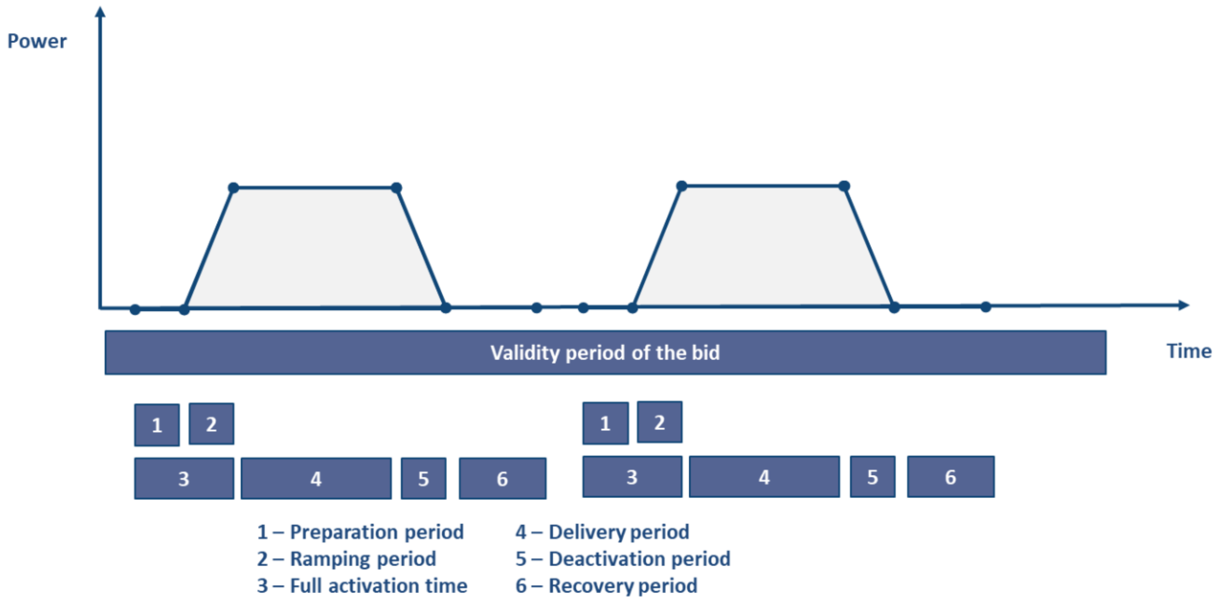

Figure 5.34 – Interactions between time related attributes [248]

5.2.3. EUniversal

In the EUniversal project a set of DSO needs and the services used to tackle them were identified, which are shown in Table 5.31.

Table 5.31 – EUniversal DSO needs and services to address them [249]

DSO need	Trigger	Time Frame	Flexibility services
Physical congestion	Failure	Operation Timeframe (real-time, on hourly basis)	Corrective Congestion Management
	Exceedance of thermal limits due to the forecasted load and generation situation	Short-term (daily or intraday)	Corrective Congestion Management Predictive Congestion Management
Voltage violation	Failure	Operation timeframe (real-time, on hourly basis)	Corrective Voltage Control
	Voltage dips		
	Voltage band violations due to the forecasted load and generation situation (e.g. under and over voltages, PV voltage fluctuation)	Short-term (daily or intraday)	Predictive Voltage Control
Support to network planning	Long-term forecasts of load and generation development	Long term	Support to Network Planning

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Phase balancing	Uneven connection of single-phase loads or generation (e.g. EV charging or one phase PV inverters)	Operation Timeframe, Short-Term	Corrective Voltage Control Predictive Voltage Control
Support to planned operations	Grid reconfiguration due to scheduled (maintenance) work	Short-term to medium term (daily, weekly)	Predictive Congestion Management Islanding Mobile Generation Capacity
Support to unplanned operations	Grid reconfiguration due to failure	Operation Timeframe (real-time, on hourly basis)	Corrective Congestion Management Corrective Voltage Control Islanding Emergency Load Control Mobile Generation Capacity
Support to extreme events	Grid reconfiguration due to failure	Operation Timeframe (real-time, on hourly basis)	Corrective Congestion Management Emergency Load Control Mobile Generation Capacity
	Voltage band violations		Corrective Voltage Control Mobile Generation Capacity
	Network Failure		Islanding
	Blackout		Black Start
Support to islanding	Network Failure	Operation Timeframe (real-time, on hourly basis)	Islanding

Unlike in the ENA proposal and in the OneNet project, in EUniversal flexibility for distribution grids goes beyond congestion management and voltage control, with the inclusion of islanding, black starts, emergency load control, among others.

Starting with congestion management, the envisioned services are Corrective Congestion Management and Predictive Congestion Management. Congestion management is an important part of the development and operation of power grids, being present right from the planning phase to the day-to-day operation. Besides, congestion management services based on flexibility from DERs are regarded as a mean to support the operation and the development of power grids. Since congestion management can be used for different timeframes, these services must reflect the different circumstances of each operational situation. For instance, for congestions that are caused by failures and subsequent corrective actions, DSOs need services which have a fast activation. Meanwhile, for congestions that are forecastable, market-related measures can be implemented to support DSOs [249]. The characteristics of the congestion management services considered in EUniversal are given in Table 5.32.

Table 5.32 – Technical requirements for Corrective and Predictive Congestion Management Services [249]

Parameter	Corrective Congestion Management	Predictive Congestion Management
Procurement timeframe and service timeframe	Operation timeframe (real-time, on hourly basis)	Short-term (daily or intraday)
Reservation and/or activation	Reservation not sensible as service is mostly necessary for emergencies and	Reservation and activation

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	scenarios with higher uncertainty. Therefore, activation when needed (directly to the service provider, for the next 15min).	Possible (based on requirements and availability)
Mode of activation	Manual	Manual
Expected duration of the response	The duration is restricted by thermal limits taking also into account the activation time of a resource.	As soon as the forecasts permit an evaluation of the measures but no later than gate closure time or regulatory imposed limits.
Full Activation time	Activation time should be aligned with thermal limits. Timeframes should be defined depending on the power ramping.	Activation time should be aligned with thermal limits. Timeframes should be defined depending on the power ramping.
Locational need / Geographic scope	Local (feeder, transformer, connection point) or regional (e.g., whole LV grid + overlaying MV feeder) or even cross regional (probably only for HV). DSO will activate (non-reserved) clients to solve the congestion issue.	Local (feeder, transformer, connection point) or regional (e.g., whole LV grid + overlaying MV feeder) or even cross regional (probably only for HV). DSO will let the market know which FSPs may solve the issue.
Mandatory (or not)	Mandatory	Procured on market or mandatory measures imposed by regulation
Aggregation	Restrictedly applicable	Aggregation from lower voltage levels is possible but may be limited dependent on market requirements and the technical characteristics of the congestion issue.
Minimum quantity	Based on the limits of power electronic equipment / measurement error	Based on the limits of power electronic equipment / measurement error
Maximum quantity	Limited to the installed capacity	Limited to the installed capacity
Deactivation period	Depends on the power Ramping	15min, considering available data
Minimum duration of delivery period	15min, considering available data (at the moment)	15min, considering available data
Maximum duration of delivery period	No limitation	No limitation

Where the requirements identified for the specification of flexibility services are [249]:

- Procurement timeframe: Identifies the timeframe for the procurement of flexibility in solving the problem, that is, the moment when the service is contracted (e.g., long-term planning, medium-term/seasonal planning, etc)
- Reservation and/or activation: Procurement of flexibility requires reservation in advance (e.g., day-ahead) or will be activated in real-time, or both.

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- Mode of activation: Flexibility can be activated manually at the request of the SO or automatically in case of local control strategies (e.g., at the inverter or other local controller) to change the reference power/voltage of flexible resources.
- Expected duration of the response: Time needed to solve the technical problem, and for which is expected the flexibility to participate. Evaluates de capability of DERs to provide the requested service. Necessary to define the bids and market procurement.
- Full Activation time: The period between the activation request by the SO and the corresponding full delivery of the concerned product.
- Locational need / Geographic scope: Identification if the response needs to be provided by node or if can be provided in a wider scope. Relevant to understand the possibility and way of aggregating resources.
- Mandatory: The participation of the mobilized flexibility is mandatory or not. After the clearing the flexibility requested by the DSO needs to ensure its response. Penalties may apply in case of non-delivery.
- Aggregation: Allowing resources to aggregate to meet the minimum quantities at a specific location. If the Aggregator doesn't have automatic control of flexible devices, this could have an impact on the time needed for activation.
- Minimum quantity: Define the minimum power that can be provided in each offer.
- Maximum quantity: Define the maximum power that can be provided in each offer.
- Deactivation period: Time expected for the flexibility resource to end delivering service after receiving a deactivation signal.
- Minimum duration of delivery period: Minimum time for the duration of the service provision.
- Maximum duration of delivery period: Maximum time for the duration of the service provision.

Regarding voltage control, the main difference between congestion management services and voltage control services is that, while the first only considerer active power, the second considers both active and reactive power. For voltage issues caused by network failures and related corrective actions, DSOs need services with fast activation. In the meantime, for forecastable voltage problems, DSOs have more technical and economical possibilities to optimize the control actions to solve the issue [249]. The characteristics of the two voltage control services considered are given in Table 5.33.

Table 5.33 – Technical requirements for Corrective and Predictive Voltage Control Services [249]

Parameter	Corrective Voltage Control	Predictive Voltage Control
Procurement timeframe and service timeframe	Operation timeframe, i.e., close to real-time	Short-term (daily, intraday or days ahead)
Reservation and/or activation	Activation when needed (directly to the FSP, for the next 15 min)	Reservation and activation are possible (based on requirements and availability)
Mode of activation	Manual (the inverters can change kVA/kVAr set point) Automatic (by using fixed voltage set point or a fixed curve in inverters)	Manual
Expected duration of the	MV: from seconds up to 1h	MV: from seconds up to 1h

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response	LV: up to 6h (e.g., at the peak of photovoltaic generation)	LV: up to 6h (e.g., at the peak of photovoltaic generation)
Full Activation time	Should be aligned to the scale of the problem. Timeframes should be defined depending on the level of voltage violation.	Activation time should be aligned to the scale of the problem. Timeframes should be defined depending on the level of voltage violation.
Locational need / Geographic scope	Locally (Substation, feeder, transformer, connection point)	Locally (Substation, feeder, transformer, connection point)
Mandatory (or not)	Mandatory	Procured on market or redispatch
Aggregation	Aggregation is possible but only within one connection point. In operation timeframe there is no time to perform complex analysis of the impact of distributed flexibility providers from lower voltage levels.	Aggregation is possible, but not in the form of simple power summation. It is necessary to perform an analysis, especially if the aggregated sources are connected at a different voltage level than the one for which the problem occurs.
Minimum quantity	Based on the limits of power electronic equipment / measurement error	Based on the limits of power electronic equipment / measurement error
Maximum quantity	Limited to the installed capacity	Limited to the installed capacity
Deactivation period	Depends on the power Ramping	15 min, considering available data
Minimum duration of delivery period	15 min, considering available data (at the moment)	15 min, considering available data (at the moment)
Maximum duration of delivery period	No limitation	No limitation

Meanwhile, flexibility services to support network planning result from the idea of considering flexibility during networking planning, as an alternative to grid investments. Here, flexibility is used as a tool to solve unexpected or forecasted congestions associated with low network capacity (voltage levels violations and/or overloads). This allows a more efficient grid development, as it can complement or even be an alternative to traditional investments, especially those intended to solve sporadic constraints. Thus, to solve the identified/predicted long-term network capacity constraints, a service which combines congestion management and/or voltage control can be used be needed. Such service considers a time frame of 1 to 3 years, longer than the timeframe for congestion management and voltage control described above (more focused on the short term). Additionally, flexibility reservation shall be done in advance, considering the identified/predicted congestions, and activated by the DSO when the time arrives, if it is still necessary. Depending on the risk/consequence associated with the identified/predicted congestion, reserved flexibility can be mandatory or not [249]. The characteristics of the only service to support network planning are given in Table 5.34.

Table 5.34 – Technical requirements for Support Network Planning [249]

Parameter	Support Network Planning
Procurement timeframe	1-3 years
Reservation and/or activation	Reservation in advance. Activated by operation.

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Mode of activation	Manual
Full Activation time	Activation time should be aligned with thermal limits. Timeframes should be defined, related to planning criteria
Locational need / Geographic scope	Substation, Feeder, Transformer, POC (equal and/or lower voltage level)
Mandatory (or not)	Depends on the risk associated with the congestion
Aggregation	Allow aggregation from equal and/or lower voltage level
Minimum quantity	Based on the limits of power electronics equipment / measurement error
Maximum quantity	Installed capacity
Delivery period	Several Hours

Regarding islanding, it allows certain parts of the grid to function independently from the rest, which is essential when it is not possible to provide energy to these areas for some reason, such as faults in lines, transformers, or other equipment. In these cases, flexible DERs can ensure power supply to all or at least to a part of the clients affected, forming a small microgrid. As a result, islanding is very important for improving the reliability and resilience of the distribution system [249]. The characteristics of the islanding service are given in Table 5.35.

Table 5.35 – Technical requirements for Islanding [249]

Parameter	Islanding service
Procurement timeframe and service timeframe	Short-term (Planned or forecasted events)
Reservation and/or activation	Reservation in advance. Activated by operation.
Mode of activation	Manual or automatic in case of unplanned faults
Expected duration of the response	1-3 hours
Activation time	Immediate after islanding (immediate after switch opens)
Locational need / Geographic scope	Locally within the microgrid area (typically HV/MV, MV feeder section or MV/LV substations)
Mandatory (or not)	Not mandatory
Aggregation	Not applicable
Minimum quantity	A minimum quantity could be established for the frequency and voltage regulation
Maximum quantity	Limited to the installed power of the provider
Deactivation period	< 1 min after reconnecting to the main grid
Minimum duration of delivery period	15 min, considering available data (at the moment)
Maximum duration of delivery period	Limited to energy capacity of the provider
Block loading size	Capability of grid forming units to respond instantaneously to load increase/decrease

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And, at last, there is the black start service. When islanding is not possible, or if, due to extreme events, there is a partial or general blackout in the main grid, storage systems can help to restore service to a local microgrid until it is possible to reconnect to the main grid [249]. The characteristics of the service for black starts are given in Table 5.36.

Table 5.36 – Technical requirements for black start [249].

Parameter	Black start
Procurement timeframe and service timeframe	Short-term (Planned or forecasted events)
Reservation and/or activation	Activation when needed (also possible reservation of units with black-start capabilities)
Mode of activation	Manual
Expected duration of the response	Depends on the time to reach the location where it is needed if provided by mobile systems
Activation time	Activation time should be aligned with the provider constraints. Timeframes should be stated by the provider and can be a parameter for selection.
Locational need / Geographic scope	Locally (typically at MV/LV Substation)
Mandatory (or not)	Not mandatory
Aggregation	Not applicable
Minimum quantity	A minimum quantity could be established for the frequency and voltage regulation
Maximum quantity	Limited to the installed power of the provider
Deactivation period	< 1 min after reconnecting to the main grid
Minimum duration of delivery period	> 30 minutes
Maximum duration of delivery period	Limited to energy capacity of the provider

5.2.4. EU-SysFlex

The services described in the EU-SysFlex projects are divided in four areas, including inertial response, frequency control, voltage control and congestion management. For each one of these areas a set of products are proposed [250], which are listed in Table 5, along with their main parameters.

Table 5- – Summary of EU-Sysflex services and products [250]

Service	Product	Capacity / Energy	Locational	Activation
Inertial Response	Inertia	Long-term capacity	no	Inherent
Frequency control	FFR	Capacity	no	Automatic (il)
	FCR	Capacity + Energy	no	Automatic (il)
	aFRR	Capacity + Energy	no	Automatic (S)
	mFRR/RR	Capacity + Energy	no	Manual
	Dynamic	Capacity	yes	Automatic (il)

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Voltage Control	Steady state reactive power	Capacity + Energy	yes	Manual
	Continuous dynamic reactive power	Capacity + Energy	yes	Automatic (S)
	Long-term capacity	Capacity	yes	-
Congestion Management	Short term Congestion Management	Capacity + Energy	yes	Manual
	Long Term/Medium Term Congestion Management	Capacity + Energy	yes	Manual
	Long Term Capacity Congestion Management Product	Capacity + Energy	yes	Manual

The first parameter, "Capacity/Energy", is related to whether the SO procures capacity and/or energy. In the case of capacity products, the buyer is provided with an obligation that an energy product corresponding to the capacity contracted will be provided when required. Meanwhile, for energy products, the buyer is provided with an energy to be delivered at the agreed delivery time for a predefined period. The next parameter, "Locational", is simply an indication if the product can only be delivered by assets located in a certain geographical area. The last parameters, "Activation", states the activation principle that suits the product [250].

5.3. Flexibility exchange proposal

This section presents the flexibility exchange proposal considered in the GDBN, with alignment with the flexibility-centric energy VC prosed in this document. The main steps include:

- Pre-Qualification
- Negotiation.
- Market Operation.
- Activation.
- Validation & Settlement.

5.3.1. Pre-qualification

The Pre-qualification phase deals with the certification of Aggregators and service providers (Company Qualification) and flexible assets, ensuring that they are financially and technically able for participating in the flexibility market and to provide flexibility. This process may have different degrees of complexity, such as market and financial pre-qualification of the flexibility providers, or technical pre-qualification, which can refer to the product or to the grid constraints, which in turn can be conditional or dynamic. However, it is assumed that these processes are performed outside the GDBN, either in the market platform, by the DSO, or both. The GDBN has the role of facilitating and increasing the interoperability of these processes. This process and the interactions with the GDBN are in Figure 5.35.

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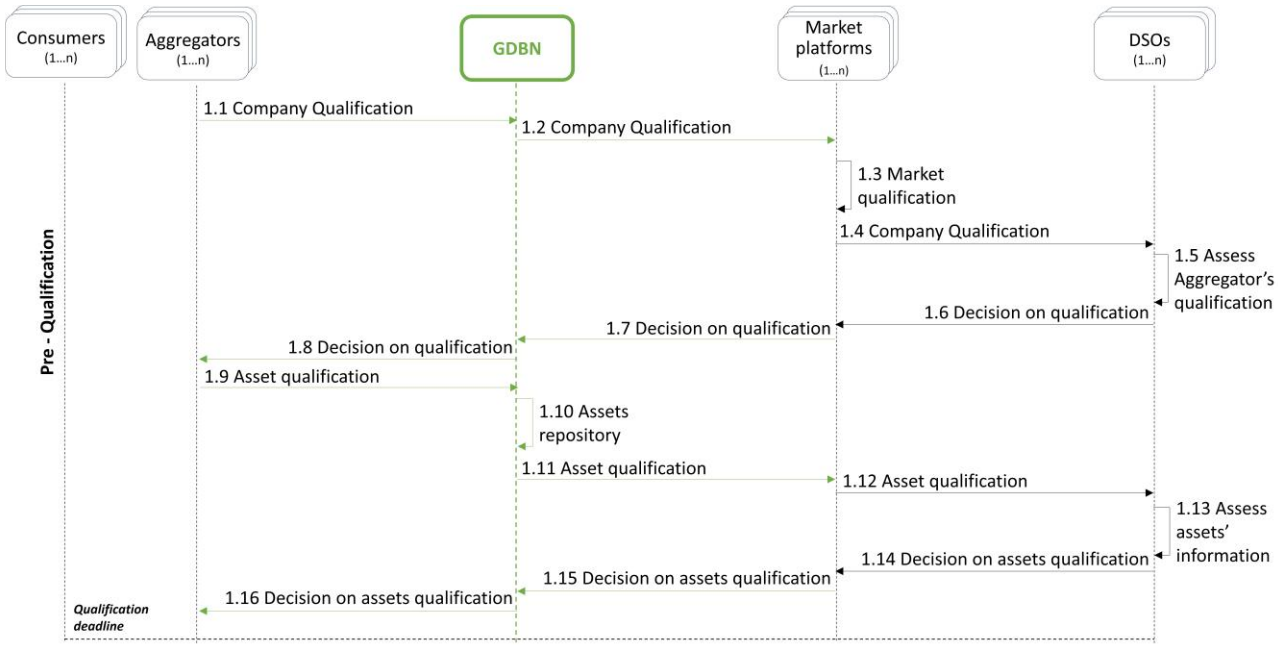

Figure 5.35 - Sequence for pre-qualification in GDBN

Two different pre-qualification are considered in the GDBN. Company pre-qualification refers normally to verifying the financial health of the Aggregator/service provider providing the flexibility service to be able to participate in the market and provide the corresponding guarantees. Asset/resource pre-qualification refers to the process of verifying that the resource owners and their resources have the technical capabilities to provide the flexibility according to the rules and technologies required.

Pre-qualification step-by-step:

1.1 The registered Aggregator requests for pre-qualification as a valid company in the GDBN, by starting the company qualification process.

1.2 The GDBN forward the request to the Market Platform, or service where pre-qualification is performed. Information about pre-qualified agents and assets is required to identify needs/capabilities of given regions and later for the flexibility activation stage.

1.3 Market pre-qualification is done, to check if the Aggregator has the necessary communication tools to connect to the market platform as well as the necessary financial guarantees, as suggested in [250].

1.4 The request for pre-qualification is also sent to the DSO, that can check non-technical information about the Aggregator, including current and historic financial data, audited financial accounts, registration number, legal relationship with the assets (as suggested in [158]). Note that this process is not standardized and mostly depends on the requirements and common practices of each DSO.

1.5 The DSO assess the information about the Aggregators.

1.6 The decision on company pre-qualification to participate in the market is communicated to the Market Platforms.

1.7 The decision on company pre-qualification to participate in the market is communicated to the GDBN.

1.8 The decision on company pre-qualification to participate in the market is communicated to the Aggregators.
1.9 If pre-qualified in the previous step, the pre-qualified Aggregator in terms of market participation can now request the pre-qualification of its flexible assets.
1.10 The technical information about the assets managed by Aggregator, already stored in the GDBN, is retrieved.
1.11 Assets' information is sent to the Market Platform
1.12 Assets' information is forwarded to the DSO to perform technical pre-qualification of the Aggregator's assets (for example based on [159]).
1.13 The DSO evaluates the technical information about the assets.
1.14 The DSO communicates the decision to the Market Platform.
1.15 The decision is forwarded to the GDBN.
1.16 The GDBN communicates that decision to the Aggregator.

Periodicity: one time process, or whenever significant changes to the assets occur.

5.3.2. Negotiation

The DSO makes their own grid analysis to assess potential constraints in the distribution grids. If one (or more) DSOs decide flexibility could solve some needs, the process to acquire flexibility using local market is started by publishing the flexibility need to which the Aggregators can respond by submitting flexibility bids if they have available resources in the DSO affected area, as shown in Figure 5.36.

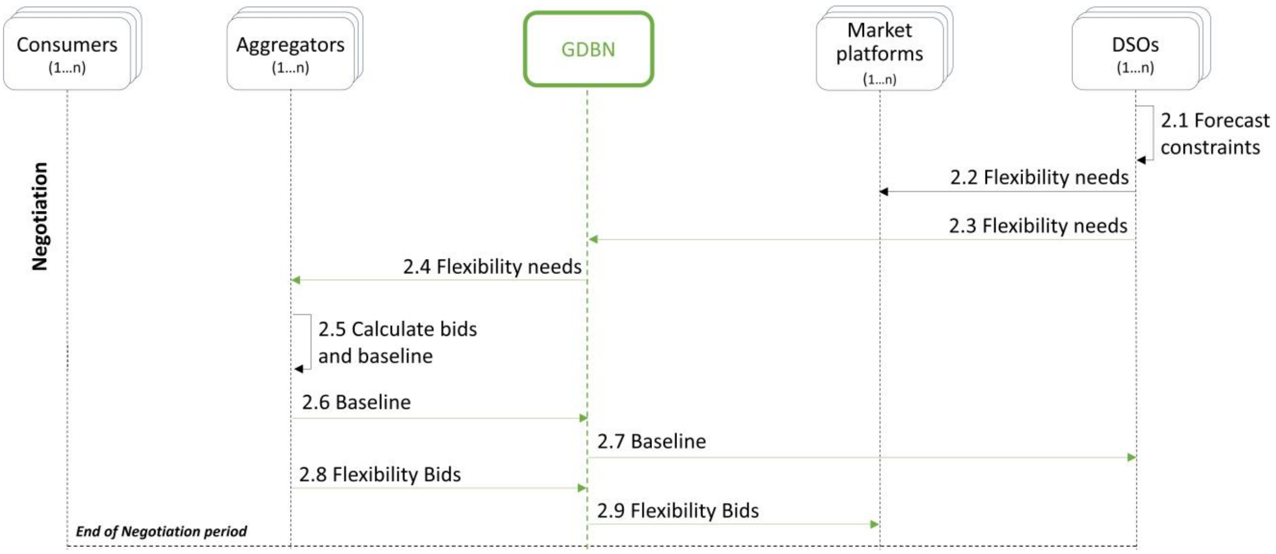

Figure 5.36 - Sequence for Negotiation in the GDBN

Negotiation step-by-step:

2.1 DSO assesses potential grid constraints (congestions or voltage problems).
2.2 If they expect constraints, and flexibility can be used to solve them, the DSO send their flexibility needs to a Market Platform.
2.3 Flexibility needs are also sent to the GDBN, either by the DSO, or the GDBN collects this information from the Market Platforms. 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 DSO decides it needs the flexibility reserved, or in activation mode, where the bid selection includes the flexibility activation that produces new Aggregator schedules.

2.4 The registered Aggregators are informed on the DSO's flexibility needs through the GDBN.
2.5 The Aggregators use the flexibility needs to determine their flexibility bids among the prequalified resources, and they also calculate their baselines.
2.6 The Aggregators who wish to submit flexibility bids send their baselines to the GDBN.
2.7 Baselines are forwarded from the GDBN to the DSO, considering that, for compatibility, even if some DSOs can implement their own verification tools, other could use a verification process supported by the GDBN.
2.8 Aggregators send their flexibility bids to the GDBN.
2.9 Flexibility bids are forwarded to the Market Platform.

Periodicity: when flexibility is requested.

Note that the GDBN is needed as an intermediator to facilitate interoperability, for example, with different market platforms, or for different DSOs that may need more or less support (services) from the GDBN for the flexibility activation and settlement. In this sense, to provide verification services to smaller DSOs using GDBN services, the baselines must be provided to the GDBN.

5.3.3. Market Operation

In the Market Operation phase, the market clearing is performed inside the Market Platforms. Due to technical requirements, the DSO might depart from the bids selected by the Market Platforms and make the final bids selection based on their technical criteria, as shown in Figure 5.37.

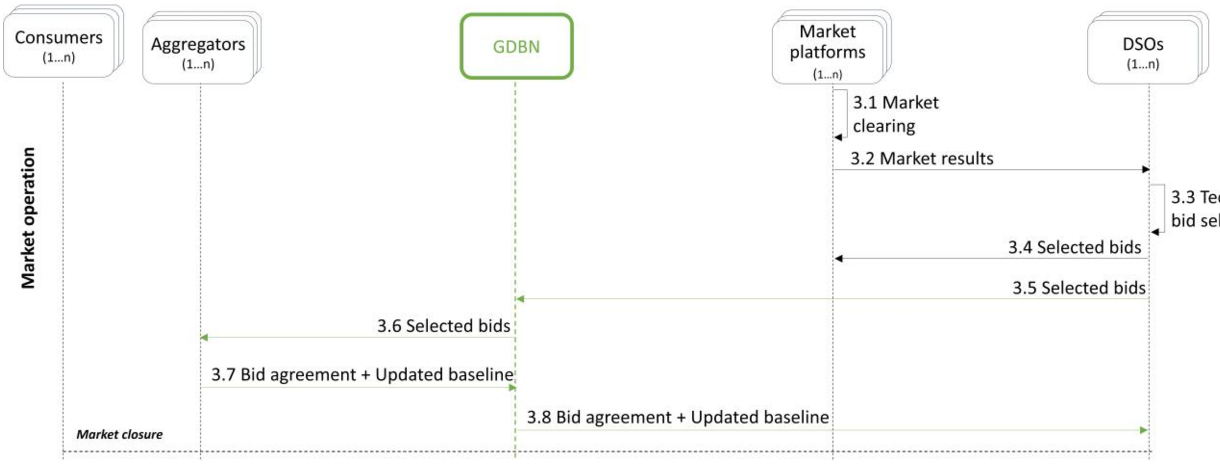

Figure 5.37 - Sequence for Market Operation in GDBN

Market Operation step-by-step:

3.1 The Market Platforms perform market clearing.
3.2 The results of market clearing are communicated to the DSO, and typically consist in a merit order list based on financial criteria.

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3.3 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.
3.4 Information on the selected bids is sent to the Market Platform.
3.5 Information on the selected bids is also sent to the GDBN.
3.6 The Aggregators receive the selected bids through the GDBN. If their offers are selected, Aggregators enter into a contractual agreement with the DSO. For the activated bids, the Aggregators integrate them into their optimal schedule and compute the new baseline (including the flexibility selected by the DSO).
3.7 The Aggregators send the signed agreement to the GDBN along with their updated baselines.
3.8 The GDBN sends the signed agreement to the DSO along with their updated baselines.

Periodicity: when scheduled after flexibility need is placed in the platform.

5.3.4. Activation

In the Activation phase, reserved flexibility can be activated close to real time. Several approaches can be found in the literature, from those that only consider the activation of the flexibility previously reserved, to those that open a close to real-time market to see if new flexibility in the market can be more cost-effective than the flexibility previously reserved. Note that the flexibility selected for activation in the previous step is already integrated into the Aggregators baselines and do not need additional explicit activation, as shown in Figure 5.38 .

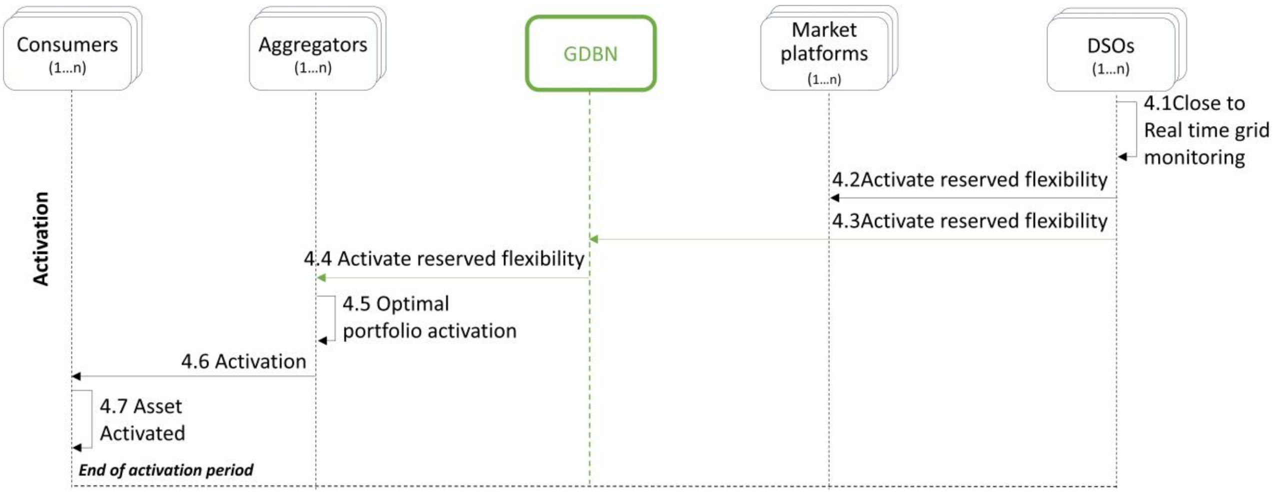

Figure 5.38 - Sequence for Activation in GDBN

Activation step-by-step:

4.1 The DSO assesses the distribution grids condition close to real time and decide that the flexibility previously reserved should be activated.
4.2 Information on the flexibility to be activated it sent to the Market Platform.
4.3 That information is also sent to the GDBN where contracted flexibility resources are registered (For simplicity, no close to real-time market is considered here, although DSOs could use this type of market to look for additional and more cost-effective flexibility).
4.4 GDBN sends the information to registered Aggregators of the resources to be activated.

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4.5 If possible, Aggregators optimize their portfolios prior to sending activation signals to the resources.
4.6 The flexibility activation is forwarded from the Aggregators to the Consumers' resources.
4.7 The flexible assets are activated.

Periodicity: close to real time, and every time reserved flexibility needs to be activated.

5.3.5. Validation & Settlement

In the last phase, Validation & Settlement, the flexibility delivered by each Aggregator is calculated using their baselines and remuneration/penalties are settled between the DSO and the Aggregators. This functionality is provided according to two possibilities, namely through services in the GDBN, or by allowing DSO specific services for the task.

5.3.5.1. Alternative 1 – service within the GDBN

In the last phase, Validation & Settlement, the flexibility delivered by each Aggregator is calculated using their baselines and remuneration/penalties are settled between the DSO and the Aggregators and between each Aggregator and its resource owners. Since the GDBN concept is designed to provide services to multiple DSOs, several alternatives can be considered.

In the first approach, depicted in Figure 5.39, the GDBN provides support to DSOs with in-built services related to verification and settlement of the flexibility provided by the Aggregators or FSPs. For that, it is important that the baselines are stored in the GDBN. This approach can be suited to smaller or regional DSOs with limited capabilities to invest in proprietary tools.

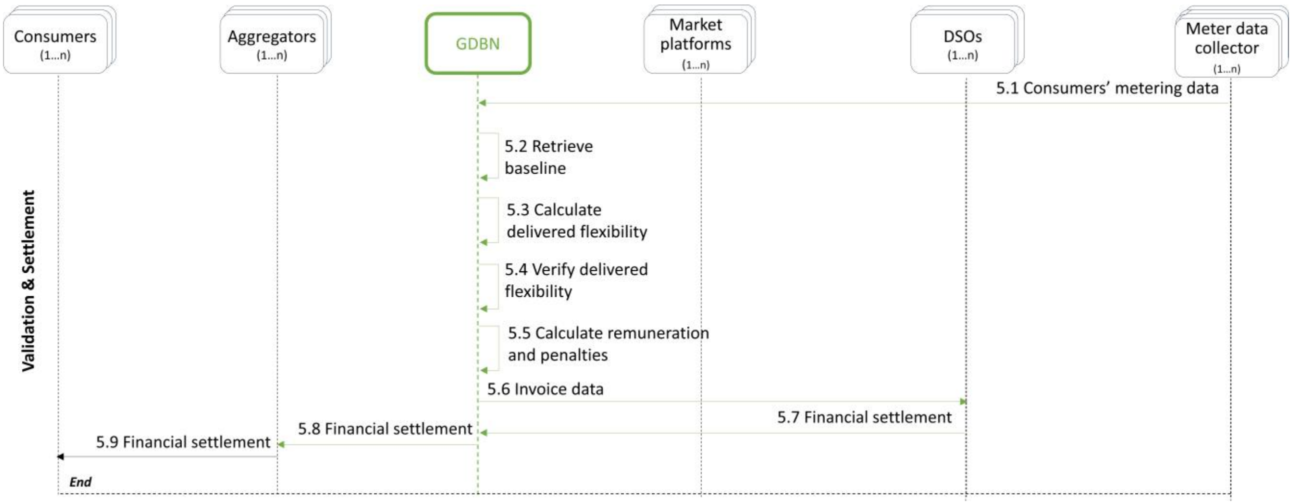

Figure 5.39 - Sequence for Validation & Settlement with service in GDBN (alternative 1)

Validation & settlement step-by-step (alternative 1 - service within GDBN):

5.1 Consumers' metering data is sent from the Meter Data Collector to the GDBN (in some cases the Meter Data Collector might be the DSO).
5.2 The GDBN retrieves the baselines of each Aggregator.

5.3 The GDBN 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 delivery.
5.4 The GDBN validates if deliverable flexibility is in line with requested activation.
5.5 The GDBN computes the flexibility remuneration (reserved, delivered and deviation penalties) according to DSO predefined flexibility remuneration rules.
5.6 The GDBN generates the data needed for invoicing and communicates it to the DSO.
5.7 The DSO communicates the financial settlements to the GDBN platform.
5.8 The GDBN forwards financial settlements to the Aggregators
5.9 The Aggregators sends the invoices to the respective Consumers completing the flexibility activation and settlement cycle.

Periodicity: monthly, like energy bills (with possibly informative daily pre-settlement).

5.3.5.2. Alternative 2 – service within DSO

As an alternative, Figure 5.40 shows the case of a larger DSO that already has its own tools related to verification and settlement.

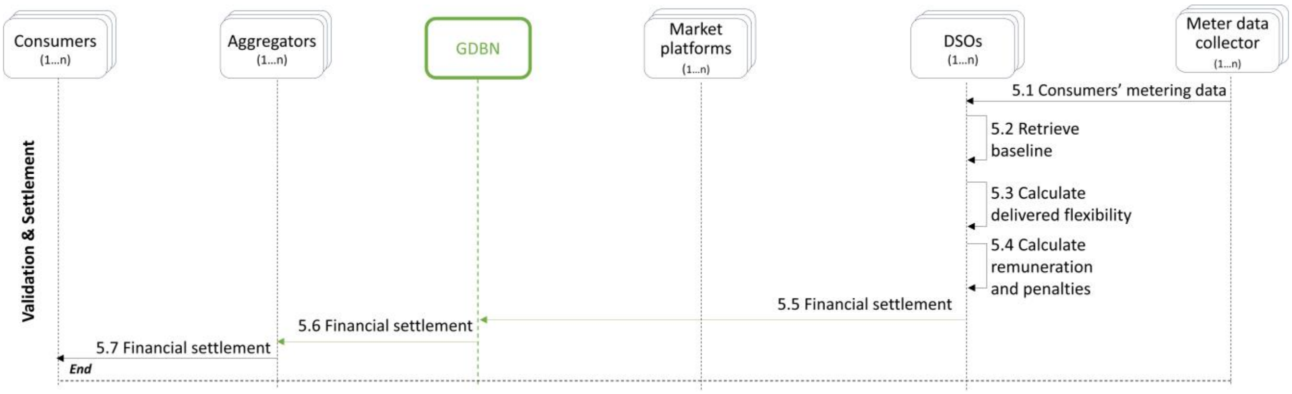

Figure 5.40 - Sequence for Validation & Settlement with service in DSO (alternative 2)

Validation & settlement step-by-step (alternative 2 - service within DSO):

5.1 Consumers' metering data is sent from the Meter Data Collector to the DSO (in the cases where the DSO is not the Meter Data Collector).
5.2 The DSO retrieves the baselines sent by the Aggregators (from the market operation phase)
5.3 DSO computes the deviation between the baselines and the delivered flexibility. 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 delivery.
5.4 The DSO compute the flexibility remuneration for the Aggregators (reserved, delivered and deviation penalties) according to the predefined flexibility remuneration rules.
5.5 The DSO communicate the financial settlements to the GDBN platform.
5.6 The GDBN forwards financial settlements to the Aggregators
5.7 The Aggregators send the invoices to the respective Consumers, completing the flexibility validation & settlement cycle.

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Periodicity: as needed after activation.

5.4. Basic Functionalities

This section describes the basic functions of the GDBN, describing the external view of the system, which consists in a use case diagram representing the exposed features.

Table 5.37 - GDBN Basic Functionalities

GDBN Basic Functionalities		
#	Name	Description
1.	Login and Authentication	Allow users to complete a user account registration and access services using it, depending on their role.
2.	Consent management	Allows users to provide consent for their data to be used, per usage intention/ service.
3.	Service registration / Cataloguing	Allows users to register services with business opportunities within the value chain. Services embody a global catalogue
4.	Catalogue of Flexible Assets	Flexible Assets from onboarded Consumers take part in the internal catalogue of assets that, in context of a usage consent is used in several services.
5.	Handling contracts between parties	Establish and control contractual agreements (through smart-contracts) for the actors enrolled in the value chain.
6.	Interoperable Data exchange across the value chain	Data exchange between operational platforms and systems of partners includes the option of being handled through an interoperable /standardized data interface.
7.	Download data	Allows users to download the data held by them in the GDBN.
8.	Value-chain orchestration	Configures the data floes between actors in a multi-tenant platform.
9.	Billing	Provides billing capabilities to the services that require them.
10.	Traceability	Allows actions and their consequent sub-actions to be tracked and verified.

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5.5. GDBN Flexibility Products and Flexibility Exchange

5.5.1. Flexibility Products

The products proposed to be implemented in the GDBN for demonstration purposes relate to predictive short-term (day ahead) active power, to react using active power to a forecasted system need within the operational planning timeframe. These products are Short-term Scheduled and Short-term Dispatched and are described in Table 5.38.

Table 5.38 - Flexibility Products selected for the GDBN

Product	Payment	Availability agreement period	Activation Instruction	Pricing Rule	Maximum admissible full activation time	Minimum Utilization
Short-term Scheduled	Reservation + Activation	Reservation at market clearing via market platform	Close to real-time via GDBN	Pay-as-clear or pay-as-bid	Close to real-time up to 1h before delivery	A multiple of 15min up to 1h
Short-term Dispatched	Activation (Activated when cleared)	No reservation	At gate closure via market platform + GDBN	Pay-as-clear or pay-as-bid	Close to real-time up to 1h before delivery	A multiple of 15min up to 1h

Product: The flexibility products provided by the GDBN. The duration of contract between the system operator and the market participant is day ahead (although larger terms could also be considered). The mode of activation (dispatch mechanism) of energy or capacity bids for flexibility needs is automatic through the GDBN, as the bid is triggered automatically in a closed-loop manner. At any time prior to the activation time the DSO can stop the activation through the GDBN.

Payment: The flexibility providers will receive payment for reservation (availability) during the life of the contract. If activation (delivery) is needed, the flexibility provider receives the payment for the delivered energy. Reservation payment depends on the type of product from Table 5.38.

Availability agreement period: The period before a product is required by a DSO, in which the DSO and FSP may agree the FSP's Availability Window.

Activation Instruction: Indicates the period before a product is required by a DSO, in which the DSO might send an activation instruction or signal to a FSP for the provision of flexibility.

Pricing Rule: This involves the method of determining the price of the flexibility product. There are two commonly used pricing rules: "Pay-as-clear" where all selected bids receive the price of the highest accepted bid, and "Pay-as-bid" where each bid is paid the price proposed on the bid. The selection between these two depends on the market design and the strategic objectives of the DSO.

Maximum Ramping period: It is the maximum allowed time for an FSP to reach their contracted flexibility capacity once an activation signal has been issued or becomes active.

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Minimum Utilization: The minimum amount of time a DSO will require the provision of a flexibility product from a FSP once a utilisation instruction has been issued. The least amount of time for which the service must be delivered once activated.

5.5.2. Short-term Dispatched

With a Short-term Dispatched product, the DSO procures, ahead of time, a pre-agreed change in the FSP's output (either increase or decrease), based on its forecasted network conditions. It corresponds to a situation when the DSO is certain that the flexibility will be needed, so that, when selected, the FSP reschedule its resources to comply with the selected flexibility. This means that the old baseline with the selected (and activated) flexibility leads to a new baseline (subsection 2.2.3 Market Operation phase). The aim is to help DSOs manage network constraints such as high or low voltage and thermal limits which are expected with high certainty, so the flexibility activation decision is taken well in advanced.

Key features are:

- When selected, this flexibility must be scheduled.
- Since there is no flexibility capacity reservation, no reservation fee is paid.
- The energy re-scheduled should be remunerated.

5.5.3. Short-term Scheduled

With a Short-term Scheduled product, the DSO procures, ahead of time, the option to activate a pre-agreed change in the FSP's output (either increase or decrease), based on its forecasted network conditions. However, the activation remains pending of a DSO decision closer to real time and according to actual grid condition, corresponding to a situation when the DSO is not certain if the flexibility will be needed.

Key features are:

- The flexibility is reserved but not activated until the DSO decides its activation close to real time.
- Since the FSP must guarantee the availability of the reserved flexibility, capacity reserved can be remunerated.
- If the activation is finally requested, the energy provided can also be remunerated.

5.5.4. Flexibility Exchange Payloads

This section overviews the data payloads considered in the flexibility requests of the GDBN. The construction of the data payloads departs from the relevant data interface specifications, namely from the OneNet Project, the UMEI specification from the EUniversal Project. Where applicable, semantic data representations mostly include domain concepts depicted in the SAREF ontology, specifically the flexibility concepts developed in the Interconnect Project.

Payload: Flexibility need request from DSO to GDBN	
Field	**Description**
request ID	Unique ID for this request.

requesterID	Unique ID in the GDBN for stakeholder issuing the request.
productID	Type of flex product request
contractDuration	Short-term
gridNodeID	Congestion node, area
flexibilityZoneID	Defines the Flexibility zone ID for which requests are sent
longFlexContractID	Long term contract Identifier
responseType	Power Up regulation or Power down regulation
periodFrom	Start time of the period
periodTo	End time of the period
volume	Required power for the specified time window
maxActivationPrice	The maximum activation price that the DSO will pay to activate the flexibility.
maxReservationPrice	The maximum reservation price that the DSO is willing to offer to reserve the flexibility.
gateClose	Market gate closure time
status	The current state for the request.

Payload: Flexibility request from GDBN to FSPs	
Field	**Description**
request ID	Unique ID for this request.
requesterID	Unique ID in the GDBN for stakeholder issuing the request.
contractDuration	Short-term
gridNodeID	Congestion node, area
flexibilityZoneID	Defines the Flexibility zone ID for which requests are sent
shortFlexContractID	Short term contract Identifier
responseType	Power Up regulation or Power down regulation
startTime	Start time of the period
endTime	End time of the period
minFlexible Capacity	The minimum amount of flexibility capacity a FSP may make available to DSO
gateOpen	Market gate open time
gateClose	Market gate closure time

Payload: Flexibility bid from FSP to GDBN

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Field	Description
bidID	Unique ID for this bid.
requesterID	Unique ID in the GDBN for stakeholder issuing the request.
energyVolume / minQuantity	The min amount of energy the FSP can provide for the time window
energyVolume / maxQuantity	The max amount of energy the FSP can provide for the time window
period / startTime	Start time of the period
period / endTime	End time of the period
period / maxNumberActivations	The maximum number of activations for the period the FSP can perform.
activationPrice	The price at which the FSP is willing to offer their flexibility service for activation for DSO needs.
reservationPrice	The price at which the FSP is willing to offer service to reserve flexibility for DSO needs.
bivisible	If this offer can be broken into sub-offers.
recoveryTime	The time required for a flexibility bid to be able to recover after one flexibility activation.
timestamp	Timestamp at which this request is issued in UTC time.

5.6. GDBN Services

5.6.1. Service: Install flexible assets in candidate consumers through service subscriptions.

Description
Service providers offer services with business models where consumers are provided with flexible assets in exchange for their participation while providing them incentives (e.g., with a no up-front investment for the consumer). This type of services will maximize the service provider portfolio of assets. Service providers specify when new candidates are included in their business plan, allowing to specify a limited by recurring period (e.g., enrolment campaign), or always have the open offer. This service in the GDBN provides a marketplace view, where primary stakeholders are creating B2C or B2B relationships / agreements.
Primary Stakeholder
Service providers, Consumers
Conditions
• Service providers have a business plan where incentives are clearly defined. • Consumers do not have flexible assets or do have them but want to increase their number

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Flexibility Value-chain stage
Flexibility Capacitation; Integration and Enablement

5.6.2. Service: Pair consumers with flexible assets and service providers exploiting flexibility BMs

Description
Service providers are matched with consumers with assets available in the value chain, engaging consumers and increasing flexibility potential. The GDBN matches enrolled consumers with and without flexible assets with service providers' offers (e.g., in specific geographies; with specific flexibility goals). Matching demand and offer will boost the service subscriptions from service providers and maximize the use of the available flexibility potential. Service providers specify the frequency when matching cycles occur for their services. A default daily matching is considered. The service will ensure service providers are not short on service subscription when using the value chain and consumers quickly start monetizing their existing assets or are contacted to subscribe services.
Primary Stakeholder
Service providers, Consumers
Conditions
• Registered consumers are available in the regional areas where service providers operate
Flexibility Value-chain stage
Flexibility Capacitation; Integration and Enablement

5.6.3. Energy Community Planning and Sizing

Description
The GDBN makes available the independent service that allows the planning and sizing of an energy community. This service conducts the evaluation of renewable energy community business models, considering different models for asset ownership and estimates its flexibility potential.
Primary Stakeholder
Aggregator, Flexibility Service Provider, Consumers
Conditions
• Registered consumers are available in the regional areas where service providers operate and consent for their data to be used. • Historical metering data for the community is available.
Flexibility Value-chain stage

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Flexibility Capacitation, Aggregation

5.6.4. Service: Operation and Management of Energy Communities

Description
The GDBN makes available the independent service that allows the management of energy communities with explicit flexibility provision. Different operation modes are considered: a) market-based, where decisions are totally or partially decentralized and therefore taken by the community members as market participants and b) centralized, but complying with market principles, where the flexibly assets schedules are computed with an optimization algorithm, and the collective benefits shared according to market-like principles based on a set of selected pricing mechanisms.
Primary Stakeholder
Aggregator, Flexibility Service Provider, Consumers
Conditions
• Registered consumers are available in the regional areas where service providers operate and consent for their data to be used. • Historical metering data for the community is available. • Flexible Asset data is available.
Flexibility Value-chain stage
Flexibility Capacitation, Aggregation

5.6.5. Service: Consumer Education

Description
The GDBN makes available the independent service educates consumers about sustainable energy consumption. Moreover, it also guides them to take decisions based on the available services on the business network (e.g., informing them about the possibilities to use roof space to install PV panels and that a service provider in the network is currently providing such services).
Primary Stakeholder
Flexibility Service Provider, Consumers
Conditions
• Registered consumers are available in the regional areas where service providers operate and consent for their data to be used.
Flexibility Value-chain stage
Flexibility Capacitation

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5.7. Deployment and life cycle

The GDBN is deployed as a cloud-based, multi-tenant application, hosted during this project in SAP's ecosystem. Despite of this deployment environment, the platform is ready to be configure elsewhere, in case that needs arises in the future. The lifecycle of the GDBN is depicted in Figure 5.41.

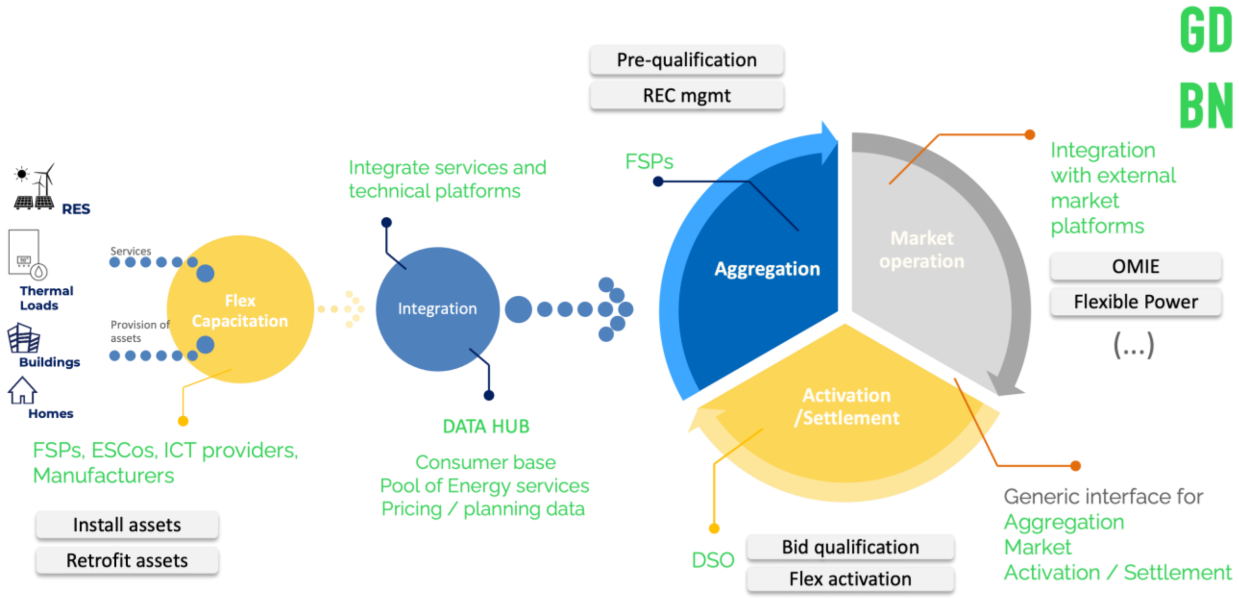

Figure 5.41 - GDBN lifecycle

It comprehends two main stages, namely a first stage, composed by the Flexibility Capacitation and the Integration steps of the Flexibility-centric Energy VC; and a second, periodic stage, comprehending the Aggregation, Market Operation and, finally, the Activation and Settlement step. While the former configures for most time a one-time-only onboarding procedure, notwithstanding the fact that it can act in parallel for different actors of the same time and as many times as changes are required, the latter configures the operational dimension, where periodic pre-qualification of flexibility occurs, aggregation, bid issuing to the market and the consequence activation commanded by DSOs. The period to which this second stage occurs default to daily, albeit it is configurable.

Along the steps, stakeholders can interact with services specifically available in these steps, or benefit from the VC integration and orchestration of data exchange for seamless operation. For each stage, either standard or interoperable data interfaces are present, allowing interoperability with foreign/external operational platforms (e.g., market platforms or DSO IT systems). Where applicable, the data modelling and data interfaces derive from results of other initiatives, namely: the representation of flexibility and flexibility zones derive from the EUniversal H2020 project UMEI API Specification [251]; or the data connectors for interoperable data exchange in the data spaces initiatives approach and OMIE interfaces developed in the OneNet H2020 project.

D3.2 details the technical architecture of the GDBN, along with the onboarding and integration requirements for different classes of stakeholders.

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5.8. Business Model for the GDBN

The growing pressure for decarbonizing the energy VC and the decentralization goals are currently opening opportunities for non-traditional stakeholders such as retailers or the automotive industry players to offer services and establish new operators along the VC, namely, to generate and aggregate. It is estimated that by 2030, the wide energy VC could produce turnovers of 23 billion Euro [252]. Capturing the flexibility potential installed will rely in ensuring resilience and stability on the operational side, while technical coordination on the IT side will be key for decision making. The need for control, interoperability, and data sharing among stakeholders, opens opportunities for operators such as those of the GDBN to return a profit from the availability of support digital services provided to stakeholders along the flexibility VC.

Despite the range of open energy marketplace initiatives launched in the past years (see section 5.1) different business, regulatory [71], and technical barriers persists. Amongst others, diverse lack of standards, APIs and semantics inhibit interoperability, while security and privacy concerns are exposing the actors to risks. The GDBN is proposing to lower these barriers for service providers by providing enterprise-ready functionalities (Table 5.37), together with an exhaustive and standardized description of the roles and interactions along the VC (Figure 4.2). The candidate BMC (Figure 5.39) highlights the main added value of the GDBN ecosystem. As the system encompass many actors and processes, we highlighted, in bold, our main contributions to the development of the flexibility market.

Still the go-to-market of a platform like GDBN should consider the different regulations and market maturity of the member states to better address the operation in the local ecosystem allowing for a certain degree of localization in the EU highly fragmented market.

One possible avenue will be to propose a franchise model to distribute the GDBN that can address country-specific / local conditions and coping with the level of maturity of the market. Within Europe, we identified two types of markets: a) Low maturity market: only few actors or experiments are currently involved in the flexibility market, the amount of flexibility traded is relatively low, e.g., France, Spain or Italy b) Medium maturity market: a number of actors, largely existing utilities, their spin-off and few "*flexible native*" actors, are involved and the amount of flexibility traded is average, e.g., UK, The Netherlands or Germany.

The GDBN will enable the flexibility development in different ways for the two level of maturity that we identified: a) Low maturity market - develop: the GDBN will enable the inception of such market by providing a new opportunity for local market players to leverage flexibility revenue leveraging standardized processes and APIs; b) Medium maturity market - scale: the GDBN will increase the adoption of the flexibility market by enabling newcomers to provide new services along the VC and will enhance the adoption of standards and better adherence to regulation.

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Table 5.39 - BMC of the GDBN

<table>
<tr><th>Key actors:</th><th>Key activities:</th><th>Value proposition:</th><th>Actors’ relationship:</th><th>Customers segment:</th></tr>
<tr>
<td rowspan="3">- Service Providers (Suppliers, Installers, O&M)
- Grid Stakeholders (DSOs)
- Resource Aggregators
- DER Manager and Provider
- Consumers and Prosumers</td>
<td>- Value Chain Engagement and Onboarding
- Contract Implementation
- Runtime and maintenance of the Business Network
- Integration and management of Cash-Flow Mechanisms
- Ensure: Data protection, Intellectual property, Regulatory compliance
- Ensure compliance with regulations</td>
<td rowspan="3">- Lower flexibility entry barriers
- Streamlined and Automated Flexibility Market
- Monetization
- Access to Flexibility Business Models
- Targeted Energy services
- Non-Energy Services: Billing, Energy Data Repository, Integration Services, Customer Data Management of Flexibility Assets
- Reduced Operational Costs through Integration and Standardization</td>
<td>- Process oriented relationship
- Sales/support agent
- Online Support for Consumers and Service Providers
- Regular Notifications and Updates on Value Chain Activities</td>
<td rowspan="3">- Owner without any Flexible Assets/DER equipment
- Owner with Flexible Assets but without services
- Service providers</td>
</tr>
<tr><th>Key resources:</th><th>Channels:</th></tr>
<tr>
<td>- Cloud-Based Grid Data Business Network (GDBN)
- Digital Platform Infrastructure
- Contracts for Value Chain Processes
- Marketing, Partnership and Development/Implementation Teams</td>
<td>- GDBN Marketplace</td>
</tr>
<tr><th colspan="3">Costs:</th><th colspan="2">Revenues:</th></tr>
<tr>
<td colspan="3">- IT Infrastructure and Security Costs
- Customer Support and Service Costs
- Platform and Software maintenance costs</td>
<td colspan="2">- Transaction Fees from Service Providers for Value Chain Participation
- Fee for accessing complete historical data (Load Generation Model)
- FlexProvider may pay a fee on the flex volume
- Enabling Providers may pay a monthly fee per device
- Franchise model (GDBN as a platform that may be customizable for different geographies and operated by different type of actors / consortium)</td>
</tr>
</table>

6. BeFlexible Business Use Cases

6.1. Use Cases Methodology

6.1.1. Definitions

The following nomenclature and definitions are used across all use cases, as well as in this report. The IEC 62559 was the baseline document for these definitions, and nomenclature defined in past European projects (e.g., FP7 evolvDSO, H2020 TDX-ASSIST and OneNet) was also used to define concepts such as business use cases (BUC) and system use cases (SUC).

Domain is an area of knowledge or activity characterized by a set of concepts and terminology understood by the practitioners in that area. EXAMPLE Taken from Smart Grid/energy system area: Generation, transmission, distribution, customer.

Actor is an entity that communicates and interacts. **Role** is played by an actor in interaction with the system under discussion. EXAMPLES: A legally defined market participant (e.g., grid operator, customer), a generic role which represents a bundle of possible roles (e.g., flexibility operator) or an artificially defined body needed for generic process and use case descriptions. It is important to emphasize that an actor can have different roles and different actors can play the same role.

Use case describes functions of a system in a technology-neutral way. It identifies participating actors that can for instance be other systems or human actors that 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 described either as BUC or SUC.

Business Use Case (BUC) describes a business process (expected to be system agnostic) and actors involved are business Roles (e.g., organisations, organisational entities, or physical persons) [253]. Defined as High Level Use Case in IEC 62559-2, and as *"describes a general requirement, idea or concept independently from a specific technical realization like an architectural solution"*.

System Use Case (SUC) describes a function or sub-function supporting one or several business processes and actors involved are business roles and system roles (e.g., devices, information system) [X]. Defined as Primary Use Case in IEC 62559-2, and as *"describes in detail the functionality of (a part of) a business process"*.

Primary actor is who or which initiates an interaction with the system under development to achieve a goal.

Functional requirements capture the intended behaviour of the system. This behaviour may be expressed as, services, tasks, and functions, which the system is required to perform. Use cases are a valuable tool to capture the functional requirements of a system.

Non-functional requirements capture general restrictions the system is subject to, such as:

- Pre-existing architectural constraints.
- Architectural qualities (extensibility, flexibility…).
- Performances, reliability, fault tolerance, frequency.
- Maintainability.

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- Security.
- Priority.
- Etc.

Business requirements (e.g., regulatory, market, legal) associated to the business function where it is important that the different parties of the involved process (change of supplier, billing, and new services) adopt and use a common model/framework. These should be formulated in a technology and technical-architecture neutral way, and in some cases are the harmonised result of discussion between various stakeholders. These business requirements are, in general, associated to the BUC.

Finally, it is important to underline that use cases must capture all the functional requirements of a given system (business process or function), and part of its non-functional requirements (performance, security, or interoperability for instance), not based on specific technologies, products, or solutions. Moreover, the BUC should capture their business requirements, which in BeFlexible are mainly related to regulatory, market and social aspects departing from the work in Tasks 1.1 and 1.2 and WP2 conducted until Month M18.

6.1.2. Use cases identification and writing process

The use case identification and writing process was inspired by the use case methodology adopted in several EU projects, e.g., FP7 evolvDSO, H2020 TDX-ASSIST, H2020 InteGrid, H2020 OneNet projects, also based in the IEC PAS 62559:2008, *"IntelliGrid methodology for developing requirements for energy systems"* standard, and using IEC 62559-2 template to describe BUC (in this document) designed to implement the key functions and services associated with the flexibility-centric value chain of TSOs, DSOs, Aggregators, ESCos, and system use cases (innovative smart grid and energy management functions described in D3.1 from Task 3.1).

In BeFlexible, the work with the use cases identification started in an Online Workshop session organized on 23rd January 2023, which aimed at conducting a first assessment of the project and end-users' goals (i.e., TSO, DSO, Aggregators, energy service providers, digital solutions providers). Five topics were defined for a discussion between all consortium members:

- Local energy sharing and flexibility market.
- Grid-centric flexibility.
- TSO-DSO flexibility coordination and information exchange.
- Cross-sector flexibility-centric services.
- Aggregation of flexible resources.

All the discussion circulated around these topics. This allowed to identify the potential benefits and/or consequences on different stakeholders and evaluate to what extent these five topics would bring value to the smart energy system ecosystem. Moreover, to ensure coherence with the BeFlexible Description of Action (DoA), the list of services in Section 1.2 of the DoA was condensed into a set of 26 potential business functions that was used as a starting point for the workshop discussion.

The outcome was a list of 20 new or improved business processes (composed by different partners) with the following information:

- Primary actor.

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- Secondary actors.
- Business goals and priority: high, medium, low.
- New functional processes.

The information presented at the end of the workshop was compiled to create a first draft version of the business goals and use cases and enabled offline assessment of the risks related to the demonstration activities. The main objective was to construct the hierarchy of goals proposed by [254], namely: summary goals; user goals; sub-functions. The business goals give a first answer to the question: *"Why is the primary actor doing this?"*; conversely, the functional processes answer: *"How is the system going to deliver the primary actor goal?"*.

In the BeFlexible nomenclature (section 6.1.1), and according to IEC 62559-2 definitions, the BUC is related with the first question and the SUC with the second one (the identification and writing of the SUCs was conducted in Task 3.1 of the project). In other words, a BUC is concerned with describing how the business operates and its associated requirements, while a SUC is concerned with using functions and sub-functions to achieve a certain goal.

A second Online Workshop was organized on 9th February 2023, and specifically dedicated to consolidating a first list of BUCs. Before the Workshop, partners involved in the demonstration activities (WP3, WP4 and WP5) were asked to provide the feedback about the list form the previous workshop and align it with their business goals, which were revised and consolidated by Task 1.4 leader into a single slide deck before the Workshop. The end-users (TSO, DSOs, Aggregators, ESCo) based this work on a thorough analysis of their roadmap, their internal organisation, as well as the current regulatory framework and its evolutions in the short and medium term. This allowed them to evaluate the potential gaps to be closed to implement the identified business processes in the demonstration sites and the impact on their organisation.

The results of the Workshop were a preliminary list of 12 BUCs (extended after the meeting to 13 BUCs by adding a consumer-centric use case to the list *"Optimal control of domestic thermal loads to reduce costs and boost flexibility"*), Use Cases Briefs (example presented in Table 6.1) and partners responsible for writing the BUCs. The criteria to consolidate and reduce the number of use cases were:

- Aggregation of use cases with common business goals and primary actor.
- The level of priority of the business process defined by the demonstration leader.
- Alignment with the objectives and WPs of the DoA.

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Table 6.1 – Example of business use case brief template.

ID	Primary actor (role)	Name of use case (Goal to be achieved)	Brief description	System Use Cases
BUC01	Energy Community Responsible (ECR)	Planning and sizing of energy communities considering customer flexibility	Study and simulate different configurations and business models for renewable energy communities (REC) and citizen energy communities (CEC), considering the role of flexibility service provider (FSP) for both TSO and DSO. This includes the sizing of the distributed energy resources (DER) within the community, including the joint ownership of assets, as well as simulation of pricing mechanisms within the community, considering the retailers' tariffs and flexibility from DER. This will enable economic feasibility analysis of energy communities, and quantify their flexibility potential to integrate, for instance, DSO long-term flexibility procurement mechanisms. It will use measured (or typical) consumption profiles, availability of renewable energy sources, and costs of technologies (both capital and operational cost).	SUC01.1 – DER sizing and economic evaluation of the REC / CEC business model

The final list of 13 BUCs was fixed in a follow-up meeting on 22nd March 2023 and each BUC brief was presented during the meeting. Furthermore, for each BUC was also made a preliminary identification of the corresponding SUCs, as illustrated in Table 6.1.

The project scope and objectives were mapped into four business domains, and thus the BUCs were also grouped according to them, namely:

- **Consumer/Community-centric flexibility**: planning and operation of renewable energy communities and citizen energy communities considering provision of energy flexibility to energy system stakeholders (e.g., DSO); consumer using flexibility to optimize its own objective function (e.g., cost minimization).
- **Grid-centric flexibility:** integration of DER flexibility (individual and aggregated) in TSO and DSO long-term and short-term management processes.
- **TSO-DSO flexibility coordination:** coordination between TSOs and DSOs in terms of flexibility monitoring, procurement, activation, and settlement, as well as related information exchange schemes.
- **Cross-sector flexibility boosters:** explore flexibility from other sectors, namely water distribution and electrical mobility; enabling interaction of the energy system sector with other business sectors (e.g., mobility, information) by solutions that support open APIs and solutions on open platforms, trust-raising technologies, and adequate service management.

The key idea is increasing energy system flexibility, enhancing cooperation among DSOs and with TSOs and easing participation of all energy-related actors through the validation and large-scale demonstration of adapted and proven cross-sectoral services, interoperable data exchange platforms for smart grids operation and the creation of required system architecture framework that will enable the creation of new business models providing additional value to meet consumers' needs in compliance with a stable regulatory framework.

The project has adapted the IEC 62559-2 template and instructions in the BeFlexible use cases template were provided to the writers (see Annex II). A commonly accepted standardized list and definition of the actors

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was used in the project, namely the BRIDGE *"Harmonized Electricity Market Role Model" (HEMRM)* [75]. Two types of use cases templates were considered:

- Long-version.
- Short-version: without the use case UML diagram and scenarios steps.

The division of BUC writing responsibility was made according to the person-month distribution for Task 1.4, and trying to push the involvement of TSOs, DSOs, demo leaders, Aggregators (IBESPAÑA) and services providers (e.g., SAP, TV). In fact, the DSO and the TSO were actively involved in leading the writing of several BUCs and cross-revision to ensure common agreement about terminology and standardized description of the business process.

To write the use case, each partner conducted interviews and workshops with the relevant internal business experts and analysts to describe the business processes, their activities and the associated information exchanges. It is important to highlight that the available smart grid infrastructure in each demonstration location and the regulatory framework were not considered to impose constraints in the use case writing. Therefore, the result was a set of business processes that go beyond the existing infrastructure and regulatory framework. The BUCs were reviewed by the Task leader and by the DSO, TSO, Aggregator and Service Provider (SAP) interested in leading the related demonstration activities.

The result of this work served as a basis for the identification of the functions to be described in SUCs and of the associated services and tools to be improved and demonstrated within the project (link with WP3 and WPs 4-6).

6.1.3. Identification of business requirements

The use case writing methodology is a powerful tool to document functional requirements and find business and non-functional requirements (mainly applied to SUCs). The methodology was also used to identify the impact of the changes and opportunities brought by energy flexibility, smart grid implementation, electricity market development and new regulatory frameworks (e.g., local energy communities).

The functional requirements correspond to each sentence of the step-by-step description of the use case ("Complete Description" – see Annex II), i.e., what its associated actors (roles) must do. When the use case is complete, we can assume that the main functional requirements were documented.

Business requirements are identified in a specific section of the use case. The partners were encouraged to identify the key business requirements covering different aspects (e.g., regulation, market, internal processes, new interactions between actors). Furthermore, to ensure a proper coordination and use of the work from Tasks 1.1/1.2 and WP2, the following process was followed:

- COMILLAS added to each applicable BUC the related regulatory changes (Task 1.1) and market structure/design (Task 1.2) for the business requirements of each BUC.
- SOUL used inputs from Tasks 2.1 and 2.2 for the business requirements, in particular related to value proposition and consumers engagement in flexibility-centric business models.

The methodology for analysing business requirements for the BeFlexible BUCs consists of the following steps:

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1. Screening of BUCs scope and objectives
2. Mapping of the BUCs, considering the demo that will demonstrate them, with the topics analysed in WP1 and WP2 and identification of the BUCs of interest for the business requirement analysis. For each BUC, analysis of the following BUC sections to identify the business requirements (market, regulatory, value proposition, social, etc.) to fully deploy the analysed BUC:
    a. Scope and objectives of use case
    b. Narrative of use case
    c. Use case conditions
    d. Diagrams of use case
    e. Technical details
    f. Step by step analysis of use case
    g. Information exchanged
    h. Common Terms and Definitions

    The final list of BUCs identified as of interest for the formalisation of the business requirements is defined as the result of this step.
3. Definition of Business requirements
    a. Business requirements analysis based on the WP1 (Tasks 1.1 and 1.2) and WP2 topics. For each topic, identification of the main aspects that links the BeFlexible BUCs to define the high-level aspects that deal with each BUC.
    b. Based on the outcome of the analysis in the previous steps, formalise the business requirements for the steps of interest for the requirement analysis defined in the section "Step by Step Analysis". Finally, fill the table in section "6 Requirement" of each BUC document with the formalised business requirement.

Finally, it is important to underline that the BUC do not capture all functional requirements. First, they do not intend to describe algorithms or aspects related to the design of a system's user interface. Besides, use cases, to be considered as generic, should not be based on specific technologies or products.

6.1.4. Identification of KPI

A set of KPIs are identified in each BUC. The BUC defined KPI linked to specific objectives and impacts from the DoA for each demonstrator, as well as the business process objectives. The list of KPIs considers different dimensions: technical, economic, environmental, and social (which will be also evaluated in WP7). For these use cases, a list of KPIs and definitions from past European projects was compiled and made available for writers to use (but only as suggestions). The writers also tried to identify economic KPIs to feed the cost-benefit analysis in in WP7.

Each KPI was characterized with the following information:

- **Type**: technical, social, economic, environmental

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- **Definition**
- **DoA KPI**: Yes, No
- **Target** (mandatory if defined in the DoA for the project duration)
- **Calculation methodology**
- **Data collection procedure:** it can be a questionnaire, data collected from the field, hybrid between collected data and simulation, historical data, etc.
- **Instrument preparation:** who collects and manage the data (e.g., who prepares the survey)
- **Instrument / data delivery**
- **Data analyst**
- **Reporting period:** describe here the reporting period of the KPI, e.g., daily, monthly, yearly
- **Business-as-usual (BAU) scenario:** describe how the BAU is calculated or estimated
- **Demo:** identification of the pilots where will be calculated
- **Identification of the associated BUC**

These KPIs will also identify room for improvement and weaknesses of the proposed innovative functionalities. The definition of these KPIs was up to the writer and there was no standardized list.

The complete list of KPIs can be found in Appendix IV, and it is presented with the associated BUC in section 6.2.

6.1.5. Benefits of the methodology for BeFlexible

The BUC consist of a coherent and structured description of business processes, which allows to analyse key issues according to different levels or perspectives while ensuring a global consistency. In fact, the use case methodology allows to represent the characteristics of a complex system and/or ecosystem according to a structuring and at the same time iterative method. Moreover, the methodology is a collective bargaining process that is based on a pragmatic approach. It is designed to involve and actively engage different partners (countries, organizations, domains, etc.) from the project, both during the writing and the review process. This contributes to provide an exhaustive and accurate list of requirements for the system under study and ensures no topic or point of view has been left aside.

Use case methodology is particularly appropriate for describing TSOs/DSOs/Aggregators/ESCOs services, business processes, and functions evolving with DER and smart grid technologies and as it allows domain experts to brainstorm new requirements. On this basis, its use is relevant to identify the impact of the changes and opportunities brought by emerging technologies in the energy sector, new business models, markets development, or regulations.

In BeFlexible, it allowed us to identify a set of new business processes across the four domains and to establish the foundations for the follow-up activities in other WP. The simple list of the BUC divided by domains gives to the stakeholders a summary image of the project’s scope, goals and activities.

Figure 6.1 summarizes the interrelations between the use cases work in Task 1.4 (WP1) and the other WPs of the project. The use case work in WP1, in combination with the work described in the DoA, will define a set of functional requirements that can lead to: a) new functions/services to specified in the SUC of WP3; b)

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improve existing minimum viable prototypes (MVP) – from past projects – in WPs 4-6 in order to comply with the new requirements. The demo preparation and validation plan from WPs 4-6 will follow the functional requirements from WP1, as well as the KPIs from the BUC.

The BUC will be analysed in WP3 (Task 3.3) in terms of requirements for the Grid Data and Business Network Ecosystem (Task 3.3) and BeFlexible reference architecture (Task 3.2). The construction of the demonstration sites and definition of their goals will be based in the outcome of the BUC work.

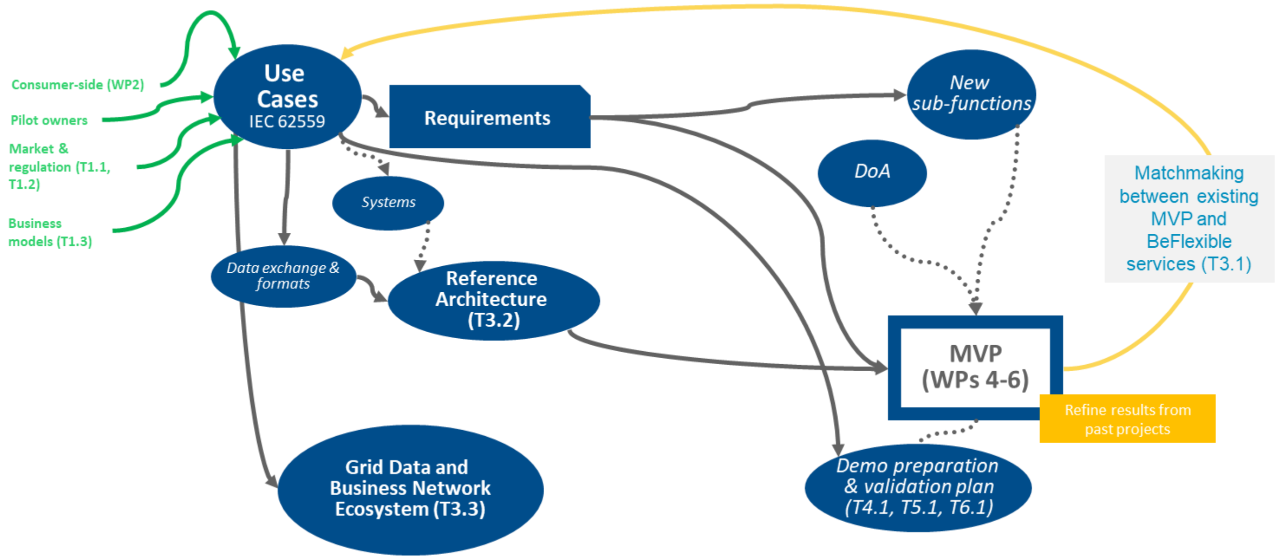

Figure 6.1 - Use cases impact across BeFlexible's work packages.

6.2. Overview of business use cases

This section presents a brief overview of the BUCs defined in the project and describes business functions, i.e., business layer of the SGAM framework. For each BUC, the scope, objectives, short-description, business requirements and SUCs are identified (fully described in Deliverable D3.1). Figure 6.2 depicts the 13 BUCs divided for the four domains.

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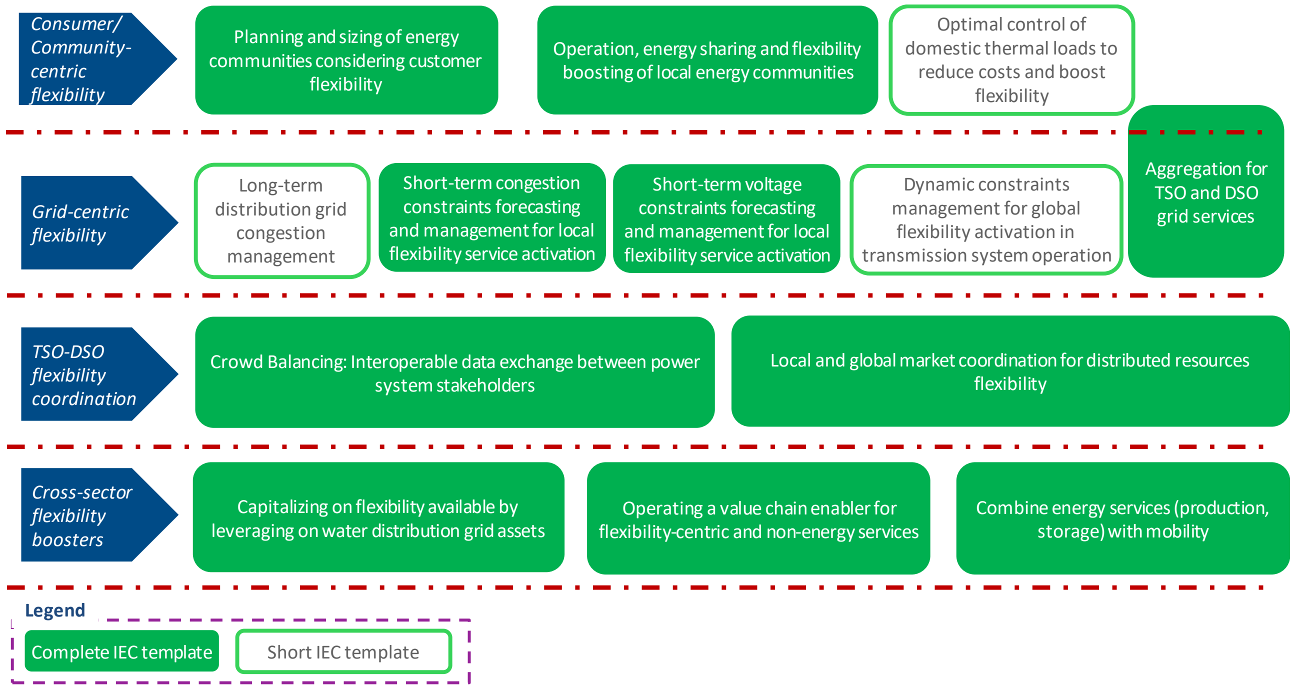

Figure 6.2 - BeFlexible's business use cases divided by domain.

Figure 6.3 depicts the mapping of the BUCs in the 11 BeFlexible's pilots distributed across four countries: Spain, Italy, France and Sweden. It is worth mentioning that this BUC list and distribution follows what was foreseen in the DoA.

Business Use Cases (BUC)	Italy			Sweden		Spain				France	
	Pilot 1.1	Pilot 1.2	Pilot 1.3	Pilot 2.1	Pilot 2.2	Pilot 3.1	Pilot 3.2	Pilot 3.3	Pilot 3.4	Pilot 3.5	Pilot 3.6
BUC 1. Planning and sizing of energy communities considering customer flexibility						■					
BUC 2. Operation, energy sharing and flexibility boosting of local energy communities						■					
BUC3. Optimal control of domestic thermal loads to reduce costs and boost flexibility							■		■	■	■
BUC 4. Long-term distribution grid congestion management		■	■	■	■	■			■		
BUC 5. Aggregation for TSO and DSO grid services					■	■	■	■	■	■	■
BUC 6. Short-term congestion constraints forecasting and management for local flexibility service activation	■	■	■	■		■	■	■	■		
BUC 7. Short-term voltage constraints forecasting and management for local flexibility service activation	■	■	■								
BUC 8. Crowd Balancing: Interoperable data exchange between power system stakeholders	■	■	■								
BUC 9. Local and global market coordination for distributed resources flexibility	■	■	■	■							
BUC 10. Dynamic constraints management for global flexibility activation in transmission system operation	■	■	■								
BUC 11. Capitalizing on flexibility available by leveraging on water distribution network assets	■										
BUC 12. Operating a value chain enabler for flexibility-centric and non-energy services							■			■	■
BUC 13. Combine energy services (production, storage) with mobility								■		■	■

Figure 6.3 – BUC mapped into each BeFlexible's pilots.

The following subsections present the scope, short description, SUCs and KPIs of each BeFlexible's BUC.

6.2.1. BUC01 – Planning and sizing of energy communities considering customer flexibility

Scope

Planning and sizing of renewable energy communities (REC) – Article 2(16) Recast Renewable Energy Directive – and Citizen Energy Communities (CEC) – Article 2(11) Recast Internal Electricity Market Directive.

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Customer flexibility is estimated in the long-term and can be integrated with long-term flexibility tenders from the DSO. The primary actor is Energy Community Manager (ECM).

Objectives

The main objective of this BUC is to conduct sizing and economic evaluation of REC and/or CEC business models, considering different assets ownership models and flexibility potential estimation. REC and CEC emphasise participation and effective control by citizens, local authorities, and smaller businesses whose primary economic activity is not the energy sector. Moreover, their main purpose is to generate social and environmental benefits rather than focusing on financial profits.

Short description

The ECM determines the optimal installed capacities in the REC/CEC, considering typical (or measured) consumption profiles, availability of RES, and costs of technologies (both capital and operational cost).

It consists in:

- Sizing of the DER within the community, including the joint ownership of assets.
- Construction of flexibility models, using field and typical data, for flexible loads.
- Simulation of pricing mechanisms within the community, considering the retailers' tariffs and flexibility from DER.

This will enable economic feasibility analysis of energy communities, which can be identified by combining data collected from the residencies with external data (e.g., weather, average income, etc.), in energy trading / sharing activities under different business models. The benefit is to de-risk investment in shared energy resources, maximize the benefits of new local energy communities, and enable quantification of grid-centric flexibility for DSO (for long-term flexibility procurement).

The BUC includes the following steps:

1. Define community design data for sizing and economic evaluation of the community
2. Request historical community data
    - 2.1 Obtain consent from data owner
    - 2.2 Data shared with the ECM
    - 2.3 Complete dataset
3. Study different sizing options and business models
    - 3.1 Solve the resources sizing problem
    - 3.2 Analyse business model
    - 3.3 Communicate results to community members and third-party service providers
4. Estimate available flexibility for flexibility procurement stages

System Use Cases

One SUC was generated from this BUC:

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- SUC01.1: DER sizing and economic evaluation of the LEC business model

Key performance indicators

KPI name	Type	Definition	Demo
Citizens benefitting from the solution	Social	Inhabitants of the building/household benefitting from service/solution (e.g., no. of employees in the organization or no. of household members). Estimated from loads facilitated by DSO using the point of delivery.	Spain/France
Typology of users (FSPs and end customers)	Social	Users classified by type, asset and/or sociodemographic information (only for end customers)	All
Literacy about flexibility	Social	Ability to understand and apply information about flexibility services	Spain/France
Trust/commitment with energy market actors	Social	Confidence in other actors' reliability and integrity/perception that a relationship is valuable and is worthy of efforts to maintain it	All
Perceived value creation: economic, functional, experiential, episteme, environmental and community	Social	Perceived benefits in the solution	Spain/Italy/Sweden
Readiness for flexibility provision	Social	Individual/organizational propensity to provide/use flexibility services, comprising perceptions of optimism, proficiency, vulnerability and dependency	All
Electricity cost reduction	Economic	Energy cost reduction for the individual members of the EC due to belonging to the EC and due to the provision of flexibility	Spain
Payback period	Economic	Time to recover the investment cost	Spain
Energy sharing ratio	Technical	Energy shared between EC members as a percentage of total locally produced energy.	Spain
Emissions reduction	Environmental	Aggregated members’ emissions reduction from participating in the EC compared to trading only with their BRPs.	Spain

6.2.2. BUC02 – Operation, energy sharing and flexibility boosting of local energy communities

Scope

Management and operation of energy communities (EC) with explicit flexibility provision. Different operation modes are considered: a) market-based, where decisions are totally or partially decentralized and therefore

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taken by the community members as market participants, and b) centralized, but complying with market principles, where the flexible assets schedules are computed with an optimization algorithm, and the collective benefits shared according to market-like principles based on a set of selected pricing mechanisms.

Objectives

1) Share energy among the community members for self-consumption. 2) Provide flexibility to third parties such as the local DSO.

Short description

The main actor is ECM, secondary but also essential actors are the prosumers, as they can become EC members of the community, and the DSO as the main flexibility procurer that will be considered. This BUC consists in:

- Operate an energy community with flexible assets to improve its economic performance, considering the provision of local flexibility.
- The energy community operation can be based on a market-based approach or be centrally managed but with market-like principles to share collective benefits among the members. Economics are based on the opportunity costs of the community members, based on the buying and selling tariffs with their retailers, and on inputs estimating the amount and price of the flexibility that could be provided to third parties.
- Members can own assets behind the meter or connected to the grid. Assets can also be shared among members. Finally, business models with assets shared among the community members and the local DSO will be considered.
- Different business models in terms of sharing and pricing mechanisms will be considered.
- Provide, as main outputs, the allocation coefficients that define how the internal energy sharing must be performed (so that retailers can be informed on the energy supplied, surplus and self-consumed), the flexibility that can be provided and indicators of the energy community performance.

This BUC has the following steps:

1. Establish and organize the EC

    1.1. Define and upload EC structure

    1.2. Configure selected business model

2. Continuously operate the EC

    2.1. Get metered and forecasted energy data.

    2.2. Compute transactions or shared energy and internal price

    2.3. Compute the flexible asset transactions and schedules considering flexibility.

    2.4. Activate the flexibility required by the DSO and verify its delivery.

    2.5. Compute the allocation coefficients or energy sharing mechanisms

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2.6. Inform DSO and retailer on energy supplied, surplus and self-consumed by EC Members.

2.7. Settle the financial compensations among the EC members and with third parties.

2.8. Provide indicators for individual and community performances.

System Use Cases

One SUC was generated from this BUC:

- SUC02.1: Operation of the energy community

Key performance indicators

KPI name	Type	Definition	Demo
Citizens benefitting from the solution	Social	Inhabitants of the building/household benefitting from service/solution (e.g., no. of employees in the organization or no. of household members). Estimated from loads facilitated by DSO using the point of delivery.	Spain/France
Typology of users (FSPs and end customers)	Social	Users classified by type, asset and/or sociodemographic information (only for end customers)	All
Literacy about flexibility	Social	Ability to understand and apply information about flexibility services	Spain/France
Trust/commitment with energy market actors	Social	Confidence in other actors' reliability and integrity/perception that a relationship is valuable and is worthy of efforts to maintain it	All
Perceived value creation: economic, functional, experiential, episteme, environmental and community	Social	Perceived benefits in the solution	Spain/Italy/Sweden
Readiness for flexibility provision	Social	Individual/organizational propensity to provide/use flexibility services, comprising perceptions of optimism, proficiency, vulnerability and dependency	All
Electricity cost reduction	Economic	Energy cost reduction for the individual members of the EC due to belonging to the EC and due to the provision of flexibility	Spain
Energy sharing ratio	Technical	Energy shared between EC members as a percentage of total locally produced energy.	Spain
Self-sufficiency	Technical	Energy consumed locally compared to the total energy consumed	Spain
Average buying price reduction	Economic	Average price of buying the energy within the EC.	Spain
Flexibility provision	Technical	Flexibility provided by the EC to the DSO compared to the flexibility required.	Spain

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6.2.3. BUC03 – Optimize domestic thermal loads to reduce costs and boost flexibility

Scope

Optimal control of thermal loads to reduce energy consumption and costs.

Objectives

1) Increase the controllability of thermal loads to enable the provision of flexibility services. 2) Reduce the energy consumption of the controlled thermal loads. 3) Reduce the energy bill associated with the consumption of the controlled thermal loads.

Short description

Optimal control of domestic thermal loads refers to the application of advanced technology and data analytics to manage energy consumption to optimize the usage of domestic thermal loads, such as electric water heaters, to reduce costs and increase flexibility. By leveraging advanced technology and data analytics, thermal loads can be controlled to reduce their energy usage and reduce energy costs by combining several services like:

- Increasing self-consumption (SC)
- Peak-shaving (PS)
- Dynamic tariff (DT) or Time-of-use (ToU) tariff optimization

It may also include the retrofit of devices to enable energy efficiency and demand response services on already installed devices.

The BUC includes the following steps:

1. Enabling thermal load controllability.

2. Optimize energy consumption.

    2.1. Monitoring

    2.2. Optimization

    2.3. Activation

3. Settlement

System Use Cases

Two SUC was generated from this BUC:

- SUC03.1 – Retrofit of thermoelectric water heaters
- SUC03.2 – Optimize thermal loads to reduce energy use and costs

Key performance indicators

KPI name	Type	Definition	Demo
Satisfaction of involved FSPs	Social	It assesses the level of satisfaction of FSPs participating in the program	All

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Registered end customers	Social	End customers signing the Terms and Conditions	Spain/France
Citizens benefitting from the solution	Social	Inhabitants of the building/household benefitting from service/solution (e.g., no. of employees in the organization or no. of household members).	Spain/France
Typology of users (FSPs and end customers)	Social	Users classified by type, asset and/or sociodemographic information (only for end customers)	All
Energy engagement (with flexibility services)	Social	It measures the level of engagement of end customers/FSPs with flexibility services	Spain/France
Literacy about flexibility	Social	Ability to understand and apply information about flexibility services	Spain/France
Trust/commitment with energy market actors	Social	Confidence in other actors' reliability and integrity/perception that a relationship is valuable and is worthy of efforts to maintain it	All
Perceived value creation: economic, functional, experiential, episteme, environmental and community	Social	Perceived benefits in the solution	Spain/Italy/Sweden
Continuance adoption	Social	Willingness to provide flex provision services once the project ends	All
Readiness for flexibility provision	Social	Individual/organizational propensity to provide/use flexibility services, comprising perceptions of optimism, proficiency, vulnerability and dependency	All

6.2.4. BUC04 – Long-term distribution grid congestion (and voltage constraints) management

Scope

Long-term congestion and voltage constraints management in the distribution grid.

Objectives

- Integrate flexibility into DSO grid planning processes and tools to properly assess its value and its potential to contribute to a smarter grid planning and operation, based on an analysis of its reliability to reach a cost-effective and reliable planning.
- Procurement of local flexibility products by the DSO to manage long term congestions (and voltage constraints) thus deferring/eliminating the need of traditional system investments.

Short description

This BUC will demonstrate long-term congestion management including procurement of local flexibility products by the DSO. Only for DEMO1 this BUC will consider also the long-term management of voltage constraints through active power modulation, since the activities and the systems involved are the same to detect both congestions and voltage constraints. This BUC describes the exchanges of information and the

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processes that should be established between DSO, forecast provider, FSP/aggregator and DER to solve long-term local distribution grid congestions (and voltage constraints) using flexibility thus deferring/eliminating the need of traditional system investments.

The objective is to integrate flexibility into DSO grid planning processes and tools to properly assess its value and its potential to contribute to a smarter grid planning and operation, based on an analysis of its reliability to reach a cost-effective and reliable planning.

It consists of the following steps:

1. Determine flexibility demand and value

    1.1 Perform long-term electricity load forecasts

    1.2 Assess congestion and voltage problems and quantify flexibility needs in a constrained grid point

    1.3 Determine the expected cost and value for the DSO to manage the constraint with flexibility

2. Acquire flexibility capital

    2.1 Procure availability contracts

    2.2 Sign non-firm connection agreements

    2.3 Prequalify DERs to market

3. Operate flexibility market

    3.1 Perform short-term load forecasts

    3.2 Activate market-based and non-market based availability contracts

    3.3 Validate delivered flexibility

    3.4 Settle with FSP

4. Evaluation of flexibility and improvement of grid planning

    4.1 Evaluate delivered flexibility and its reliability

    4.2 Improve the integration of flexibility into DSO grid planning processes and tools

System Use Cases

Four SUC was generated from this BUC:

- SUC04.1 –Load forecasts for long-term grid demand and quantification of flexibility needs
- SUC04.2 – Procure availability contracts
- SUC04.3 – Activate market-based and non-market-based long-term availability contracts
- SUC04.4 – Integrate flexibility into DSO grid planning processes and tools

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Key performance indicators

KPI name	Type	Definition	Demo
Number of prequalified FSP for flexibility provision	Technical	Number of FSPs able to provide system services.	Italy / Sweden
Number of flexibility activations	Technical	Number of services activated by the DSOs and TSOs.	Italy / Sweden
Satisfaction of involved FSPs	Social	It assesses the level of satisfaction of FSPs participating in the program	All
Typology of users (FSPs and end customers)	Social	Users classified by type, asset and/or sociodemographic information (only for end customers)	All
Energy engagement (with flexibility services)	Social	It measures the level of engagement of end customers/FSPs with flexibility services	Spain/France
Literacy about flexibility	Social	Ability to understand and apply information about flexibility services	Spain/France
Continuance adoption	Social	Willingness to provide flex provision services once the project ends	All
Available long-term flexibility	Technical	Available power flexibility in a defined period (e.g., per day) that can be allocated by the DSO at a specific grid segment. Measured in MW. This in relation with the total amount of power in the specific grid perimeter in the same period. One KPI for each test. the term power refer to measure demand in the area in reporting time at the specific grid location	Spain/Sweden
Congestion forecast accuracy	Technical	Degree of accuracy in predicting the occurrence and severity of grid congestions.	Spain/Sweden
Activated flexibility	Technical	This indicator measures the amount of activated flexibility by the DSO.	Sweden
Delivered flexibility	Technical	This indicator measures the amount of delivered flexibility in comparison with requested activated flexibility (%).	Spain/Sweden
Quality of flexibility delivery per FSP	Technical	This indicator measures how well each FSP delivers the flexibility that was activated by the DSO.	Sweden
Active flexibility service providers	Technical	This indicator measures the number of flexibility service providers that participate actively in the market.	Spain/Sweden
Economic value	Economic	Compare cost for flexibility and its management with cost if flexibility was not available, e.g., cost deferral or avoidance of network reinforcement.	Spain/Sweden

6.2.5. BUC05 – Aggregation for TSO and DSO grid services

Scope

Aggregation of flexibility from household thermal assets, battery energy systems, and building energy management systems.

Objectives

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Use aggregation services to offer flexibility in the local flexibility market to the DSO aiming to solve short and long-term congestion issues (DSO services procurement), and also offer flexibility to the TSO for different purposes.

Short description

As the main actor of this BUC is the Resource Aggregator aiming to aggregate different flexible assets (e.g., controllable loads, electric vehicle chargers, storage, distributed generation) located in different areas to offer local flexibility services to both TSO and DSO, considering short-term flexibility markets and long-term flexibility tenders for congestion management. Balancing services for TSO are also considered and its potential is evaluated against local flexibility services in terms of cost, technical requirements, and opportunity. The aggregation target is small-scale consumers (i.e., households and buildings) considering manual control from users.

The participation in aggregation needs tools to provide digital support. A Virtual Power Plant manages structural and dynamic data in order operate asset flexibility to solve DSO & TSO constraints. VPP is a software placed in the cloud which uses Internet-of-things, Artificial Intelligence and digitalization to communicate, aggregate and optimize distributed energy resources in different markets.

It consists in:

- Engage with DSO and TSO flexibility procurement processes in the short and long-term and offer flexibility potential (amount, location, and price).
- Incentivize final users to provide flexibility when requested by the Resources Aggregator, targeting their most flexibility (and cost-effective) assets, including the manual/automatic control of the resources.
- Decide the best flexibility products/mechanisms participate in, covering different time horizons and both TSOs/DSOs. Quantify and bid the aggregated flexibility in the selected markets and products.
- Settlement of the flexibility provision, e.g., division of benefits with the consumers.

The BUC has the following steps:

Short Term

1. Receive at VPP information from TSO and/or DSO about short-term flexibility needs in different network areas

    1.1 Check if this flexibility request corresponds to any flexibility products contracted in the short-term

    1.2 Submit short-term flexibility offer

2. Estimate flexibility potential

    2.1 Estimate flexibility potential per areas under procurement

    2.2 Decide how much flexibility capacity can be offered in the short-term:

3. Receive information about accepted flexibility offers

    3.1 The VPP will communicate this information to the DERs associated with the flexibility provision

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4. Through the VPP receive notification signal for flexibility activation by the TSO and DSO to the DERs

    4.1 Notify consumers (flexibility providers)

    4.2 Implement activation signals to provide requested flexibility

    4.3 Monitor provision of the flexibility per resource/point-of-delivery

    4.4 Apply remedial actions in case of flexibility shortage

    4.5 Manual control will be activated by DER's

5. Settlement of flexibility provision

    5.1 Settlement with consumers

Long Term

6. Receive at VPP information from TSO and/or DSO about long-term flexibility needs in different network areas

    6.1 Check if this flexibility request corresponds to any flexibility products contracted in the long-term

    6.2 Submit long-term flexibility offer

7. Estimate flexibility potential

    7.1 Estimate flexibility potential per areas under procurement

    7.2 Decide how much flexibility capacity can be offered in the long-term

8. Receive information about accepted flexibility offers

    8. 1. The VPP will communicate this information to the DERs associated with the flexibility provision

9. Through the VPP receive notification signal for flexibility activation by the TSO and DSO to the DERs

    9.1 Notify consumers (flexibility providers)

    9.2 Implement activation signals to provide requested flexibility

    9.3 Monitor provision of the flexibility per resource/point-of-delivery

    9.4 Apply remedial actions in case of flexibility shortage

    9.5 Manual control will be activated by DERs

10. Settlement of flexibility provision:

    10.1 Settlement with consumers

System Use Cases

Two SUC was generated from this BUC:

- SUC05.1 – Aggregate controllable assets to solve congestion problems to the DSO
- SUC05.2 – Aggregate controllable energy assets to provide flexibility services to the TSO

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Key performance indicators

KPI name	Type	Definition	Demo
Reduction of asset electrical energy consumption	Technical	Baseline: forecasted baseline vs flexibility activation.	Spain/France/Sweden
Reduction of asset energy wholesale value consumption	Economic	Baseline: forecasted baseline cost in day ahead market vs flexibility activation price.	Spain/France/Sweden
Number of DER's participants in aggregation	Technical	Number of aggregated flexibility providers.	Sapin/France/Sweden

6.2.6. BUC06 – Short-term congestion constraints forecasting and management for local flexibility service activation

Scope

Forecast of congestions and subsequent management of local flexibility.

Objectives

- Integrate flexibility into DSO grid operation processes and tools to exploit its potential in solving possible congestions.
- Demonstrates business potential of demand side products from DERs.
- Demonstrates the ability of the system operator in procuring the right amount of flexibility for occurring congestions.
- Demonstrates the ability of FSP in respecting the received activation signal.

Short description

This BUC analyses the short-term congestion management by means of the procurement of local flexibility products by the DSO. This BUC describes the exchanges of information and the processes that should be established between DSO, LFMO and FSP to solve distribution network local congestions.

Single or multiple timeframe markets are considered: a day-ahead market and possibly different following market sessions nearest to real time (such as intraday markets).

Both “day-ahead” and “intraday” markets will be used for short-term procurement of flexibility availability to support the network operational planning. The DSO will procure flexibility that could be activated one or more times during the life of the contract. The product will be usually set as an energy product, because of the necessity of short-term activation, but it could be set also as an availability and energy (activation) product, depending on the timeframe and characteristics of the problem to be solved. In both cases, the DSO procures flexibility with predefined activation characteristics (e.g., time of activation, duration, ramping periods, etc.). At activation time, the DSO monitors the delivery of the service. In the case of availability contract, the flexibility providers will receive a payment for the availability during the life of the contract. If activation is needed, the flexibility provider may receive an additional utilization payment or not (to be

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defined in the product specifications). If activation is needed and the flexibility provider is not able to deliver it as contracted, a penalty may apply.

The BUC has the following steps:

1. Prepare/pre-qualification
2. Plan/forecast
3. Market phase
4. Monitoring and activation
5. Metering and settlement phase

System Use Cases

Three SUC was generated from this BUC:

- SUC06.1 – Short-term flexibility procurement based on congestion and voltage constraints forecasting
- SUC06.2 – Short term flexibility activation for DSO congestion and voltage constraints management
- SUC06.3 – Settlement of flexibility services from DER participating to local market

Key performance indicators

KPI name	Type	Definition	Demo
Number of prequalified FSP for flexibility provision	Technical	Number of FSPs able to provide system services.	Italy / Sweden
Number of flexibility activations	Technical	Number of services activated by the DSOs and TSOs.	Italy / Sweden
Satisfaction of involved FSPs	Social	It assesses the level of satisfaction of FSPs participating in the program	All
Typology of users (FSPs and end customers)	Social	Users classified by type, asset and/or sociodemographic information (only for end customers)	All
Energy engagement (with flexibility services)	Social	It measures the level of engagement of end customers/FSPs with flexibility services	Spain/France
Literacy about flexibility	Social	Ability to understand and apply information about flexibility services	Spain/France
Continuace adoption	Social	Willingness to provide flex provision services once the project ends	All
Available long-term flexibility	Technical	Available power flexibility in a defined period (e.g., per day) that can be allocated by the DSO at a specific grid segment. Measured in MW. This in relation with the total amount of power in the specific grid perimeter in the same period. One KPI for each test. the term power refer to measure demand in the area in reporting time at the specific grid location	Spain/Sweden
Congestion forecast accuracy	Technical	Degree of accuracy in predicting the occurrence and severity of grid congestions.	Spain/Sweden

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Delivered flexibility	Technical	This indicator measures the amount of delivered flexibility in comparison with requested activated flexibility (%).	Spain/Sweden
Quality of flexibility delivery per FSP	Technical	This indicator measures how well each FSP delivers the flexibility that was activated by the DSO.	Sweden
Active flexibility service providers	Technical	This indicator measures the number of flexibility service providers that participate actively in the market.	Spain/Sweden
Economic value	Economic	Compare cost for flexibility and its management with cost if flexibility was not available, e.g., cost deferral or avoidance of network reinforcement.	Spain/Sweden
Number of consumers that have used the GDBN	Technical	Number of customers onboarded on services of the GDBN	Spain/France
Number of prequalified FSP for flexibility provision	Technical	Number of FSPs able to provide system services.	Italy / Sweden

6.2.7. BUC07 – Short-term congestion constraints forecasting and management for local flexibility service activation

Scope

Short-term voltage constraint forecasting and management in the distribution grid.

Objectives

Compensate for local voltage violations using the available flexibility from the resources installed in the grid.

Short description

The short-term voltage constraints forecasting and management can be used by the DSO to compensate for local voltage violations using the available resources installed in the grid. The main actors involved are the DSO and the Market. The problem to be solved is local, meaning that the resources installed in the vicinity of the voltage would have a higher impact in solving the voltage violations. The result of the control algorithm is formulated as flexibility demand for the Market, which then interacts with the Flexibility Service providers. The short-term control is performed on a day-ahead basis considering the predicted voltage violations. The resulting activation signal is sent on the same day using the latest information and eventually modified based on the updated forecasts and grid conditions. Monitoring devices installed in the electrical grid are required to enhance the grid observability, together with the knowledge of the electrical grid model.

The BUC includes the following steps.

1. Prepare/Pre-qualification

1.1 Grid pre-qualification

1.2 Product pre-qualification

2. Plan/Forecast

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3. Market Phase

4. Monitoring and Activation

5. Measurement phase

System Use Cases

The following SUC are associated to this BUC:

- SUC06.1 – Short-term flexibility procurement based on congestion and voltage constraints forecasting
- SUC06.2 – Short term flexibility activation for DSO congestion and voltage constraints management
- SUC06.3 – Settlement of flexibility services from DER participating to local market
- SUC07.1 – Online monitoring and observability enhancement to quantify the actual voltage condition

Note that in the Italian pilot, the activation of flexibility services described in SUC06.1, SUC06.2 and SUC06.3 can be implemented also to avoid voltage constraints violation (as defined in this BUC). Since the activities and the systems involved for the activation are the same for both congestions and voltage constraint violations these SUC are considered also applicable to BUC07.

Key performance indicators

KPI name	Type	Definition	Demo
Delivered flexibility	Technical	This indicator measures the amount of delivered flexibility in comparison with requested activated flexibility (%).	Spain/Sweden
Available short-term flexibility	Technical	Available power flexibility in a defined period (e.g., per day) that can be allocated by the DSO at a specific grid perimeter. This in relation with the total amount of flexible power registered in the specific grid perimeter in the same period (but not always entirely available and/or responsive).	Spain/Italy/Sweden
Voltage violations forecasting accuracy	Technical	Degree of accuracy (Mean Absolute error) in predicting the voltage violations.	Italy
State estimation accuracy	Technical	Degree of accuracy (Mean Absolute error) in estimating voltage values in the grid based on a limited number of measuring points.	Italy

6.2.8. BUC08 – Crowd Balancing: Interoperable data exchange between stakeholders

Scope

Coordinate local flexibility markets and global ancillary services market in the processes for procuring flexibility services from distributed resources.

Objectives

- Provide to global and/or local BSPs a common channel allowing data registry, market operation functionalities.
- Enable a common data exchange approach between TSO, DSOs and BSPs.

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Short description

The Crowd Balancing Platform (CBP) is a blockchain-based system available for sharing information between TSO, DSOs and BSPs in a trusted and secured way.

The BUC describes how TSO, DSOs, BSPs can register flexibility resources and exchange data via the Flexibility Register functionality during the resource prequalification process, facilitating TSO-DSO common information exchanges and Balance Service Provider (BSP) participation through a single channel for multiple markets access. Moreover, it supports transactions for market operations and Traffic Light data exchange between stakeholders enabling secure coordination between local markets and global market.

The BUC has the following steps:

1. Registration and pre-qualification

2. Market coordination

3. Constraints definition

4. TSO and DSO verification and settlement

System Use Cases

Four SUC was generated from this BUC:

- SUC08.1 – Flexibility Register
- SUC08.2 – Market data exchange functionalities
- SUC08.3 – Traffic light data exchange functionalities
- SUC08.4 – Verification functionalities

Key performance indicators

KPI name	Type	Definition	Demo
Impact of local constraints on DER providing global services	Technical	Amount of flexible power that can be reliably delivered from DERs to provide global services, with respect to their total potential. Evaluate the hosting capacity of the distribution network for DERs providing global services. KPI improvements can be expected in case of: - Effective and functional TSO-DSO coordination scheme - Local markets aimed at maximising global market participation	Italy

6.2.9. BUC09 – Local and global market coordination for distributed resources system service provision

Scope

The Business Use Case describes how TSO and DSO can coordinate the procurement of system services from distributed resources through local and global markets.

Objectives

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The market-based coordination among the involved actors aims to manage the procurement of services via efficient data exchange, avoiding network constraint violation when the resources are activated, allowing value stacking for the distributed resources, and striving for overall economic efficiency of market-based procurement.

Short description

The Business Use Case describes how TSO and DSO can coordinate the procurement of system services from distributed resources through local and global markets. Market-based coordination among the involved actors aims to efficiently allocate the resources available eventually avoiding over-procurement, avoiding network constraint violation when the resources are activated, allowing value stacking for the distributed resources, and striving for overall economic efficiency of market-based procurement. This opportunity depends on the market design and on the degree of integration within the DSO and TSO markets. The main actors involved are the TSO and DSO, and the secondary actors are the TSO, DSO, MO (when different from the system operator), Balance Responsible Parties, Flexibility Service providers, producer, and consumer. The local and global market coordination defined in this BUC considers the possible coordination at the market phase level (e.g., pre-qualification, demand forecast, procurement, activation, measurement, settlement) to increase the liquidity in all markets. The coordination between the TSO and DSO depends on different elements, such as where the need is located, who is the primary buyer of the service, how many markets are used and whether the TSO can directly acquire services from the distribution-connected resources via its own market. The coordination between the two markets will also allow for the DSO to monitor and control the participation of DERs in the balancing markets, and also allow for better market liquidity due to the increased possibility of value stacking.

The BUC includes the following steps:

1. Product/service prequalification in both the DSO and TSO flexibility markets;
2. Market based procurement:
    a. Explicit bids placement
    b. Local market clearing
    c. Local and Global Markets Coordination via the Dynamic Traffic Light
    d. Global market clearing
3. Service/product activation and real-time data exchange
4. Settlement

System Use Cases

The following SUC are associated to this BUC:

- SUC08.1 – Flexibility register
- SUC10.1 – Ex-ante validation
- SUC10.3 – Bids placements and verification
- SUC8.2 – Market data exchange functionalities

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- SUC 8.3 – Traffic light data exchange functionalities
- SUC 10.2 – Constraints definition
- SUC06.2 – Short term flexibility activation for DSO congestion and voltage constraints management
- SUC08.4 – Verification functionalities
- SUC10.4 – Delivery validation
- SUC06.3 – Settlement of flexibility services from DER participating to local market

Key performance indicators

KPI name	Type	Definition	Demo
Number of prequalified FSP for flexibility provision	Technical	Number of FSPs able to provide system services.	Italy / Sweden
Number of flexibility activations	Technical	Number of services activated by the DSOs and TSOs.	Italy / Sweden
Volume of data exchange	Technical	Volume of data exchange between local and TSO markets.	Italy / Sweden
Efficiency of prequalification process in coordinated markets	Technical	The decoupled nature of local and global markets leads to inefficiencies when they manage shared (aggregates of) DERs. This KPI measures how the TSO-DSO coordination improves the total cost of activated flexibility with respect to the ideal situation (fully coupled market).	Italy

6.2.10. BUC10 – Dynamic constraints management for global flexibility activation in transmission system operation

Scope

To guarantee the distribution grid security and quality during the provision of global services from distributed resources.

Objectives

- To integrate in the global flexibility procurement the possibility to make use of recourses connected to the distribution grid.
- To avoid indirect contingencies on DSOs.

Short description

Dynamic constraints management aims to integrate in the global flexibility procurement the possibility to make use of resources connected to the distribution grid while avoiding indirect contingencies on DSOs.

For this purpose, the Traffic Light Model is implemented as the following coordination scheme describes: the DSO expresses a constraint in terms of capacity available per grid portion to allow the flexibility activation of MV/LV connected resources without creating bottleneck; TSO, when selecting resources needed for the correct and safe operations of the Electricity System, is called to respect the constraints identified by the

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DSO. To properly enable the Traffic Light Model, a set of coordinated prequalification processes between TSO and DSO should be established and an accessible, customer friendly and secure data exchange platform should be provided to all the stakeholders.

The BUC has the following steps:

1. Registration and prequalification

2. Dynamic traffic lights creation

3. Grid constraints integration

4. TSO and DSO verification

System Use Cases

Four SUC integrate this BUC:

- SUC10.1 – Ex-ante validation
- SUC10.2 – Constraints definition
- SUC10.3 – Bids placements and verification
- SUC10.4 – Delivery validation

Key performance indicators

KPI name	Type	Definition	Demo
Impact of local constraints on DER providing global services	Technical	Amount of flexible power that can be reliably delivered from DERs to provide global services, with respect to their total potential. Evaluate the hosting capacity of the distribution network for DERs providing global services. KPI improvements can be expected in case of: - Effective and functional TSO-DSO coordination scheme - Local markets aimed at maximising global market participation	Italy

6.2.11. BUC11 – Capitalizing on flexibility available by leveraging on water distribution network assets

Scope

Investigate new methods to boost cross-sector flexibility between the water and electricity distribution systems.

Objectives

Exploitation of Water Distribution Network (WDN) capability to provide flexibility services to avoid/solve grid issues.

Short description

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Traditionally, water and power systems have been designed and operated as two uncoupled systems. However, in reality these systems are mutually interdependent. Water is used, often in large amounts, in energy sector for mining, fuel production, hydropower, and power plant cooling. On the other hand, energy is an indispensable component of the water facilities as electricity is used for pumping, treatment and distribution of water. This interrelationship is often referred to as water-energy nexus and couples these critical infrastructures upon which human civilization depends. The large energy consumption of water facilities along with their flexible assets such as water pumps and tanks make them suitable candidates for energy efficiency and optimization applications. The water distribution system operators (W-DSOs) have a natural incentive to act energy-conscious, where the operation coordination with power systems could reduce their electricity costs. However, W-DSOs may be also concerned about the negative impacts of modifying the operation of their systems on the reliable delivery of water to the consumers.

For the reasons outlined above, the BUC is focused on determining the flexibility potential from water distribution network to make it available to the electrical grids, thanks to a device provided by DSO to monitor the flexibility resource. It consists in:

1. Studying of the behaviour of water distribution assets.

2. Defining the process to monitor flexibility asset (tools and devices to provide flexibility).

3. Quantify flexibility potential to make it available to the electrical grids.

System Use Cases

One SUC integrates this BUC:

- SUC11.1 – Evaluate the flexibility capability of water distribution networks

Key performance indicators

KPI name	Type	Definition	Demo
Available flexibility from water distribution grids	Technical	Available Power Flexibility in a defined asset configuration that can be allocated by the DSO at a specific grid perimeter. Measured in kW.	Italy

6.2.12. BUC12 – Operating a value chain enabler for flexibility-centric energy and non-energy services

Scope

Describes the operation of a value chain enabler for flexibility-centric and non-energy services. The vision is taken from the main perspective of a Digital Platform Provider to: 1) Promote sustainable business models to unlock the distributed flexibility capacity of final consumers for an improved system operation, with special emphasis on DSO flexibility system services; 2) Facilitate DSOs of all sizes to participate in the flexibility value chain.

Objectives

- Identify and unlock consumers flexibility capacity by facilitating flexible resources acquisition or retrofit and their integration into the flexibility provision value chain.

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- Simplify the process of customer identification and acquisition in the scope of DSF services.
- Streamline a low-cost establishment of renewable energy communities with flexibility provision.
- Create business opportunities by linking prosumers, aggregators, DSOs and local flexibility and aggregator platforms for the different steps of the value chain.
- Facilitate the dispatch and activation process of flexibility.

Short description

Operation of a flexibility-centric value chain that leverages from a cloud-based digital platform (Grid Data Business Network - GDBN) to connect and engage key stakeholders in promoting new business services for energy flexibility. The main tasks are:

- Connect consumers with suppliers/installers/O&M service providers of flexible DER to participate in the value chain and exploit flexibility business models.
- Offer and search for targeted energy and non-energy services to consumers.
- Validate contractual agreements between parties.
- Integrate cash-flow mechanisms in the value chain.
- Enable the DSO to dispatch and activate flexibility in a fully interoperable way.

It consists in the following steps:

1. Engage flexibility stakeholders to participate in the value chain [Flexibility Capacitation]

2. Integrate flexible assets and services in the value chain [Integration/Enablement]

3. Aggregate flexibility potential [Aggregation]

4. Prepare flexibility bids and take them to Market [Negotiation]

5. Operate Market and select flexibility bids [Market Operation]

6. Enable the DSO to dispatch flexibility in a fully interoperable way [Activation & Settlement]

System Use Cases

Two SUC integrate this BUC:

- SUC12.1 – Connect flexibility providers across the value chain
- SUC12.2 – Support investment in flexibility by value chain actors

Key performance indicators

KPI name	Type	Definition	Demo
Registered end customers	Social	End customers signing the Terms and Conditions	Spain/France
Number of consumers that acquired demand side flexibility potential through the GDBN	Technical	Number of consumers that acquired demand side flexibility potential through the GDBN	France

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Consumer satisfaction about the GDBN services	Social	Measure the satisfaction on consumers using the services available in the GDBN (including those from external parties - ESCos and FSPs)	France
Number of services operating in the GDBN	Technical	The total number of services in the GDBN.	France
Number of consumers that have used the GDBN	Technical	Number of customers onboarded on services of the GDBN	Spain/France
Number of GDBN user connections	Technical	Averaged number of users connecting to the GDBN every month.	Spain/France
Flexibility capacity unlocked through the GDBN	Technical	Flexible assets (classified by type) made available via services provided in the GDBN.	France
Flexibility activated by the DSO via the GDBN	Technical	The flexibility activation requests that were dispatched by the DSO to be activated in FSPs onboarded in the GDBN, if regulation allows it.	Spain

6.2.13. BUC13 – Combine energy services (production, storage) with mobility

Scope

Electric Vehicle Supply Equipment (EVSE) powered by renewable energy sources considering charging flexibility, digital platforms, and data sharing.

Objectives

Decarbonize the corporate's fleet, offer EV users uniform charging tariffs (independently if they charge at home or office), maximize the use of local and grid RES, and ensure maximum availability of the EVSE.

Short description

The advent of e-mobility blurs the current organization framework of companies as it impacts fleet, facilities, human resources, and corporate social responsibility (CSR). As the main actor of this Business Use Case (BUC) we introduce the figure of Energy Facility Manager aiming to decarbonize the corporate's fleet, offer EV users uniform charging tariffs (independently if they charge at home or office), maximize the use of local and grid RES, and ensure maximum availability of the EVSE. It will leverage charging point operator (CPO) data to induce via direct and indirect control optimal charging policies in communities (e.g., sharing EV charging points), homes, and offices with PV and battery energy storage, combined seamlessly (by data sharing) with a portfolio of value-added non-energy services (associated to mobility) targeting both end-users and energy facility managers (e.g., resolve timely EV supply equipment faults, multi-site charging).

It consists in:

- Incentivize EV drivers to privilege low cost or carbon friendly charging from private EVSE (e.g., home or office) leveraging grid renewable energy sources (RES), including EVSE control with prioritization and community sharing of EVSE.
- Offer convenient EV charging tariffs, independently if the EV user charges the car at home or at the office relying on Charging Detail Records (CDR) provided by EVSE aiming to incentive best practices.

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- Optimize the energy consumption at domestic homes by combining EVSE and smart appliances flexibility to maximize self-consumption.
- Provide data access for enabling cross-sector service development, that may include maintenance, predictive EVSE usage forecast, recommendation services or carbon footprint reports.

The BUC includes the following steps.

1. Provide data and information to EV users and service providers

    1.1 Inform EV users about the best charging periods at office and at home

    1.2 Share charging point data with service providers

2. Manage and optimize office EV charging

    2.1 Send state-of-charge warnings to EV drivers when a threshold is reached

    2.2 Manage charging queue of the corporate fleet and community users

    2.3 Notify stakeholders about EVSE failures

3. Optimize energy consumption and flexibility at domestic homes

    3.1 Define optimal schedules for controllable assets

    3.2 Obtain and share data for behind-the-meter and EV flexibility quantification

    3.3 Get EVSE charging session data

4. Revenue management for invoicing or cost claim systems

    4.1 Provide CDR data for EVSE usage

    4.2 Provide RES generation / Energy storage usage

System Use Cases

Four SUC integrate this BUC:

- SUC13.1 – Optimize residential demand-side flexibility
- SUC13.2 – Incentives for charging from RES and EV chargers sharing
- SUC13.3 – Optimize and manage corporate EV charging
- SUC13.4 – Share EV charging data for non-energy services

Key performance indicators

KPI name	Type	Definition	Demo
Registered end customers	Social	End customers signing the Terms and Conditions	Spain/France
Citizens benefitting from the solution	Social	Inhabitants of the building/household benefitting from service/solution (e.g., no. of employees in the organization or no. of household members). ESTIMATED FROM LOADS FACILITATED BY DSO USING THE POINT OF DELIVERY, AS SUGGESTED BY MARCO ROSSI	Spain/France

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Typology of users (FSPs and end customers)	Social	Users classified by type, asset and/or sociodemographic information (only for end customers)	All
Energy engagement (with flexibility services)	Social	It measures the level of engagement of end customers/FSPs with flexibility services	Spain/France
Literacy about flexibility	Social	Ability to understand and apply information about flexibility services	Spain/France
Trust/commitment with energy market actors	Social	Confidence in other actors' reliability and integrity/perception that a relationship is valuable and is worthy of efforts to maintain it	All
Perceived value creation: economic, functional, experiential, episteme, environmental and community	Social	Perceived benefits in the solution	Spain/Italy/Sweden
Continuace adoption	Social	Willingness to provide flex provision services once the project ends	All
Readiness for flexibility provision	Social	Individual/organizational propensity to provide/use flexibility services, comprising perceptions of optimism, proficiency, vulnerability and dependency	All
Reduction of EV charging CO2 emissions	Environmental	Baseline: starts charging when EV plug-in in EVSE; typical charging profile; no corporate electrification. Means: Charging is controlled to maximize use of RES or low-CO2 generation (carbon signal); signals for behavioral shift of charging hours; increase electrification of corporate car fleet.	France
Reduction of EV charging cost	Economic	Baseline: starts charging when EV plug-in in EVSE; typical charging profile; no corporate electrification. Means: Charging is controlled to maximize use of RES or low-CO2 generation (carbon signal); signals for behavioral shift of charging hours; increase electrification of corporate car fleet.	France
Increase energy flexibility from e-mobility	Technical	Baseline: "dumb" EV charging. Means: direct control of EV charging flexibility (can be quantified for each session).	France

6.3. Business requirements

This section presents a summary of the main business requirements identified in the BUC description (see Annex III) divided in the following categories: a) market and regulatory domain, b) social sciences and consumer engagement domain, and c) other requirements mainly related to data privacy and security.

6.3.1. Market and regulatory domain

The business requirement analysis aims to check the BeFlexible BUCs definitions considering the opportunities and barriers concerning regulation and market structure & design. Considering the regulatory

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analysis addressed in Task 1.1, the objective is to identify, on the one hand, the processes of the BUCs that are already exploitable considering the current regulation and market structure, and, on the other hand, those processes that would require a change in the regulation or in the market structure to outclass the corresponding barrier.

DSO remuneration

The European Electricity Market Directive 944/2019 recognizes the need for DSO remuneration schemes to evolve. This directive highlights the need to incentivize the DSO to procure flexibility and delay network reinforcement when cost-efficient. Still, many European countries present a CAPEX-biased regulatory framework as noted by the Council of European Energy Regulators [255]. Therefore, the analysis of the BUC04 results (i.e. pilots 1.2 and 1.3 from Italy, pilots 2.1 and 2.2 from Sweden and pilots 3.1 and 3.4 from Spain) should address this topic if a grid reinforcement alternative is compared with a flexibility solution alternative when planning the grid.

The Electricity Market Directive 944/2019 requires the submission of network development plans every two years, with load forecasting and grid planning falling under BUC04. It is crucial to ensure that these plans align with cost-efficiency considerations. Evaluating scenario definitions is essential, as it is a challenging task with potential critical impacts on expected savings, influencing the justification for alternatives such as grid reinforcement or flexibility solutions. Consequently, it is recommended to closely collaborating with the regulatory agency during scenario definition.

Regarding short-term flexibility procurement (BUC06 and BUC07), most of the remuneration schemes for DSOs analysed in D1.1 establish an *ex-ante* allowance for operational expenditures with an incentive rate. This type of regulatory framework tends to favour the most cost-effective operational solution if flexibility is treated as any other operational expenditure, therefore correctly incentivizing flexibility solutions in the short-term. If the regulatory framework does not incentivise the DSO to reduce OPEX, the regulatory framework may introduce distorting incentives, thus not promoting cost-efficiency and the analysis of the demo results should highlight if the DSO incentives are aligned with cost-efficiency under the current regulatory framework for each demo (i.e. pilots 1.1, 1.2 and 1.3 from Italy, pilots 2.1 from Sweden and pilots 3.1, 3.2, 3.3 and 3.4 from Spain) that includes BUC06 or BUC07.

Regulatory experimentation

Regarding regulatory experimentation, none of the BUCs is part of a regulatory experiment. Italy presents BUCs linked to a regulatory experiment (i.e. national pilots). Still, the demo only tests processes not foreseen in the national pilots themselves, as noted in D4.1: *"The demo operates as a layer for the coordination, integration and improvement of the national pilot projects which are the main container of the experimentation. All the experimentation specific to the respective national pilots is carried out within themselves outside of this demo"*. Therefore, there are no business requirements related to regulatory experimentation. Still general recommendations for designing a regulatory experimentation framework and requisites for regulatory experiments can be found in deliverable D1.1. The recommendations given on D1.1 are based on studies of previous experiences in different countries [256], [257] and EC guidance on regulatory sandboxes[258], as well as documents from different NRAs [259], [260]. It is worth considering that the demos presented for the BeFlexible BUCs can serve as a starting point for defining future experiments in close collaboration with the national regulatory agency of each specific country.

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Energy communities

The EU regulatory framework for energy communities primarily relies on three documents: Regulation 2018/1999 [261], Directive 2018/2001 [262], and Directive 2019/944 [91]. However, national frameworks do not completely transpose these EU regulations into national regulations. As a result, the activities of energy communities may currently be restricted or could become subject to compliance requirements soon. For the case of Spain, where the BUCs on energy communities are expected to be demonstrated, only the renewable energy community's directive (Directive 2018/2001) is transposed. Moreover, collective self-consumption is also regulated and may cover some of the energy communities' activities. Furthermore, local regulation defined at Nomenclature of territorial units for statistics (NUTS) 2 level must be considered depending on the pilot location.

The business requirements identified for the BeFlexible BUCs cover aspects such as membership, extension, size, and internal organisation topics such as voting. In Spain, the regulatory draft defines REC participants as physical persons, local authorities, small and medium enterprises, and associations of SMEs, local entities, and individuals, with a maximum 51% vote or control threshold. The draft specifies a minimum of five members or shareholders for both REC and CEC.

Moreover, benefit sharing among the members of the communities may be also subject to regulation that vary from country to country. In Spain, consumers may either use fixed or variable coefficients [263]. Using the former, the energy is distributed always using a fixed set of coefficients between the different members of the community [264]. Using the latter, the energy is distributed using a set of defined ex-ante for each of the hours of the year. Dynamic coefficients have not been implemented yet, but are mentioned in the legislation, and other documents as the Self-consumption Roadmap [265].

Moreover, energy communities, when serving as aggregators for their members' assets in the electricity market, may be subject to regulations applicable to aggregator activities. Therefore, the market participation of energy communities as aggregated entities should carefully assess whether the conditions outlined for aggregation specifically apply. Like the regulation for energy communities, the regulatory framework for aggregator activities is not fully developed in member states at present, and the existing conditions may undergo changes in the near future.

Aggregation

The EU regulation covering aggregators activities is formed by Regulation 2019/943 [266], Directive 2019/944 [91], Regulation 2017/2195 [267], Regulation 2017/1485 [268], Regulation 2016/1388 [269], Regulation 2015/1222 [270] and the ACER's framework guidelines for demand response [271]. However, national frameworks do not completely transpose these EU regulations into national regulations. As a result, the aggregation activities may currently be restricted or could become subject to compliance requirements soon.

Regulations on aggregators may outline boundaries for the aggregation and market participation practices. National regulations prescribe for aggregation activities rules concerning data exchange and confidentiality, market access and compensation for aggregated entities. Moreover, the relation with the retailer considering unbalance responsibility and transfer of energy requires bilateral agreements whether not regulated. Table 6.2 provides a summary of the current situation on the primary regulation.

Table 6.2 – Current situation of independent aggregators in the European Union.

Country	Directive 2019/944 has been transposed regarding aggregators	Main regulation
France	Yes	Decree n. 2015-1832 Decree n. 2016-1132 Decree n. 2017-437
Italy	Yes	Legislative Decree, November 8th 2021, n. 210 Deliberation August 3rd 2021 352/2021/R/eel Deliberation May 5th 2017 300/2017/R/eel
Portugal	Yes	Decree-Law 15/2022
Spain	Only the definition	Royal Decree 23/2020
Sweden	Yes	The legal proposal has been approved and turned into force the 1st of June. The Swedish Energy Act is updated according to SFS 2023:238.

Submetering

The regulatory challenges in submetering stem from the absence of specific regulations in many countries. These regulations should address submetering standards and functionalities, like those specified in the Electricity Directive (EU) 2019/944 [91]. National regulatory authorities are key in ensuring compliance with these standards. The Draft Proposal for Network Code on Demand Response [272] highlights the role of submetering in aggregator models. In these models, submeters or controllable units are used for measuring the energy withdrawals and/or injections of units involved in services like balancing, congestion management, and voltage control.

Besides the technical regulations that need to be defined to guarantee accurate measurements, privacy and cybersecurity protection, submetering could be used for different market phases and they can play a key role as supported by surveyed TSO, DSOs and retail companies: prequalification, forecast of needs, bid collection, monitoring, activation and settlement. The conditions and exact activities submetering can play depend on the national regulations to be defined.

Baseline

Baselining is a key requirement to measure the delivery of SO services. The Draft Proposal for a Network Code on Demand Response jointly submitted to public consultation by the EU DSO Entity and ENTSO-E [272] states that *"depending on the aggregation models applied, the national market design, the type of service and the type of technical resource, different baselining methods can be nationally implemented and applied"*. Therefore, it is required that national regulation define guidelines for defining the baseline for different services, considering national market design and resources characteristic.

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Acquisition mechanisms

Regulatory challenges in the acquisition mechanism are mainly due to the absence of clear regulations in some countries regarding access to flexible resources. In countries where regulations are not explicitly defined, such as in Spain’s local markets or Italy's non-firm connection agreements, there is a significant gap in how flexible resources are accessed and utilized. This gap led to underutilization and inefficiencies. The Draft Proposal for Network Code on Demand Response [272], CEER Paper on Alternative Connection Agreements [273] and CEER, DSO Procedures of Procurement of Flexibility [255], ACER Report on Electricity Transmission and Distribution Tariff Methodologies in Europe [274] support the idea that flexibility provided by various resources connected to the network can be accessed through different mechanisms or a combination of them to unlock their potential in solving network issues.

Market Structure

Research and innovation projects developing demonstration activities that involve the definition of novel electricity markets, nevertheless the product exchanged, must consider the existing market structure to ensure overall economic efficiency and avoid distortions and gaming. Coherent design of novel flexibility markets is needed to ensure an efficient allocation of the resources across the electricity system value chain. Therefore, the business requirements for the analysed BUCs dealing with market design should consider aspects such as timing coordination with the existing electricity markets to foster the efficient allocation of resources, avoid distortions, and prevent gaming. Moreover, possible energy and power imbalances should be adequately considered to avoid system level impacts.

6.3.2. Social science and consumer engagement domain

Based on the work of WP2 (“Market actors value propositions, engagement and legal & ethics compliance”), a set of business requirements were defined taking into consideration value proposition to prosumers and engagement strategies.

In the context of local energy communities (BUC01 and BUC02), the concept of joint assets ownership can be perceived as a potential source of tension among community members. It becomes imperative to elucidate and communicate that these shared resources are not a disruptive force but rather contribute positively to the community dynamics. Clarifying how joint assets promote cooperation, collective benefit, and sustainable energy practices is essential in dispelling any misconceptions or concerns that might arise within the community. By highlighting the positive aspects and emphasizing the shared advantages of these joint assets, a more cohesive understanding can be fostered, promoting unity and mutual support within the local energy community. Moreover, in the same context of local energy communities, when addressing the aspect of data sharing, it is crucial to acknowledge the prevailing mistrust that consumers may harbour. Recognizing and understanding this scepticism is essential in developing transparent and trustworthy practices. Therefore, it is imperative to consider the concerns surrounding data sharing and implement measures that actively address and mitigate these apprehensions. By adopting robust privacy protocols, providing clear communication about the purpose and benefits of data sharing, and incorporating mechanisms for user consent and control, the community can work towards establishing a foundation of trust. Ultimately, acknowledging and proactively responding to consumer mistrust ensures that data sharing practices align with community values, fostering a sense of security and cooperation among community members.

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Furthermore, for participation in the local energy community, a fundamental requirement that involves the establishment of a contractual agreement: a) with a commitment to be a part of the community and entails explicit acceptance of the governance rules, and b) covering various crucial components, including but not limited to, data sharing consent, a willingness to provide flexibility services, and granting access to flexible resources.

For BUC03, ensuring effortless installation of devices/software for optimal control of domestic thermal loads is paramount for any deployable component. The user's economic constraints, given the modest efficiency-related benefits, highlight the need for a streamlined and user-friendly installation process. Simplifying deployment not only accommodates financial limitations but also promotes widespread adoption, aligning technology with practicality in diverse economic landscapes. Moreover, users require a sense of control when automation is in play. Providing users with a tangible degree of influence over automated processes is essential. This ensures a harmonious interaction where users feel empowered and informed, fostering trust and confidence in the automated systems. The value proposition should be focused on prioritise not only optimised energy use but also emphasises an unwavering commitment to user comfort and safety. An user-centric approach is required to assuring users that comfort is non-negotiable and will never be compromised in the pursuit of sustainable energy practices and energy flexibility exploitation.

Concording BUC12, the following business requirements were identified:

- Only economic incentives fail to drive user participation in flexibility mechanisms. The preliminary analysis in WP2, approach recognizes that incentives must extend beyond financial gains. It is necessary to introduce multifaceted “inductors” where customers (e.g., prosumers) find intrinsic value, making participation in flexibility mechanisms not only economically appealing but also inherently interesting and rewarding.
- Users prioritize non-energy services such as information (traffic, weather), health (air quality), and comfort. Therefore, energy flexibility services should be complemented with features that go beyond energy concerns, e.g., real-time information, ensuring air quality, and enhancing overall comfort.

Finally, regarding BUC13 two important business requirements from WP2 are:

- Users exhibit a preference for a fixed tariff, citing a decrease in trust when faced with a range of pricing options. However, in the event of dynamic tariff or signals (e.g., CO2 emissions), timely advance notifications are fundamental, as well as ensuring transparency in terms of tariff/signal calculation and rational.
- Encouraging users to adapt their charging behaviour requires accessible, user-friendly, and reliable charging points, also because EV drivers might be hesitant due to concerns about potential damage to their batteries.

6.3.3. Others

The adherence to GDPR standards emerged as a fundamental prerequisite across all BUCs involving customers. Recognizing the paramount importance of safeguarding customer data privacy, the identification of GDPR compliance as a primary requirement underscores the commitment to uphold legal and ethical standards in handling personal information. The focus should be on promoting responsible data management practices and reinforcing the trust and confidence of customers in the handling of their sensitive information.

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7. Conclusion

The growing integration of renewable energy resources in distribution grids is reshaping electricity markets, altering the dynamics of system flexibility and offering opportunities for new business activities. Consequently, there is a compelling need to reassess the design and operation of distribution grids and power sector markets. The response from BeFlexible project to these challenges covers four domains: a) consumer/Community-centric flexibility, b) grid-centric flexibility, c) TSO-DSO flexibility coordination, and d) cross-sector flexibility boosters (i.e., explore flexibility from other sectors). The main idea is to combine technologies and new BMs from these domains, supported by consumer engagement and awareness strategies, to design an integrated solution for smart energy flexibility management.

This document presents the results of the work carried out in T1.3 and T1.4, which were centred on the design of a flexibility-centric value chain, and the development of BUCs and KPIs, respectively.

As part of T1.3, the design of new BMs was based on an extensive review of existing BMs, where it was identified a large variety of proposals and commercial solutions already capable of increasing consumers' flexibility. Also, a set of eight BMs was defined and thoroughly analysed, including financing mechanisms to support them, and the main roles and interactions among these roles were also identified, allowing to define BMs by allocating different set of roles to the actual actors.

From the BMs and the analysis of the steps needed to provide flexibility, the flexibility-centric value chain was designed. It is divided in six stages:

- Flexibility capacitation
- Integration/Enablement
- Aggregation
- Negotiation preparation
- Market Operation
- Activation and settlement

For each stage, the main actors involved and the main activities essential and complementary for its operation were identified. The value chain was presented to and validated with all the partners of WP1 during a workshop session.

The last part of T1.3 was related to the GDBN design to support the activities of the flexibility value chain. To support its development, it was carried out a review of pre-existing digital platforms, where the most advanced or widespread platforms identified were described. To identify data exchange requirements of the GDBN, it was necessary to foresee the information it would process. Therefore, it was necessary to propose an end-to-end methodology for the provision of flexibility. At last, some basic functionalities and services of the GDBN were also introduced, which will be developed in WP3.

Regarding T1.4 that deals with the definition of the BUCs to be developed in BeFlexible project, the use case methodology applied provides a description through a structured methodology of roles and business processes related with the abovementioned goals. The following results were obtained from this methodology:

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- 13 BUCs that fully address the project's objectives and challenges.
- Identification of market, regulatory and social sciences-based business requirements to implement the envisioned business processes [inputs for WPs 3-7].
- Identification of new functional requirements to implement the envisioned business processes [inputs for WPs 3-6].
- KPIs (technical, economic, environmental, and social) for measuring project's goals and systems' performance [inputs for WPs 4-7].

The detailed business requirements analysis carried out as part of the project in the BUC drafting underlined the following:

- Market and regulatory domain
  - Emphasis on DSO remuneration aligns with directive 944/2019, urging incentivisation for flexibility over network reinforcement.
  - Energy communities face challenges due to incomplete transposition of EU regulations, necessitating careful consideration of national frameworks.
  - Aggregator activities, submetering, and baseline definition highlight regulatory gaps, urging standardised guidelines.
  - Acquisition mechanisms demand clarity in flexible resource access by SOs, particularly in local flexibility markets.
  - The resulting market structure from integrating local flexibility markets underscores the importance of a coherent design to prevent distortions.
  - In overall, the business requirements analysis underlines the diverse and evolving regulatory environments across European countries, requiring tailored approaches to align requirements with specific national regulations and market conditions.
- Social science and consumer engagement
  - For local energy communities, fostering understanding around joint assets and addressing data sharing concerns are pivotal. A contractual agreement encompassing governance rules and commitment elements emerges as a fundamental requirement for community participation.
  - User-friendly installation of devices for thermal load control is crucial, aligning technology with economic constraints. Users' demand for control in automation, coupled with a strong emphasis on comfort and safety, shapes the value proposition.
  - Need for diverse incentives beyond economic gains, focusing on intrinsic value for participation in flexibility mechanisms.
  - In overall, these requirements emphasise user-centric, transparent, and adaptable solutions in the energy landscape.
- Data privacy and security

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- The adherence to GDPR standards emerged as a fundamental prerequisite across all BUCs involving customers.

In conclusion, the BeFlexible project's comprehensive analysis and proposed solutions described in this document contribute significantly to the ongoing discourse on electricity market design and flexibility integration. The development of new BMs and the articulation of the flexibility-centric VC facilitate the transition towards more dynamic, inclusive, and sustainable energy markets. Moreover, the formulation of BUCs and KPIs not only guarantees adherence to changing regulatory settings, but also prioritizes a consumer-centric approach, thus supporting the incorporation of social and economic considerations into the rapidly transforming energy sector. Together, these elements underscore the project's crucial role in advancing both the theoretical and practical aspects of energy and flexibility.

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8. References

[1] A. Bankel and I. Mignon, 'Solar business models from a firm perspective – an empirical study of the Swedish market', *Energy Policy*, vol. 166, p. 113013, Jul. 2022, doi: 10.1016/j.enpol.2022.113013.

[2] Solarshop, 'Solarshop'. Accessed: Dec. 29, 2022. [Online]. Available: https://www.solarshop.pt/gb/

[3] SunPower, 'SunPower'. Accessed: Dec. 29, 2022. [Online]. Available: https://us.sunpower.com/

[4] Trina Solar, 'Trina Solar'. Accessed: Dec. 29, 2022. [Online]. Available: https://www.trinasolar.com/pt

[5] Iberdrola, 'Painéis Solares Iberdrola'. Accessed: Dec. 29, 2022. [Online]. Available: https://www.iberdrola.pt/casa/energia-solar/paineis-solares

[6] EDP, 'Energia Solar EDP'. [Online]. Available: https://www.edp.pt/particulares/servicos/energia-solar/

[7] Fundo Ambiental, '2ª FASE Programa de Apoio Edifícios + Sustentáveis'. Accessed: Dec. 29, 2022. [Online]. Available: https://www.fundoambiental.pt/apoios-prr/c13-eficiencia-energetica-em-edificios/01c13-i01-paes-ii.aspx

[8] GreenMatch, 'Solar Panels Grants and Funding in 2022 in the UK'. Accessed: Dec. 29, 2022. [Online]. Available: https://www.greenmatch.co.uk/solar-energy/solar-panels/solar-panel-grants

[9] VentureRadar, 'Similar companies to Sunwealth Power'. Accessed: Dec. 28, 2022. [Online]. Available: https://www.ventureradar.com/similar/Sunwealth%20Power/592fbaa0-b94d-4a63-8f8f-e9ad2e0c2ecc

[10] Ecoligo, 'Startseite'. [Online]. Available: https://ecoligo.com/en/

[11] G. Fitzgerald, J. Mandel, J. Morris, and H. Touati, 'The Economics of Battery Energy Storage', 2019. [Online]. Available: https://rmi.org/wp-content/uploads/2017/05/RMI_Document_Repository_Public-Reprts_RMI-TheEconomicsOfBatteryEnergyStorage-ExecutiveSummary.pdf

[12] Tesla, 'Powerwall'. Accessed: Dec. 29, 2022. [Online]. Available: https://www.tesla.com/powerwall

[13] AlphaESS, 'Residential Energy Storage System'. [Online]. Available: https://www.alphaess.com/residential-energy-storage-system

[14] EDP, 'Bateria Solar'. [Online]. Available: https://www.edp.pt/particulares/servicos/energia-solar/baterias/

[15] Connected Energy, 'Connected Energy: Energy Storage'. [Online]. Available: https://c-e-int.com/energy-storage

[16] Powervault, 'Home electricity storage'. Accessed: Dec. 29, 2022. [Online]. Available: https://www.powervault.co.uk/

[17] H. Zandi, T. Kuruganti, E. A. Vineyard, and D. Fugate, 'Home Energy Management Systems: An Overview', Oak Ridge National Lab. (ORNL), Oak Ridge, TN (United States), Jan. 2018. Accessed: Jan. 04, 2023. [Online]. Available: https://www.osti.gov/biblio/1423114

[18] Control4, 'Home Automation and Smart Home Control'. Accessed: Jan. 04, 2023. [Online]. Available: https://www.control4.com/

[19] Smarthomes Solutions, 'Smart Home Automation & Installation'. Accessed: Jan. 04, 2023. [Online]. Available: https://www.smarthomessolutions.net/

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union. Neither the European Union nor the granting authority can be held responsible for them.

[20] ABB, ‘Smart Home Solutions’. Accessed: Jan. 04, 2023. [Online]. Available: https://new.abb.com/buildings/smarter-home

[21] EDP, ‘Termoacumuladores’. [Online]. Available: https://www.edp.pt/edp-store/termoacumuladores/

[22] EDP, ‘Bombas de Calor’. [Online]. Available: https://www.edp.pt/edp-store/bombas-de-calor/?page=2

[23] EDP, ‘Ar condicionado’. Accessed: Jan. 03, 2023. [Online]. Available: https://www.edp.pt/edp-store/ar-condicionado/

[24] Iberdrola, ‘Servicio Aire Acondicionado’. Accessed: Jan. 03, 2023. [Online]. Available: https://www.iberdrola.es/smart-clima/aire-acondicionado

[25] Thermovault, ‘Thermovault’. Accessed: Jul. 21, 2023. [Online]. Available: https://www.thermovault.com/

[26] H. Yllemo, ... ‘as a service’. Accessed: Jan. 04, 2023. [Online]. Available: https://almbok.com/kb/as_a_service

[27] M. Fehling, ‘Everything as a service: a closer look at the business model of the future’. Accessed: Jan. 04, 2023. [Online]. Available: https://blogs.sw.siemens.com/thought-leadership/2019/07/11/everything-as-a-service-a-closer-look-at-the-business-model-of-the-future/

[28] Object Management Group, ‘XaaS (Anything as a Service) Glossary’. 2022. Accessed: Jan. 04, 2023. [Online]. Available: https://www.omg.org/cloud/Anything-as-a-Service-Glossary-22-06-08.pdf

[29] Consultancy.eu, ‘“As a service” business models: What it is and its benefits’. Accessed: Jan. 04, 2023. [Online]. Available: https://www.consultancy.eu/news/7350/as-a-service-business-models-what-it-is-and-its-benefits

[30] Sunrun, ‘Solar as a Service’. Accessed: Dec. 28, 2022. [Online]. Available: https://www.sunrun.com/go-solar-center/solar-terms/definition/solar-as-a-service

[31] Small Business, ‘What Is the Business Model for a Solar Developer?’ Accessed: Dec. 29, 2022. [Online]. Available: https://smallbusiness.chron.com/business-model-solar-developer-74095.html

[32] EDP, ‘PV as a service’. [Online]. Available: https://www.edpenergia.pl/en/business/solutions-for-your-company/solar-pv-products/pv-as-a-service/

[33] N. Przemysł, ‘Fotowoltaika jest dla firm bardzo ważnym rozwiązaniem, by obniżyć ceny energii elektrycznej’. Accessed: May 24, 2023. [Online]. Available: https://www.nowoczesny-przemysl.pl, https://nowoczesny-przemysl.pl/fotowoltaika-waznym-rozwiazaniem-dla-firm/

[34] EDP, ‘Bairro Solar’. [Online]. Available: https://www.edp.pt/bairro-solar/

[35] Repsol, ‘Repsol Solmatch’. Accessed: Dec. 09, 2022. [Online]. Available: https://www.repsol.es/particulares/hogar/energia-solar/solmatch/

[36] J. Villar, R. Rocha, and J. Mello, ‘Projeto Negocer – Análise de Novas Possibilidades de Negócio para a Elergone no âmbito do DL162/2019’, INESC TEC, 2021.

[37] Plico, ‘Solar as a Service (SAAS)’. Accessed: Dec. 28, 2022. [Online]. Available: https://www.plicoenergy.com.au/article-solar-as-a-service

[38] Göteborg Energi, ‘Solabonnemang’. Accessed: Dec. 28, 2022. [Online]. Available: https://www.goteborgenergi.se/privat/solenergi/solabonnemang

[39] Wartsila, ‘Energy storage as a service’. Accessed: Dec. 29, 2022. [Online]. Available: https://www.wartsila.com/encyclopedia/term/energy-storage-as-a-service

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union. Neither the European Union nor the granting authority can be held responsible for them.

[40] PV Europe, 'Younicos launches energy storage as a service'. Accessed: Dec. 29, 2022. [Online]. Available: https://www.pveurope.eu/solar-storage/younicos-launches-energy-storage-service

[41] Green Mountain Power, 'Tesla Powerwall'. Accessed: Dec. 29, 2022. [Online]. Available: https://greenmountainpower.com/rebates-programs/home-energy-storage/powerwall/

[42] T. Hoium, 'Renting Energy Storage: Tesla's Powerwall Showing a Path for Batteries in the Home', The Motley Fool. Accessed: Dec. 29, 2022. [Online]. Available: https://www.fool.com/investing/2017/05/20/teslas-powerwall-showing-path-for-home-energy-stor.aspx

[43] WattLogic, 'Commercial Energy Storage'. Accessed: Dec. 30, 2022. [Online]. Available: https://wattlogic.com/commercial/commercial-energy-storage/

[44] Mercku, 'Smart Home as a Service – Why is it Relevant?' Accessed: Jan. 05, 2023. [Online]. Available: https://www.mercku.com/2022/03/02/smart-home-as-a-service-why-is-it-relevant-shaas-series/

[45] Friendly Technologies, 'Challenges Telcos Face Offering Smart Home as a Service'. Accessed: Jan. 05, 2023. [Online]. Available: https://friendly-tech.com/challenges-telcos-face-offering-smart-home-as-a-service/

[46] Tridens, 'What is EV Charging as a Service (EV CaaS)?' Accessed: Dec. 30, 2022. [Online]. Available: https://tridenstechnology.com/what-is-ev-charging-as-a-service/

[47] EV Connect, 'EV CaaS: Is This Service Model Service Right for You?' Accessed: Dec. 30, 2022. [Online]. Available: https://www.evconnect.com/blog/ev-charging-as-a-service

[48] Z. Hoover, F. Nägele, E. Polymeneas, and S. Sahdev, 'How charging in buildings can power up the electric-vehicle industry'. 2021. [Online]. Available: https://digitaldealership.com/wp-content/uploads/2021/01/How-charging-in-buildings-can-power-up-the-electric-vehicle-industry-vF2.pdf

[49] C. Goeres, 'What Is HVAC as a Service? Maybe, the Future of HVAC', PrimexVents. Accessed: Jan. 03, 2023. [Online]. Available: https://www.primexvents.com/hvac-as-a-service/

[50] InteGrid, 'D7.5 Business Models to Support the Developed Concepts'. 2020. [Online]. Available: https://integrid-h2020.eu/uploads/public_deliverables/D7.5_Business%20Models.pdf

[51] USEF, 'Flexibility Value Chain'. 2018. Accessed: Jan. 04, 2024. [Online]. Available: https://www.usef.energy/app/uploads/2018/11/USEF-White-paper-Flexibility-Value-Chain-2018-version-1.0_Oct18.pdf

[52] Endesa, 'Electricity tariffs'. Accessed: May 23, 2023. [Online]. Available: https://www.endesa.com/en/catalog/light

[53] Electric Ireland, 'Time-of-Use Tariffs for Residential Customers'. Accessed: May 23, 2023. [Online]. Available: https://www.electricireland.ie/residential/help/smart-electricity-meters/time-of-use-tariffs-for-residential-customers

[54] European Commission, 'Energy Performance Contracting'. Accessed: Dec. 20, 2022. [Online]. Available: https://e3p.jrc.ec.europa.eu/articles/energy-performance-contracting

[55] TÜV SÜD, 'Industry, mobility, logistics – all about hydrogen-powered applications'. Accessed: May 23, 2023. [Online]. Available: https://www.tuvsud.com/en/themes/hydrogen/explore-the-hydrogen-value-chain/hydrogen-in-applications

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union. Neither the European Union nor the granting authority can be held responsible for them.

[56] HyBalance, 'D7.5 - Final Technical Performance Report'. 2021. Accessed: May 23, 2023. [Online]. Available: https://hybalance.eu/wp-content/uploads/2021/12/HyBalance-D7.5-Final-Technical-Performance-Report.pdf

[57] WeaveGrid, 'Enabling an electric future'. Accessed: Dec. 13, 2022. [Online]. Available: https://www.weavegrid.com/

[58] Fast Company, 'The next step for electric cars is to make them part of the grid'. Accessed: Dec. 13, 2022. [Online]. Available: https://www.fastcompany.com/90682274/the-next-step-for-electric-cars-is-to-make-them-part-of-the-grid

[59] Canary Media, 'A better way to do smart EV charging: Talk to the car'. [Online]. Available: https://www.canarymedia.com/articles/ev-charging/a-better-way-to-do-smart-ev-charging-talk-to-the-car

[60] Bia, 'Software for smart EV charge management'. [Online]. Available: https://www.biapower.io/

[61] N. Nhede, 'Using smart meters in health and care monitoring systems', Smart Energy International. Accessed: Jul. 21, 2023. [Online]. Available: https://www.smart-energy.com/industry-sectors/smart-meters/using-smart-meters-in-health-and-care-monitoring-systems/

[62] InterConnect, 'D1.1 – Services and use cases for smart buildings and grids'. 2021. Accessed: Jan. 05, 2023. [Online]. Available: https://interconnectproject.eu/wp-content/uploads/2022/02/InterConnect_WP1_D1.1_v2.2.pdf

[63] NobelGrid, 'D2.3 Business Models & Incentive Schema Definition', 2016. [Online]. Available: http://stecon.cs.aueb.gr/media/1031/nobel-grid-d23-bm-incentive-schema-definition.pdf

[64] R. Rocha, J. Mello, J. Villar, and J. T. Saraiva, 'Comparative Analysis of Self-Consumption and Energy Communities Regulation in the Iberian Peninsula', presented at the PowerTech 2021, Jun. 2021.

[65] Regen, 'Why aren't communities providing more network flexibility services?' [Online]. Available: https://www.regen.co.uk/how-can-communities-provide-more-flexibility/

[66] K. E. Thorvaldsen, S. Nessa, S. Sandell, and H. Sæle, 'Spatial dependency on flexibility value considering stacked transformer overload cost'. TechRxiv, Apr. 05, 2023. doi: 10.36227/techrxiv.22346326.v1.

[67] EUniversal, 'D5.1 Identification of relevant market mechanisms for the procurement of flexibility needs and grid services', 2021. [Online]. Available: https://euniversal.eu/wp-content/uploads/2021/02/EUniversal_D5.1.pdf

[68] S. T. Bryant, K. Straker, and C. Wrigley, 'The typologies of power: Energy utility business models in an increasingly renewable sector', *Journal of Cleaner Production*, vol. 195, pp. 1032–1046, Sep. 2018, doi: 10/gd2pfd.

[69] ERSE, 'Retail suppliers'. Accessed: Mar. 08, 2023. [Online]. Available: https://www.erse.pt/en/electricity/functioning-pt/retail-suppliers/

[70] F. Tounquet, 'Energy Communities in the European Union', ASSET (Advanced System Studies for Energy Transition) project, May 2019. [Online]. Available: https://www.powerpeers.nl/media/1330/asset-energy-comminities-revised-final-report.pdf

[71] BeFlexible, 'D1.1: Regulatory framework for fostering flexibility deployment: roles, responsibility of agents & flexibility mechanism designs'.

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union. Neither the European Union nor the granting authority can be held responsible for them.

[72] I. F.G. Reis, I. Gonçalves, M. A.R. Lopes, and C. Henggeler Antunes, 'Business models for energy communities: A review of key issues and trends', *Renewable and Sustainable Energy Reviews*, vol. 144, p. 111013, Jul. 2021, doi: 10.1016/j.rser.2021.111013.

[73] M. Hamwi and I. Lizarralde, 'A Review of Business Models towards Service-Oriented Electricity Systems', *Procedia CIRP*, vol. 64, pp. 109–114, Jan. 2017, doi: 10.1016/j.procir.2017.03.032.

[74] L. Rodrigues *et al.*, 'Analysis of Flexibility-centric Energy and Cross-sector Business Models', in *2023 19th International Conference on the European Energy Market (EEM)*, Jun. 2023, pp. 1–6. doi: 10.1109/EEM58374.2023.10161816.

[75] E. De Luca, A. Vito Mantineo, G. Fedele, E. D'Alessandro, A. Colafrancheschi, and K. Kukk, 'Harmonized Electricity Market Role Model: A Differential Analysis with Respect to the ENTSO-E – ebIX – EFET Model'. Apr. 01, 2021. [Online]. Available: https://energy.ec.europa.eu/system/files/2021-06/bridge_wg_regulation_eu_bridge_hemrm_report_2020-2021_0.pdf

[76] BeFlexible, 'D2.1: Value Propositions for Market Actors'. Accessed: Jan. 15, 2024. [Online]. Available: https://beflexible.eu/wp-content/uploads/2023/10/BEFLEXIBLE-D2.1-Value-Propositions-for-market-actors.pdf

[77] A. Osterwalder and Y. Pigneur, *Business Model Generation: A Handbook for Visionaries, Game Changers, and Challengers*. Wiley, 2010.

[78] Strategyzer, 'The Business Model Canvas'. Accessed: May 02, 2023. [Online]. Available: https://www.strategyzer.com/canvas/business-model-canvas

[79] E.ON, '100% Renewable Electricity'. Accessed: Mar. 08, 2023. [Online]. Available: https://www.eonenergy.com/renewable.html

[80] Ecotricity, 'Switch to Ecotricity's renewable green electricity and gas for your home or business'. Accessed: Mar. 08, 2023. [Online]. Available: https://www.ecotricity.co.uk/

[81] Arthur D. Little, 'Digital energy'. Accessed: Mar. 08, 2023. [Online]. Available: https://www.adlittle.com/be-de/node/23636

[82] A. Moreno, J. Villar, C. S. Gouveia, J. Mello, and R. Rocha, 'Investments and Governance Models for Renewable Energy Communities', in *2022 18th International Conference on the European Energy Market (EEM)*, Sep. 2022, pp. 1–6. doi: 10.1109/EEM54602.2022.9921004.

[83] USEF, 'USEF: The Framework Explained', 2015. [Online]. Available: https://www.usef.energy/app/uploads/2016/12/USEF_TheFrameworkExplained-18nov15.pdf

[84] GAIA-X, 'Data Space Business Committee - Position Papers: Consolidated Version for Industry Verticals'. 2021. Accessed: Mar. 03, 2023. [Online]. Available: https://gaia-x.eu/wp-content/uploads/files/2021-08/Gaia-X_DSBC_PositionPaper.pdf

[85] M. Robaina, K. Murillo, E. Rocha, and J. Villar, 'Circular economy in plastic waste: efficiency analysis of European countries', *Science of the Total Environment*, vol. 730, Aug. 2020, doi: 10.1016/j.scitotenv.2020.139038.

[86] J. Villar, R. Bessa, and M. Matos, 'Flexibility products and markets: Literature review', *Electric Power Systems Research*, vol. 154, pp. 329–340, Jan. 2018, doi: 10.1016/j.epsr.2017.09.005.

[87] G. J. Osório, M. Shafie-khah, P. D. L. Coimbra, M. Lotfi, and J. P. S. Catalão, 'Distribution System Operation with Electric Vehicle Charging Schedules and Renewable Energy Resources', *Energies*, vol. 11, no. 11, Art. no. 11, Nov. 2018, doi: 10.3390/en11113117.

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union. Neither the European Union nor the granting authority can be held responsible for them.

[88] F. Chasin, U. Paukstadt, P. Ullmeyer, and J. Becker, 'Creating Value From Energy Data: A Practitioner's Perspective on Data-Driven Smart Energy Business Models', *Schmalenbach Bus Rev*, vol. 72, no. 4, pp. 565–597, Oct. 2020, doi: 10.1007/s41464-020-00102-1.

[89] D. A. Contreras and K. Rudion, 'Improved Assessment of the Flexibility Range of Distribution Grids Using Linear Optimization', in *2018 Power Systems Computation Conference (PSCC)*, Jun. 2018, pp. 1–7. doi: 10.23919/PSCC.2018.8442858.

[90] K. Berg, R. Rana, and H. Farahmand, 'Quantifying the benefits of shared battery in a DSO-energy community cooperation', *Applied Energy*, vol. 343, p. 121105, 2023, doi: https://doi.org/10.1016/j.apenergy.2023.121105.

[91] European Commission, *Directive (EU) 2019/944 of the European Parliament and of the Council of 5 June 2019 on common rules for the internal market for electricity and amending Directive 2012/27/EU*, vol. 158. 2019. Accessed: Jul. 25, 2023. [Online]. Available: http://data.europa.eu/eli/dir/2019/944/oj/eng

[92] W. Guedes, C. Oliveira, T. Soares, B. Dias, and M. Matos, 'Collective asset sharing mechanisms for PV and BESS in renewable energy communities', *IEEE Transactions on Smart Grid*, pp. 1–1, 2023, doi: 10.1109/TSG.2023.3288533.

[93] R. Rocha *et al.*, 'A Three-Stage Model to Manage Energy Communities, Share Benefits and Provide Local Grid Services', *Energies*, vol. 16, no. 3, Art. no. 3, Jan. 2023, doi: 10.3390/en16031143.

[94] M. Kubli and S. Puranik, 'A typology of business models for energy communities: Current and emerging design options', *Renewable and Sustainable Energy Reviews*, vol. 176, p. 113165, Apr. 2023, doi: 10.1016/j.rser.2023.113165.

[95] BlackRock, 'Equities'. [Online]. Available: https://www.blackrock.com/us/individual/education/equities

[96] Royal Bank of Canada, 'What Does It Mean To Be a Shareholder?' Accessed: Oct. 25, 2023. [Online]. Available: https://www6.royalbank.com/en/di/hubs/investing-academy/article/what-does-it-mean-to-be-a-shareholder/jk0dlkvw

[97] Investopedia, 'Debt'. Accessed: Dec. 16, 2022. [Online]. Available: https://www.investopedia.com/terms/d/debt.asp

[98] SmartEn, 'Scalable Innovative Financing for Smart Buildings'. 2018. [Online]. Available: https://www.smarten.eu/wp-content/uploads/2018/10/Smart-Financing_final_with-date-1.pdf

[99] D. Leboullenger, Z. Toth, J. Johnson, and L. Bertalot, 'White paper on a Common Minimum Pan-European Green Reporting Criteria'. 2021. Accessed: Oct. 24, 2023. [Online]. Available: https://energyefficientmortgages.eu/wp-content/uploads/2021/07/EEMI-Master-Template-Explanatory-Document.pdf

[100] Investopedia, 'Bond: Financial Meaning With Examples and How They Are Priced'. Accessed: Dec. 16, 2022. [Online]. Available: https://www.investopedia.com/terms/b/bond.asp

[101] Vanguard, 'What is a Bond and How do they Work?' Accessed: Oct. 24, 2023. [Online]. Available: https://investor.vanguard.com/investor-resources-education/understanding-investment-types/what-is-a-bond

[102] Investopedia, 'Green Bond'. Accessed: Dec. 16, 2022. [Online]. Available: https://www.investopedia.com/terms/g/green-bond.asp

[103] Investopedia, 'Mezzanine Financing: What Mezzanine Debt Is and How It's Used'. Accessed: Dec. 16, 2022. [Online]. Available: https://www.investopedia.com/terms/m/mezzaninefinancing.asp

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union. Neither the European Union nor the granting authority can be held responsible for them.

[104] Editorial Inc, ‘Mezzanine Financing’, Inc.com. Accessed: Oct. 25, 2023. [Online]. Available: https://www.inc.com/encyclopedia/mezzanine-financing.html

[105] European Commission, ‘Crowdfunding explained’. Accessed: Dec. 16, 2022. [Online]. Available: https://single-market-economy.ec.europa.eu/access-finance/guide-crowdfunding/what-crowdfunding/crowdfunding-explained_en

[106] e-SAFE, ‘D6.2 Business Models and Financial Schemes: identification and development’. 2022. [Online]. Available: https://zenodo.org/records/6497154

[107] Corporate Finance Institute, ‘Equity Crowdfunding’. [Online]. Available: https://corporatefinanceinstitute.com/resources/valuation/equity-crowdfunding/

[108] Office of Energy Efficiency & Renewable Energy, ‘Energy Savings Performance Contracts’. Accessed: Oct. 25, 2023. [Online]. Available: https://www.energy.gov/eere/buildings/energy-savings-performance-contracts

[109] edie, ‘Energy Performance Contract (EPC)’. Accessed: Oct. 25, 2023. [Online]. Available: https://www.edie.net/definition/energy-performance-contract-epc/

[110] Energy Education, ‘Fiscal incentive’. [Online]. Available: https://energyeducation.ca/encyclopedia/Fiscal_incentive

[111] M. Dorleans, ‘Financial Incentives for Companies’ engagement in workbased learning’. 2018. [Online]. Available: https://www.etf.europa.eu/sites/default/files/document/5.%20Financial%20Incentives%20for%20Companies_Marie%20Dorleans_EN.pdf

[112] A. Srivastav and D. Vaidya, ‘Revolving Fund’. Accessed: Oct. 24, 2023. [Online]. Available: https://www.wallstreetmojo.com/revolving-fund/

[113] Gent Knapt Op, ‘Gent’. 2023. Accessed: Oct. 24, 2023. [Online]. Available: https://stad.gent/sites/default/files/media/documents/22_00589_Minimagazine_Gent%20Knapt%20OP_web_0.pdf

[114] M. Giannakopoulou, ‘From House to Home’ The Recurring Fund: A sustainable future for low-income housing renovations?’ Accessed: Dec. 19, 2022. [Online]. Available: https://uia-initiative.eu/en/news/house-home-recurring-fund-sustainable-future-lowincome-housing-renovations

[115] Merriam-Webster, ‘Definition of self-finance’. Accessed: May 26, 2023. [Online]. Available: https://www.merriam-webster.com/dictionary/self-finance

[116] Climate Policy Database, ‘The Energy Transition Tax Credit (CITE)’. Accessed: May 26, 2023. [Online]. Available: https://www.climatepolicydatabase.org/policies/energy-transition-tax-credit-cite

[117] De Breed & Partners, ‘Energy Investment Allowance (EIA)’. Accessed: May 26, 2023. [Online]. Available: https://debreed.nl/en/financing-form/eia/

[118] Monard Law, ‘Building renovations: obligations and extra tax incentives as of 1 january 2022’. Accessed: May 26, 2023. [Online]. Available: https://monardlaw.be/en/stories/renovatie-van-gebouwen-verplichtingen-en-extra-fiscale-tegemoetkomingen-vanaf-1-januari-2022/

[119] Italia Domani, ‘Ecobonus and Sismabonus up to 110% for energy efficiency and safety of buildings’. Accessed: May 26, 2023. [Online]. Available: https://www.italiadomani.gov.it:443/content/sogei-ng/it/en/Interventi/investimenti/ecobonus-e-sismabonus-fino-al-110-per-efficienza-energetica-e-la-sicurezza-degli-edifici.html

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union. Neither the European Union nor the granting authority can be held responsible for them.

[120] V. Vishnubhotla, 'Solar Panels and Heat Pumps VAT down to 0%'. Accessed: May 26, 2023. [Online]. Available: https://www.greenmatch.co.uk/blog/uk-announces-zero-vat-on-solar-panels-and-heat-pumps

[121] M. Beyer, 'EU adopts directive allowing reduced VAT on several goods, including solar panels', pv magazine International. Accessed: May 26, 2023. [Online]. Available: https://www.pv-magazine.com/2022/04/13/eu-adopts-directive-allowing-reduced-vat-on-several-goods-including-solar-panels/

[122] Ofgem, 'Get help if you can't afford your energy bills'. Accessed: May 26, 2023. [Online]. Available: https://www.ofgem.gov.uk/information-consumers/energy-advice-households/getting-help-if-you-cant-afford-your-energy-bills

[123] KfW, 'KfW "Energy-Efficient Refurbishment" programme becomes even more attractive'. Accessed: May 26, 2023. [Online]. Available: https://www.kfw.de/About-KfW/Newsroom/Latest-News/Pressemitteilungen-Details_254272.html

[124] Interreg Europe, 'The zero-rated eco-loan scheme to encourage renewable energy (ECO-PTZ)'. Accessed: May 26, 2023. [Online]. Available: https://www.interregeurope.eu/good-practices/the-zero-rated-eco-loan-scheme-to-encourage-renewable-energy-eco-ptz

[125] Siemens, 'Energy Performance Contracting (EnPC)', siemens.com Global Website. Accessed: May 26, 2023. [Online]. Available: https://www.siemens.com/global/en/products/services/services-large-drives-applications/service-agreements/energy-performance-contracting.html

[126] Ameresco, 'ESPC – Energy Performance Contracting'. Accessed: May 26, 2023. [Online]. Available: https://www.ameresco.com/espc-energy-savings-performance-contract/

[127] SSE Energy Solutions, 'Energy Performance Contracts'. Accessed: May 26, 2023. [Online]. Available: https://www.sseenergysolutions.co.uk/distributed-energy-infrastructure/our-solutions/smart-buildings/energy-performance-contracts

[128] Banco Santander, 'Energy Efficiency Loan'. Accessed: May 26, 2023. [Online]. Available: https://www.bancosantander.es/en/santander-sostenible/prestamo-verde-eficiencia-energetica

[129] Maryland Department of Housing and Community Development, 'BeSMART Energy Efficiency Loan for Homeowners'. Accessed: May 26, 2023. [Online]. Available: https://dhcd.maryland.gov/Residents/Pages/default.aspx

[130] 'How it works for Providers', EaaS - Efficiency as a Service. Accessed: May 26, 2023. [Online]. Available: https://www.eaas-initiative.org/how-it-works-for-providers/

[131] EDP Comercial, 'EDP Solar Battery'. Accessed: May 26, 2023. [Online]. Available: https://www.edp.pt/particulares/servicos/energia-solar/baterias/

[132] Endesa, 'Photovoltaic Energy'. Accessed: May 26, 2023. [Online]. Available: https://www.endesa.com/en/companies/energy-efficiency/photovoltaic-energy

[133] Scottish Power, 'Interested in a solar panel installation?' Accessed: May 26, 2023. [Online]. Available: https://www.scottishpower.co.uk/blog/interested-in-a-solar-panel-installation

[134] SCCALE 203050, 'Financing guide for energy communities'. 2023. Accessed: May 26, 2023. [Online]. Available: https://www.sccale203050.eu/wp-content/uploads/2023/02/SCCALE203050_financingguide_energycommunities.pdf

[135] UNEP, 'Demystifying Adaptation Finance For The Private Sector'. 2016. Accessed: May 26, 2023. [Online]. Available: https://www.unepfi.org/wordpress/wp-

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union. Neither the European Union nor the granting authority can be held responsible for them.

content/uploads/2016/11/DEMYSITIFYING-ADAPTATION-FINANCE-FOR-THE-PRIVATE-SECTOR-AW-FULL-REPORT.pdf

[136] Cleantech Group, 'Cleantech Research Agenda Update – Q1 2021'. Accessed: Jan. 04, 2024. [Online]. Available: https://www.cleantech.com/cleantech-research-agenda-update-q1-2021/

[137] O. Valarezo *et al.*, 'Analysis of New Flexibility Market Models in Europe', *Energies*, vol. 14, no. 12, Art. no. 12, Jan. 2021, doi: 10.3390/en14123521.

[138] Frontier Economics, 'Review of Flexibility Platforms'. 2021. Accessed: Apr. 11, 2023. [Online]. Available: https://eepublicdownloads.azureedge.net/clean-documents/SOC%20documents/SOC%20Reports/210957_entso-e_report_neutral_design_flexibility_platforms_04.pdf

[139] USEF, 'USEF: White paper on flexibility platforms', Nov. 2018. Accessed: Jan. 29, 2020. [Online]. Available: https://www.usef.energy/app/uploads/2018/11/USEF-White-Paper-Flexibility-Platforms-version-1.0_Nov2018.pdf

[140] N. Constantinescu, 'Active System Management and Distributed Flexibilities: the value of TSO-DSO Cooperation'. ENTSO-E, 2019. Accessed: Apr. 11, 2023. [Online]. Available: https://smartnet-project.eu/wp-content/uploads/2019/05/02.Costantinescu-ENTSOE.pdf

[141] M. Shafie-khah and A. S. Gazafroudi, Eds., *Trading in Local Energy Markets and Energy Communities: Concepts, Structures and Technologies*, vol. 93. in Lecture Notes in Energy, vol. 93. Cham: Springer International Publishing, 2023. doi: 10.1007/978-3-031-21402-8.

[142] Tiko, 'Tiko'. Accessed: Aug. 16, 2023. [Online]. Available: https://tiko.energy/

[143] Tiko, 'Solutions'. Accessed: Aug. 16, 2023. [Online]. Available: https://tiko.energy/solutions/

[144] Tiko, 'K-Box A4: User's Manual'. 2022. Accessed: Mar. 21, 2023. [Online]. Available: https://um.tiko.energy/static/9004/K-Box%20A4%20User%20Manual.5c33fe3b7b44.pdf

[145] M. Geidl, B. Arnoux, T. Plaisted, and S. Dufour, 'A fully operational virtual energy storage network providing flexibility for the power system', in *Proceedings of the 12th IEA Heat Pump Conference, Rotterdam, The Netherlands*, 2017, pp. 15–18.

[146] Tiko, 'Temperature and Humidity Sensor – Connected Accessories'. 2020. Accessed: Mar. 21, 2023. [Online]. Available: https://tiko.energy/wp-content/uploads/2020/11/Sense-3-Datasheet.pdf

[147] Tiko, 'Gateway (M-Box): User's Manual'. 2022. Accessed: Mar. 21, 2023. [Online]. Available: https://um.tiko.energy/static/0005/M-Box%20NG%20User%20Manual.74d71bc7cacb.pdf

[148] Tiko, 'Solution: On Premises Peak Shaving'. Accessed: Aug. 16, 2023. [Online]. Available: https://tiko.energy/solution-on-premises-peak-shaving/

[149] Tiko, 'One platform'. Accessed: Aug. 16, 2023. [Online]. Available: https://tiko.energy/oneplatform/

[150] M. Geidl, 'Virtual Energy Storage Network based on Residential Heating Systems'. 2017. Accessed: Mar. 21, 2023. [Online]. Available: https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&ved=2ahUKEwj-4dyzqu39AhV4UqQEHZ6NDzYQFnoECBwQAQ&url=https%3A%2F%2Fwww.hslu.ch%2F-%2Fmedia%2Fcampus%2Fcommon%2Ffiles%2Fdokumente%2Fta%2Fenergiewende%2Ftevt%2Fta-cctevt-sstes-2017%2Fsstes-referat-geidl.pdf%3Fla%3Den&usg=AOvVaw2Y0Ck7oO6NdQe279Kp2tl5

[151] K. Tsatsakis, 'PHOENIX. WP2 – Requirements, Use case definition and Architecture Blueprint. D2.1Business, market & regulatory requirements', Dec. 2020. Accessed: Mar. 20, 2023. [Online].

Available: https://web.archive.org/web/20220616235946/https:/ec.europa.eu/energy/sites/default/files/documents/session_2_-_5_katrinschweren_tiko.pdf

[152] V. Z. Gjorgievski, N. Markovska, A. Abazi, and N. Duić, 'The potential of power-to-heat demand response to improve the flexibility of the energy system: An empirical review', *Renewable and Sustainable Energy Reviews*, vol. 138, p. 110489, Mar. 2021, doi: 10.1016/j.rser.2020.110489.

[153] enerTIC, 'Repsol Solmatch, la primera gran comunidad solar de España', Repsol Solmatch, la primera gran comunidad solar de España. Accessed: Apr. 04, 2023. [Online]. Available: https://enertic.org/repsol-solmatch-la-primera-gran-comunidad-solar-de-espana/

[154] Repsol, 'Comunidades solares en núcleos urbanos'. 2021. Accessed: Apr. 04, 2023. [Online]. Available: https://www.fenercom.com/wp-content/uploads/2021/07/2.-Comunidades-solares-en-n%C3%BAcleos-urbanos_Repsol-Solmatch.pdf

[155] Piclo, 'Piclo Response to Terna Consultation: Pilot project for TSO-DSO coordination'. 2023. Accessed: Mar. 09, 2023. [Online]. Available: https://uploads-ssl.webflow.com/6123718de4b96c44035b9af8/6401d732936d32e1799cfb60_Terna%20pilot%20project%20for%20TSO-DSO%20coordination.pdf

[156] EUniversal Consortium, 'D1.2 EUniversal - Observatory of research and demonstration initiatives on future electricity grids and markets', Jan. 2021. Accessed: Feb. 22, 2021. [Online]. Available: https://euniversal.eu/wp-content/uploads/2021/02/EUniversal_D1.2.pdf

[157] Piclo, 'Register for a Flexible Service Provider Account'. Accessed: Aug. 28, 2023. [Online]. Available: https://support.picloflex.com/article/89-register-for-a-flex-provider-account

[158] *Dynamic Purchasing System/company qualification*, (May 19, 2022). Accessed: Apr. 26, 2023. [Online Video]. Available: https://www.youtube.com/watch?v=mFst5tN_5cM

[159] *Asset qualification - Piclo Flex demo for Flexibility Service Providers*, (May 19, 2022). Accessed: Apr. 26, 2023. [Online Video]. Available: https://www.youtube.com/watch?v=cI4FXj7aSeo

[160] Piclo, 'Growing DSO flexibility markets to reach net zero'. Accessed: Aug. 24, 2023. [Online]. Available: https://www.enwl.co.uk/globalassets/go-net-zero/flexible-services/engagement/events/slides-and-feedback/growing_dso_flexibility_to_reach_net_zero_slides.pdf

[161] Piclo, 'Case study: Storage and EVs take the lead in £14million worth of awarded UK Power Networks flexibility contracts enabled by Piclo Flex'. 2020. Accessed: Aug. 24, 2023. [Online]. Available: https://uploads-ssl.webflow.com/6123718de4b96c44035b9af8/61e6c519f623fb46a117aad5_Piclo%20Case%20Study%20-%20UKPN%20-%20July%202020%20-%20Release.pdf

[162] Piclo, 'Adding and Editing Planned Assets'. Accessed: Aug. 28, 2023. [Online]. Available: https://support.picloflex.com/article/170-adding-and-editing-planned-assets

[163] UKPN, 'Pre-Qualification Questionnaire'. 2022. Accessed: Aug. 24, 2023. [Online]. Available: https://www.google.pt/url?sa=i&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=0CDgQw7AJahcKEwjQv5iggIKBAxUAAAAAHQAAAAAQAg&url=https%3A%2F%2Fsmartgrid.ukpowernetworks.co.uk%2Fwp-content%2Fuploads%2F2022%2F04%2FAppendix-2-Pre-Qualification-Questionnaire-v1.1.xlsx&psig=AOvVaw3KS6wk9D2fqqrqm7vkwlEq&ust=1693403040970371&opi=89978449

[164] UKPN, 'Pre-Qualification Questionnaire'. 2022. Accessed: Aug. 24, 2023. [Online]. Available: https://smartgrid.ukpowernetworks.co.uk/wp-content/uploads/2022/04/Participation-Guidance-PE1-0036-2022-Flexibility-Services-Dynamic.pdf

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union. Neither the European Union nor the granting authority can be held responsible for them.

[165] Piclo, 'Competition Qualification'. Accessed: Aug. 29, 2023. [Online]. Available: https://support.picloflex.com/article/139-competition-qualification

[166] Piclo, 'https://picloflex.com/dashboard'. Accessed: Jun. 21, 2023. [Online]. Available: https://support.picloflex.com/article/142-submitting-a-bid#data

[167] Piclo, 'Pricing Signals'. Accessed: Jun. 21, 2023. [Online]. Available: https://support.picloflex.com/article/144-pricing-signals

[168] Piclo, 'Bid Results'. Accessed: Jun. 21, 2023. [Online]. Available: https://support.picloflex.com/article/147-bid-results

[169] ENWL, 'DSO functions: Forecasting and flexibility in the North West'. 2022. Accessed: Mar. 14, 2023. [Online]. Available: https://www.enwl.co.uk/globalassets/go-net-zero/flexible-services/engagement/events/slides-and-feedback/dso-functions-webinar-april-2022--slides.pdf

[170] *Cost Calculator*, (Aug. 22, 2022). Accessed: Mar. 14, 2023. [Online Video]. Available: https://www.youtube.com/watch?v=WILlwyA30Q8

[171] ENA, 'Common evaluation methodology and tool'. 2021. Accessed: Aug. 24, 2023. [Online]. Available: https://uploads-ssl.webflow.com/6123718de4b96c44035b9af8/642ee92c2f23b24e2f773739_on22-ws1a-p1-statement-for-common-evaluation-methodology(14-jan-2022).pdf

[172] ENA, 'Common Evaluation Methodology Good Practice Guide'. 2022. Accessed: Mar. 14, 2023. [Online]. Available: https://www.energynetworks.org/industry-hub/resource-library/on22-ws1a-p1-good-practice-guide-for-cem-tool-(dec-2022).pdf

[173] ENA, 'Resource library'. Accessed: Mar. 14, 2023. [Online]. Available: https://www.energynetworks.org/industry-hub/resource-library/

[174] ENA, 'Common Evaluation Methodology (CEM): Cost Benefit Analysis User Guide (Version: 2.0)'. 2022. Accessed: Mar. 14, 2023. [Online]. Available: https://www.energynetworks.org/industry-hub/resource-library/on22-ws1a-p1-common-evaluation-methodology-(cem)-and-tool-v2.0-user-guide-(14-jan-2022).pdf

[175] ENA, 'Active Power Services Implementation Plan'. 2020. Accessed: Aug. 24, 2023. [Online]. Available: https://www.energynetworks.org/assets/images/Resource%20library/ON-WS1A-P3%20Active%20Power%20Services%20-%20Final%20Implementation%20Plan-PUBLISHED.23.12.20.pdf

[176] Piclo, 'Adding and Managing Competitions'. Accessed: Aug. 29, 2023. [Online]. Available: https://support.picloflex.com/article/53-competitions

[177] Piclo, 'Dashboard'. Accessed: Aug. 29, 2023. [Online]. Available: https://picloflex.com/dashboard

[178] INTERRFACE, 'D3.2 Definition of new/changing requirements for Market Designs'. 2022. Accessed: Mar. 09, 2023. [Online]. Available: http://www.interrface.eu/sites/default/files/publications/INTERRFACE_D3.2_v1.0.pdf

[179] Piclo, 'Product'. Accessed: Aug. 21, 2023. [Online]. Available: https://www.piclo.energy/product

[180] Piclo, 'API Reference'. Accessed: Jun. 23, 2023. [Online]. Available: https://docs.picloflex.com/

[181] Flexible Power, 'Flexible Power', Flexible Power. Accessed: Mar. 13, 2023. [Online]. Available: http://flexiblepower.co.uk/

[182] SP Energy Networks, 'Preparing For Net Zero Conference: Whole Systems Approach'. 2023. Accessed: Mar. 15, 2023. [Online]. Available:

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union. Neither the European Union nor the granting authority can be held responsible for them.

https://www.spenergynetworks.co.uk/userfiles/file/SPEN_Preparing_for_Net_Zero_Conference_-_Whole_System_Approach_-_Wednesday_8th_March_2023.pdf

[183] SP Energy Networks, 'Flexibility Services'. Accessed: Mar. 17, 2023. [Online]. Available: https://www.spenergynetworks.co.uk/pages/flexibility.aspx

[184] SP Energy Networks, 'Procurement Report for SP Distribution PLC and SP Manweb PLC'. 2022. Accessed: Mar. 15, 2023. [Online]. Available: https://www.google.com/url?sa=i&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=0CAMQw7AJahcKEwiYvMqf3939AhUAAAAAHQAAAAAQAg&url=https%3A%2F%2Fwww.flexiblepower.co.uk%2Fdownloads%2F1089&psig=AOvVaw0iH2sNysFDrHj64EYCsdKh&ust=1678962742475570

[185] SP Energy Networks, 'Pre-qualification Requirements'. 2022. Accessed: Mar. 15, 2023. [Online]. Available: https://www.flexiblepower.co.uk/downloads/1080

[186] ENA, 'Open Networks Common Evaluation Methodology Background'. 2020. Accessed: Mar. 15, 2023. [Online]. Available: https://www.flexiblepower.co.uk/downloads/798

[187] ENA, 'CEM Tool'. 2021. Accessed: Mar. 15, 2023. [Online]. Available: https://energynetworks.us18.list-manage.com/track/click?u=340f59cdee83f2a666cd804be&id=caeaf24bee&e=e002264c4d

[188] SP Energy Networks, 'Bid Assessment Criteria'. 2022. Accessed: Mar. 15, 2023. [Online]. Available: https://www.flexiblepower.co.uk/downloads/1074

[189] SP Energy Networks, 'Pricing Strategy'. 2022. Accessed: Mar. 17, 2023. [Online]. Available: https://www.flexiblepower.co.uk/downloads/1083

[190] Flexible Power, 'About Flexibility Services', About Flexibility Services. Accessed: Mar. 13, 2023. [Online]. Available: http://flexiblepower.co.uk/about-flexibility-services

[191] Flexible Power, 'Flexibility Services Agreement'. 2021. Accessed: Aug. 24, 2023. [Online]. Available: https://www.flexiblepower.co.uk/downloads/936?__cf_chl_tk=Z_3XMXjEHpBTG9OvfPn62EQlSN6P6kjkKFguO9Zle6Y-1693585615-0-gaNycGzNDaU

[192] Flexible Power, 'Constraint Management Zones: Payment Mechanism'. Accessed: Nov. 23, 2023. [Online]. Available: https://www.flexiblepower.co.uk/downloads/52?__cf_chl_tk=1SNlJyuF8_WPvIQApjLrEed1TH5hj.kMboMSVDo3uP8-1700731526-0-gaNycGzNDzs

[193] Flexible Power, 'API Documentation'. Accessed: Dec. 15, 2023. [Online]. Available: https://flexiblepowerportal.co.uk/docs/public

[194] Flexible Power, 'FAQs'. Accessed: Mar. 15, 2023. [Online]. Available: http://flexiblepower.co.uk/questions

[195] Flexible Power, 'Earnings Statement'. 2021. Accessed: Aug. 24, 2023. [Online]. Available: https://www.flexiblepower.co.uk/downloads/1026

[196] National Grid, 'Gamma Flex - Draft Market Design & Stakeholder Questionnaire'. 2022. Accessed: Apr. 19, 2023. [Online]. Available: https://www.nationalgrid.co.uk/downloads-view-reciteme/607149

[197] SP Energy Networks, 'Baseline Methodology V1 December 2020'. 2020. Accessed: Mar. 15, 2023. [Online]. Available: https://www.flexiblepower.co.uk/downloads/783

[198] SP Energy Networks, 'FUSION Interim Trial Learnings Report'. 2022. Accessed: Mar. 15, 2023. [Online]. Available:

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union. Neither the European Union nor the granting authority can be held responsible for them.

https://www.spenergynetworks.co.uk/userfiles/file/Interim%20Trial%20learnings%20Report_Dec%20 2022.pdf

[199] Flexible Power, 'Frequently Asked Questions'. Accessed: Jun. 28, 2023. [Online]. Available: https://flexiblepowerportal.co.uk/docs/public/faq.html

[200] Enedis, 'Flexibilities to enhance the Energy Transition and the performance of the Distribution Network'. Oct. 21, 2019. Accessed: Jun. 05, 2023. [Online]. Available: https://www.enedis.fr/sites/default/files/documents/pdf/flexibilities-enhance-energy-transition-performance-distribution-network.pdf

[201] Enedis, 'How to take part in the co-building of DSO local flexibility?' Accessed: Jun. 05, 2023. [Online]. Available: https://www.enedis.fr/co-building-dso-local-flexibility

[202] A. Desegaulx, T. Kuhn, H. Dupin, and S. Chevalier, 'Enedis two-step market approach to local flexibilities', in *CIRED 2020 Berlin Workshop (CIRED 2020)*, Sep. 2020, pp. 803–806. doi: 10.1049/oap-cired.2021.0231.

[203] Enedis, 'RFI Platform'. Accessed: Jun. 07, 2023. [Online]. Available: https://flexibilites-enedis.fr/

[204] F. Gonzalez Venegas, M. Petit, and Y. Perez, 'Can DERs fully participate in emerging local flexibility tenders?', in *2019 16th International Conference on the European Energy Market (EEM)*, Sep. 2019, pp. 1–5. doi: 10.1109/EEM.2019.8916343.

[205] S. Chondrogiannis, J. Vasiljevska, A. Marinopoulos, I. Papaioannou, and G. Flego, 'Local electricity flexibility markets in Europe', JRC Publications Repository. Accessed: Jun. 05, 2023. [Online]. Available: https://publications.jrc.ec.europa.eu/repository/handle/JRC130070

[206] Enedis, 'Les flexibilites locales sur le reseau public de distribution d'electricite'. 2019. Accessed: Dec. 11, 2023. [Online]. Available: https://flexibilites-enedis.fr/upload/documentation/130619-appel-a-contributions-enedis-flexibilites-locales-synthese.pdf?1

[207] Enedis, 'Appel d'Offres Flexibilités Locales 2023 RFQ-2301: Résultats'. 2023. Accessed: Dec. 11, 2023. [Online]. Available: https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&ved=2ahUKEwiXxfSHu4iDAxUHe6QEHaFPDK4QFnoECA4QAQ&url=https%3A%2F%2Fwww.enedis.fr%2Fmedia%2F3594%2Fdownload&usg=AOvVaw3U_D6kS56e0nT8L-RLUvT_&opi=89978449

[208] Enedis, 'Appels d'offres Flexibilités Locales'. 2022. Accessed: Dec. 11, 2023. [Online]. Available: https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ahUKEwj4nZyvlYeDAxUvgv0HHcS6C-AQFnoECBIQAQ&url=https%3A%2F%2Fwww.enedis.fr%2Fmedia%2F3148%2Fdownload&usg=AOvVaw2R-hBeVMcIBeVyfnALFsvD&opi=89978449

[209] Enedis, 'Marché de flexibilité locale sans réservation de capacité'. 2022. Accessed: Dec. 11, 2023. [Online]. Available: https://www.enedis.fr/media/3141/download

[210] Enedis, 'Roadmap for the transformation of network planning methods and the integration of flexibilities'. Feb. 01, 2020. Accessed: Jun. 05, 2023. [Online]. Available: https://www.enedis.fr/sites/default/files/documents/pdf/roadmap-tranformation-network-planning-methods-integration-flexibilities.PDF

[211] OneNet, 'D3.4: Regulatory and demo assessment of proposed integrated'. Aug. 30, 2023. Accessed: Dec. 11, 2023. [Online]. Available: https://onenet-project.eu/wp-content/uploads/2023/09/OneNet_D3.4_V1.0.pdf

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union. Neither the European Union nor the granting authority can be held responsible for them.

[212] OMIE, 'IREMEL Publications'. Accessed: Dec. 14, 2023. [Online]. Available: https://www.omie.es/en/proyecto-iremel

[213] 'DRES2Market'. Accessed: Dec. 14, 2023. [Online]. Available: https://www.dres2market.eu/

[214] OneNet, 'OneNet'. Accessed: Feb. 20, 2024. [Online]. Available: https://onenet-project.eu/

[215] OneNet, 'D9.1 - Specifications and guidelines for Western Demos'. 2021. Accessed: Jul. 24, 2023. [Online]. Available: https://onenet-project.eu/wp-content/uploads/2022/10/D9.1-Specifications-and-guidelines-for-Western-Demos.pdf

[216] OneNet, 'D3.1 - Overview of market designs for the procurement of system services by DSOs and TSOs'. 2021. Accessed: Jan. 16, 2024. [Online]. Available: https://onenet-project.eu/wp-content/uploads/2023/05/OneNet_D9.3_v1.0.pdf

[217] OneNet, 'D9.3 - Validation and results of concept test - Spain'. 2023. Accessed: Oct. 24, 2023. [Online]. Available: https://onenet-project.eu/wp-content/uploads/2023/05/OneNet_D9.3_v1.0.pdf

[218] NODES, 'About', NODES. Accessed: Aug. 25, 2023. [Online]. Available: https://nodesmarket.com/about/

[219] NODES, 'A Fully Integrated Marketplace For Flexibility'. 2019. Accessed: Mar. 21, 2023. [Online]. Available: https://d1jagcpmche0d6.cloudfront.net/wp-content/uploads/2019/11/10125443/1-NODES-market-design_WhitePaper.pdf

[220] NODES, 'Market Design'. Accessed: Mar. 29, 2023. [Online]. Available: https://nodesmarket.com/market-design/

[221] EUniversal, 'D2.2 Business Use Cases to unlock flexibility service provision'. 2021. [Online]. Available: https://euniversal.eu/wp-content/uploads/2021/05/EUniversal_D2.2.pdf

[222] NODES, 'LongFlex'. Accessed: Aug. 25, 2023. [Online]. Available: https://nodesmarket.com/longflex/

[223] NODES, 'White Paper: Trading in NorFlex 2020-22'. 2022. Accessed: Aug. 24, 2023. [Online]. Available: https://d1jagcpmche0d6.cloudfront.net/wp-content/uploads/2022/08/16123829/White-Paper-Trading-in-NorFlex-2020-22-Published.pdf

[224] *Redefining flexibility management in Energy*, (Aug. 10, 2022). Accessed: Aug. 18, 2023. [Online Video]. Available: https://www.youtube.com/watch?v=yqkdJpzx53s

[225] EPEX SPOT, 'EPEX SPOT and N-SIDE jointly address one of the major challenges of the energy transition | EPEX SPOT'. Accessed: Apr. 21, 2023. [Online]. Available: https://www.epexspot.com/en/news/epex-spot-and-n-side-jointly-address-one-major-challenges-energy-transition

[226] EUniversal, 'NODES market', NODES market. Accessed: Apr. 21, 2023. [Online]. Available: https://nodesmarket.com/euniversal/

[227] N-SIDE, 'Forecasting and optimization solutions for power grids and markets'. Accessed: Aug. 18, 2023. [Online]. Available: https://energy.n-side.com

[228] AELĒC, 'Sistema Intercambio De Información Operadores De La Red De Distribución - Documento de motivación'. 2021. Accessed: Apr. 10, 2023. [Online]. Available: https://aelec.es/wp-content/uploads/2021/03/Documento-motivacion-SIORD-vF.pdf

[229] Interconnect, 'Customer data management crucial to distribution system operators'. Accessed: May 29, 2023. [Online]. Available: https://interconnectproject.eu/events/interconnect-webinar-series-4-customer-data-management-crucial-to-distribution-system-operators/

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union. Neither the European Union nor the granting authority can be held responsible for them.

[230] C. Moises *et al.*, 'SIORD, a New DSO-shared Data Hub to Monitor and Control Distributed Energy Resources in Spain', presented at the 27th International Conference on Electricity Distribution, Rome, Jun. 2023. [Online]. Available: https://www.researchgate.net/publication/371608969_SIORD_A_NEW_DSO-SHARED_DATA_HUB_TO_MONITOR_AND_CONTROL_DISTRIBUTED_ENERGY_RESOURCES_IN_SPAIN

[231] V2Market, 'D3.2 - Report on flexibility and local market potential, opportunities for V2G in local distributed markets'. 2022. Accessed: Apr. 10, 2023. [Online]. Available: https://v2market-project.eu/wp-content/uploads/2022/07/D3.2-Flexibility-local-market-potential_M9_v1.0_OMIE.pdf

[232] AELĒC, 'Sistema de Información de los Operadores de Redes de Distribución - Presentación de la consulta'. 2021. Accessed: Apr. 10, 2023. [Online]. Available: https://aelec.es/wp-content/uploads/2021/04/20210420_SIORD-Presentacion-webinar.pdf

[233] AELĒC, 'Sistema de Información de los Operadores de Redes de Distribución - Especificaciones de diseño'. 2021. Accessed: Apr. 10, 2023. [Online]. Available: https://aelec.es/wp-content/uploads/2021/03/Especificaciones-tecnicas-de-SIORD-vF.pdf

[234] V2Market, 'D3.3 - Conclusions of the market study'. 2022. Accessed: Apr. 10, 2023. [Online]. Available: https://v2market-project.eu/wp-content/uploads/2022/07/D3.3-Conclusions-of-study_M9_v1.0_OMIE.pdf

[235] Sia Partners, 'Atrias and MIG6.0: Towards a new energy market model in Belgium'. Accessed: Apr. 11, 2023. [Online]. Available: https://www.sia-partners.com/en/insights/publications/atrias-and-mig60-towards-a-new-energy-market-model-belgium

[236] A. Forouli *et al.*, 'Assessment of Demand Side Flexibility in European Electricity Markets: A Country Level Review', *Energies*, vol. 14, no. 8, 2021, doi: 10.3390/en14082324.

[237] EU-SysFlex, 'Market and Governance of Existing Data Access & Exchange Platforms'. 2021. Accessed: Apr. 11, 2023. [Online]. Available: https://eu-sysflex.com/wp-content/uploads/2021/03/EUSYSFLEX-5.1.3-Report-Data-Platforms-FINAL-1.pdf

[238] eBIX, 'Survey: DataHub v1.3'. 2022. Accessed: Apr. 11, 2023. [Online]. Available: https://mwgstorage1.blob.core.windows.net/public/Ebix/EBG%20Survey%20DataHub%20v1r3%2020220914.pdf

[239] FEVER, 'D4.1 - Flexibility-related European electricity markets: Modus operandi, proposed adaptations and extensions and metrics definition'. 2020. Accessed: Apr. 11, 2023. [Online]. Available: https://www.fever-h2020.eu/data/deliverables/FEVER_D4.1_-_Flexibility_related_European_electricity_markets.pdf

[240] ENA, 'Active Power Products Review'. Accessed: Oct. 16, 2023. [Online]. Available: https://www.energynetworks.org/assets/images/Resource%20library/ON22-WS1A-P6%20Active%20Power%20Products%20Review%20(01%20Aug%202022).pdf?1697462920

[241] ENA, 'Challenge Group slides'. 2023. Accessed: Oct. 16, 2023. [Online]. Available: https://www.energynetworks.org/assets/images/Publications/2023/230727-opennetworks-challenge-group-slides.pdf?1693303502

[242] SSEN, 'Flexibility Services Document Library'. Accessed: Oct. 16, 2023. [Online]. Available: https://www.ssen.co.uk/our-services/flexible-solutions/flexibility-services/flexibility-services-document-library/our-services/flexible-solutions/flexibility-services/flexibility-services-document-library/

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union. Neither the European Union nor the granting authority can be held responsible for them.

[243] SSEN, 'Global Call Webinar Slides September 2023'. 2023. Accessed: Oct. 16, 2023. [Online]. Available: https://www.ssen.co.uk/globalassets/our-services/flexibility-services-document-library/current-tenders/global-call-webinar-slides-september-2023.pdf

[244] *Autumn 2023 Flexibility Tender launch webinar*, (Oct. 04, 2023). Accessed: Oct. 16, 2023. [Online Video]. Available: https://www.youtube.com/watch?v=lYEn53ChhUQ

[245] UKPN, 'Participation Guidance Autumn 2023 Flexibility Tender'. 2023. Accessed: Oct. 16, 2023. [Online]. Available: https://d1lf1oz5vvdb9r.cloudfront.net/app/uploads/2023/07/Autumn-2023-Tender-Participation-Guidance-v1.0-1.pdf

[246] E-Redes, 'Regulamento dos concursos para a prestação de serviços de flexibilidade'. 2023. Accessed: Oct. 16, 2023. [Online]. Available: https://www.e-redes.pt/sites/eredes/files/2023-08/Regulamento_concursos_prestacao_servicos.pdf

[247] E-Redes, 'Contrato de serviços de flexibilidade'. 2023. Accessed: Oct. 16, 2023. [Online]. Available: https://uploads-ssl.webflow.com/6123718de4b96c44035b9af8/64d0d2969480c5b67d4064fc_E-REDES_FIRMe_FSP%20Standard%20Contract_20230801.pdf

[248] OneNet, 'D2.2: A set of standardised products for system services in the TSO-DSO-consumer value chain'. 2021. Accessed: Dec. 22, 2022. [Online]. Available: https://onenet-project.eu/wp-content/uploads/2021/08/D22-A-set-of-standardised-products-for-system-services-in-the-TSO-DSO-consumer-value-chain-1.pdf

[249] EUniversal, 'D2.1 Grid flexibility services definition'. 2021. [Online]. Available: https://euniversal.eu/wp-content/uploads/2021/02/EUniversal__D2.1.pdf

[250] EU-SysFlex, 'D3.2: Conceptual market organisations for the provision of innovative system services: role models, associated market designs and regulatory frameworks'. Accessed: Aug. 30, 2023. [Online]. Available: https://eu-sysflex.com/wp-content/uploads/2020/06/EU-SysFlex_Task-3.2-Deliverable-Final.pdf

[251] EUniversal, 'UMEI OpenAPI Specification'. Accessed: Feb. 22, 2024. [Online]. Available: https://euniversal.github.io/umei-api-specification/swagger-ui.html

[252] CEO Alliance, 'CEO Alliance Connected Systems Feasibility study', 2022.

[253] TDX-ASSIST, 'D1.3 - Assessment on data aggregation and information exchange requirements'. 2018. Accessed: Sep. 04, 2023. [Online]. Available: https://ec.europa.eu/research/participants/documents/downloadPublic?documentIds=080166e5be7f01e7&appId=PPGMS

[254] A. Cockburn, *Writing Effective Use Cases*. Addison-Wesley Professional, 2001. Accessed: Dec. 28, 2023. [Online]. Available: https://www.pearson.com/en-us/subject-catalog/p/writing-effective-use-cases/P200000009217/9780321605801

[255] CEER, 'CEER Paper on DSO Procedures of Procurement of Flexibility', Distribution Systems Working Group, Brussels, Belgium, Jul. 2020. [Online]. Available: https://www.ceer.eu/documents/104400/-/-/e436ca7f-a0df-addb-c1de-5a3a5e4fc22b

[256] E. Beckstedde, M. C. Ramírez, R. Cossent, J. Vanschoenwinkel, and L. Meeus, 'Regulatory Sandboxes: Do They Speed Up Innovation in Energy?' Rochester, NY, Dec. 22, 2022. doi: 10.2139/ssrn.4309455.

[257] T. Schittekatte, L. Meeus, T. Jamasb, and M. Llorca, 'Regulatory experimentation in energy: Three pioneer countries and lessons for the green transition', *Energy Policy*, vol. 156, p. 112382, Sep. 2021, doi: 10.1016/j.enpol.2021.112382.

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union. Neither the European Union nor the granting authority can be held responsible for them.

[258] European Commission, 'Guidance on regulatory sandboxes, testbeds, and living labs in the EU, with a focus section'. Aug. 29, 2023. Accessed: Nov. 22, 2023. [Online]. Available: https://research-and-innovation.ec.europa.eu/system/files/2023-08/swd_2023_277_f1.pdf

[259] Ofgem, 'Energy Regulation Sandbox: Guidance for Innovators'. Jul. 20, 2020. Accessed: Feb. 15, 2021. [Online]. Available: https://www.gasgovernance.co.uk/sites/default/files/ggf/book/2018-02/Ofgem%20Regulatory%20Sandbox%20-%20Innovation%20Link.pdf

[260] Energy inspectorate, 'Ei R2023:03 Innovationscenter och regulatoriska sandlådor'. 2023. Accessed: Jun. 14, 2023. [Online]. Available: https://ei.se/download/18.56edc373186a1d5a9df2b8f/1678094189173/Innovationscenter-och-regulatoriska-sandl%C3%A5dor-Ei-R2023-03.pdf

[261] European Union, *Regulation (EU) 2018/1999 of the European Parliament and of the Council of 11 December 2018 on the Governance of the Energy Union and Climate Action, amending Regulations (EC) No 663/2009 and (EC) No 715/2009 of the European Parliament and of the Council, Directives 94/22/EC, 98/70/EC, 2009/31/EC, 2009/73/EC, 2010/31/EU, 2012/27/EU and 2013/30/EU of the European Parliament and of the Council, Council Directives 2009/119/EC and (EU) 2015/652 and repealing Regulation (EU) No 525/2013 of the European Parliament and of the Council*, vol. 328. 2018. Accessed: Jan. 02, 2024. [Online]. Available: http://data.europa.eu/eli/reg/2018/1999/oj/eng

[262] European Union, *Directive (EU) 2023/2413 of the European Parliament and of the Council of 18 October 2023 amending Directive (EU) 2018/2001, Regulation (EU) 2018/1999 and Directive 98/70/EC as regards the promotion of energy from renewable sources, and repealing Council Directive (EU) 2015/652*, vol. 2023/2413. 2023. Accessed: Feb. 20, 2024. [Online]. Available: http://data.europa.eu/eli/dir/2023/2413/oj

[263] Ministerio para la Transición Ecológica y el Reto Demográfico, *Orden TED/1247/2021, de 15 de noviembre, por la que se modifica, para la implementación de coeficientes de reparto variables en autoconsumo colectivo, el anexo I del Real Decreto 244/2019, de 5 de abril, por el que se regulan las condiciones administrativas, técnicas y económicas del autoconsumo de energía eléctrica*, vol. BOE-A-2021-18706. 2021, pp. 141114–141119. Accessed: Jan. 02, 2024. [Online]. Available: https://www.boe.es/eli/es/o/2021/11/15/ted1247

[264] Ministerio para la Transición Ecológica, *Real Decreto 244/2019, de 5 de abril, por el que se regulan las condiciones administrativas, técnicas y económicas del autoconsumo de energía eléctrica*, vol. BOE-A-2019-5089. 2019, pp. 35674–35719. Accessed: Jan. 02, 2024. [Online]. Available: https://www.boe.es/eli/es/rd/2019/04/05/244

[265] Ministerio para la Transición Ecológica y el Reto Demográfico, 'Hoja de Ruta del Autoconsumo'. Dec. 01, 2021. Accessed: Jan. 02, 2024. [Online]. Available: https://www.miteco.gob.es/content/dam/miteco/es/ministerio/planes-estrategias/hoja-ruta-autoconsumo/hojaderutaautoconsumo_tcm30-534411.pdf

[266] European Union, *Regulation (EU) 2019/943 of the European Parliament and of the Council of 5 June 2019 on the internal market for electricity (recast) (Text with EEA relevance.)*, vol. 158. 2019. Accessed: Jan. 02, 2024. [Online]. Available: https://eur-lex.europa.eu/eli/reg/2019/943/oj/eng

[267] European Union, *Commission Regulation (EU) 2017/2195 of 23 November 2017 establishing a guideline on electricity balancing (Text with EEA relevance.)*, vol. 312. 2017. Accessed: Jan. 02, 2024. [Online]. Available: http://data.europa.eu/eli/reg/2017/2195/oj/eng

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union. Neither the European Union nor the granting authority can be held responsible for them.

[268] European Union, *Commission Regulation (EU) 2017/1485 of 2 August 2017 establishing a guideline on electricity transmission system operation (Text with EEA relevance.)*, vol. 220. 2017. Accessed: Jan. 02, 2024. [Online]. Available: http://data.europa.eu/eli/reg/2017/1485/oj/eng

[269] European Union, *Commission Regulation (EU) 2016/1388 of 17 August 2016 establishing a Network Code on Demand Connection (Text with EEA relevance)*, vol. 223. 2016. Accessed: Jan. 02, 2024. [Online]. Available: http://data.europa.eu/eli/reg/2016/1388/oj/eng

[270] European Union, *Commission Regulation (EU) 2015/1222 of 24 July 2015 establishing a guideline on capacity allocation and congestion management (Text with EEA relevance)*, vol. 197. 2015. Accessed: Jan. 02, 2024. [Online]. Available: http://data.europa.eu/eli/reg/2015/1222/oj/eng

[271] ACER, 'Framework Guideline on Demand Response'. Accessed: Sep. 12, 2023. [Online]. Available: https://www.acer.europa.eu/Official_documents/Acts_of_the_Agency/Framework_Guidelines/Framework%20Guidelines/FG_DemandResponse.pdf

[272] EUDSO Entity and ENTSO-E, 'EUDSO Entity and ENTSO-E DRAFT Proposal for a Network Code on Demand Response'. Accessed: Dec. 12, 2023. [Online]. Available: https://consultations.entsoe.eu/markets/public-consultation-networkcode-demand-response/supporting_documents/Network%20Code%20Demand%20Response%20v1%20draft%20proposal.pdf

[273] CEER, 'CEER Paper on Alternative Connection Agreements', May 2023. [Online]. Available: https://www.ceer.eu/documents/104400/-/-/e473b6de-03c9-61aa-2c6a-86f2e3aa8f08

[274] ACER, 'Report on Electricity Transmission and Distribution Tariff Methodologies in Europe'. Jan. 01, 2023. Accessed: Jan. 02, 2024. [Online]. Available: https://www.acer.europa.eu/sites/default/files/documents/Publications/ACER_electricity_network_tariff_report.pdf

[275] K. L. Anaya and M. G. Pollitt, 'How to Procure Flexibility Services within the Electricity Distribution System: Lessons from an International Review of Innovation Projects', *Energies*, vol. 14, no. 15, p. 4475, Jul. 2021, doi: 10.3390/en14154475.

[276] CEER, 'DSO Procedures of Procurement of Flexibility'. 2022. Accessed: Nov. 22, 2023. [Online]. Available: https://www.ceer.eu/documents/104400/-/-/f65ef568-dd7b-4f8c-d182-b04fc1656e58

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9. Annex I – Workshop

9.1. Overview

In the scope of T1.3, INESC TEC delivered a workshop on the 19th of May 2023. The primary objectives of this session included:

- Validate the flexibility VC and identify missing steps or activities
- Explain the role model according to the VC
- Map BUC and services on the VC
- Present the roadmap with the steps to operationalise, implement and sustain the VC

9.2. Minute

The workshop encompassed the activities described next.

9.2.1. Overview of the Grid Data and Business Network

A high-level summary and characterization of the GDBN, along with the anticipated services to be included in it, were presented to the participants.

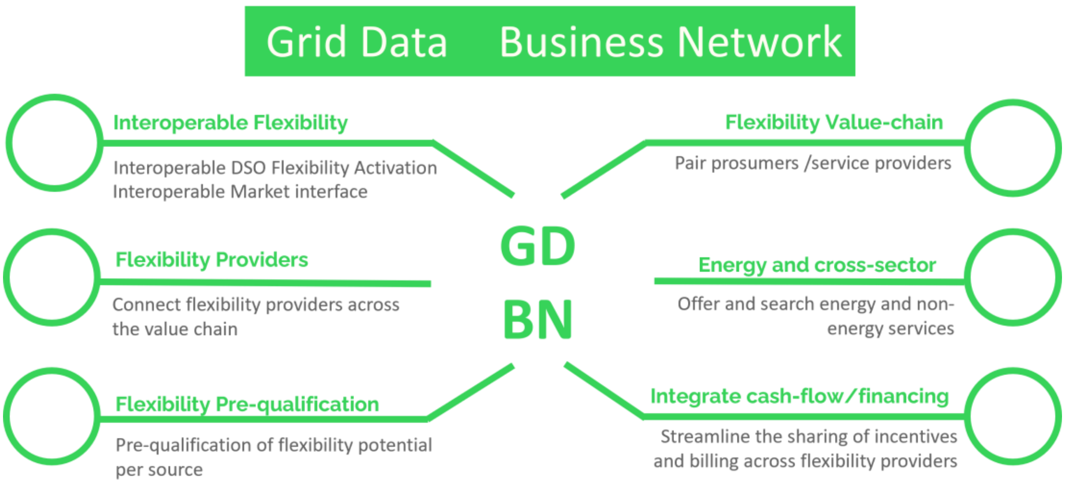

Figure 9.1 – Grid Data and Business Network

9.2.2. Presentation of the flexibility-centric energy and cross-sector value chain

The structure of the VC (Figure 9.2) was thoroughly described step by step, detailing the main and secondary activities and the main roles encompassed in each stage.

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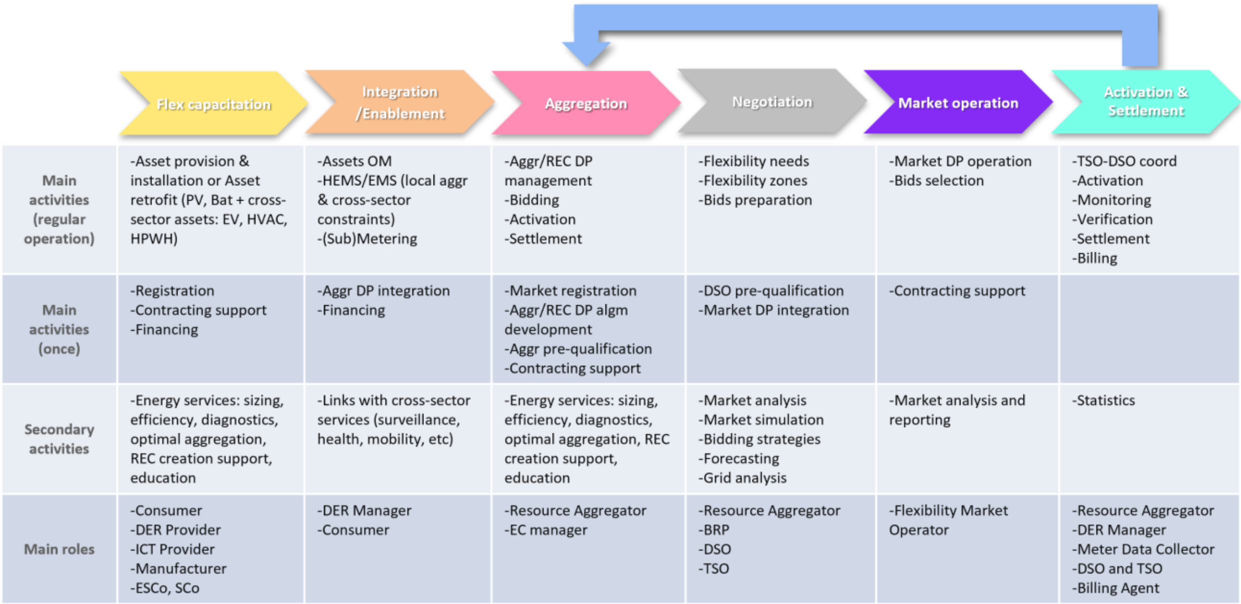

	Flex capacitation	Integration /Enablement	Aggregation	Negotiation	Market operation	Activation & Settlement
Main activities (regular operation)	-Asset provision & installation or Asset retrofit (PV, Bat + cross-sector assets: EV, HVAC, HPWH)	-Assets OM -HEMS/EMS (local aggr & cross-sector constraints) -(Sub)Metering	-Aggr/REC DP management -Bidding -Activation -Settlement	-Flexibility needs -Flexibility zones -Bids preparation	-Market DP operation -Bids selection	-TSO-DSO coord -Activation -Monitoring -Verification -Settlement -Billing
Main activities (once)	-Registration -Contracting support -Financing	-Aggr DP integration -Financing	-Market registration -Aggr/REC DP algm development -Aggr pre-qualification -Contracting support	-DSO pre-qualification -Market DP integration	-Contracting support	
Secondary activities	-Energy services: sizing, efficiency, diagnostics, optimal aggregation, REC creation support, education	-Links with cross-sector services (surveillance, health, mobility, etc)	-Energy services: sizing, efficiency, diagnostics, optimal aggregation, REC creation support, education	-Market analysis -Market simulation -Bidding strategies -Forecasting -Grid analysis	-Market analysis and reporting	-Statistics
Main roles	-Consumer -DER Provider -ICT Provider -Manufacturer -ESCo, SCo	-DER Manager -Consumer	-Resource Aggregator -EC manager	-Resource Aggregator -BRP -DSO -TSO	-Flexibility Market Operator	-Resource Aggregator -DER Manager -Meter Data Collector -DSO and TSO -Billing Agent

Figure 9.2 – Structure of the VC presented on the workshop

9.2.3. User stories

Three representative user stories, which included “Flexibility capacitation”, “Energy Community” and “DSO flexibility dispatch” were presented. For each of the user stories the involved roles were stated, the main goals identified, and the needs specified. Moreover, it was indicated which of the services of the GDBN could support each user story.

9.2.4. Compare the GDBN to other platforms

The GDBN was compared with other platforms, by mapping them along the VC.

9.2.5. Q/A session

To check if all BUC were covered by the VC and identify any missing steps, a Q/A session was hold. Two questions were posed to the participants:

- Considering your BUC, which stages from the flexibility value chain are covered?
- Do you identify any missing stage in the flexibility-centric energy value-chain?

All participants stated they were able to map their BUC on the VC and no missing stages were identified. Nevertheless, there were suggestions to add some new activities (see 9.3).

9.2.6. Description of the Role Model

The role model and all the roles included in it were described to the participants.

9.2.7. User-stories mapping

The user stories were mapped on the role model and on the VC, as in Figure 9.3.

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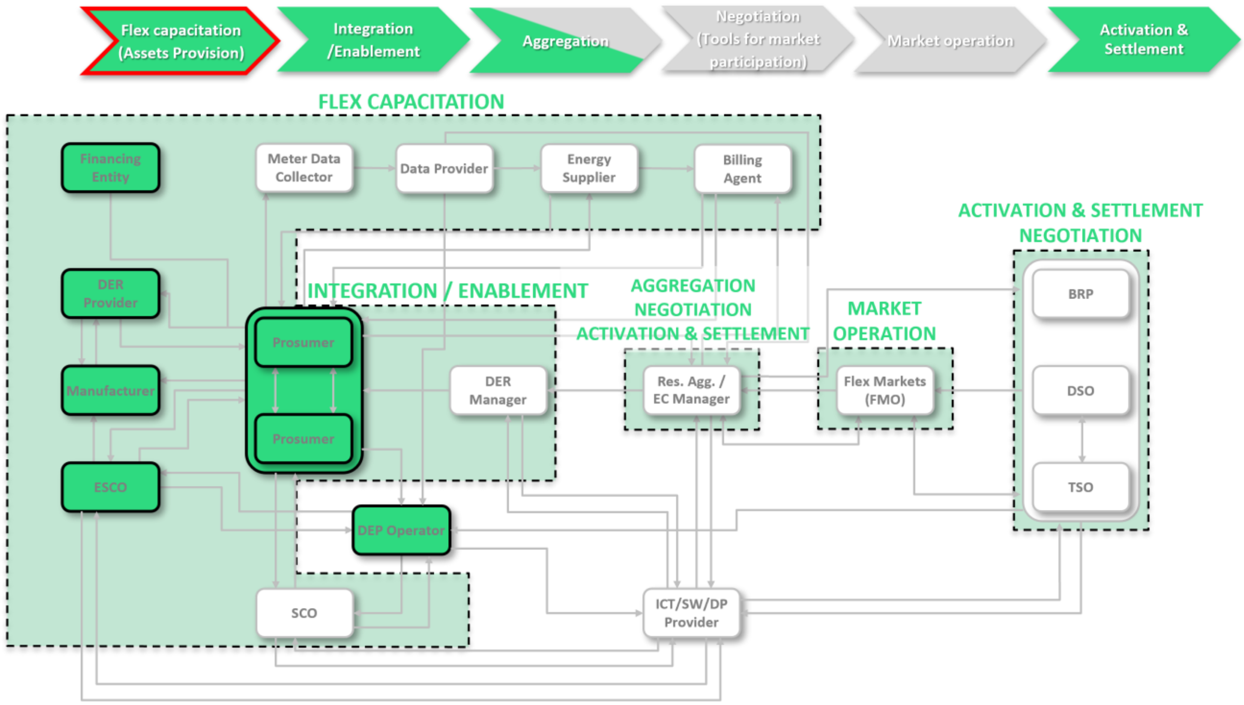

Figure 9.3 - Mapping of the Flex capacitation stage of the user story Energy Community

9.2.8. Presentation of a roadmap

Lastly, a roadmap with the steps and actions required to operationalise, implement, and sustain the VC was presented. It is depicted in Figure 9.4.

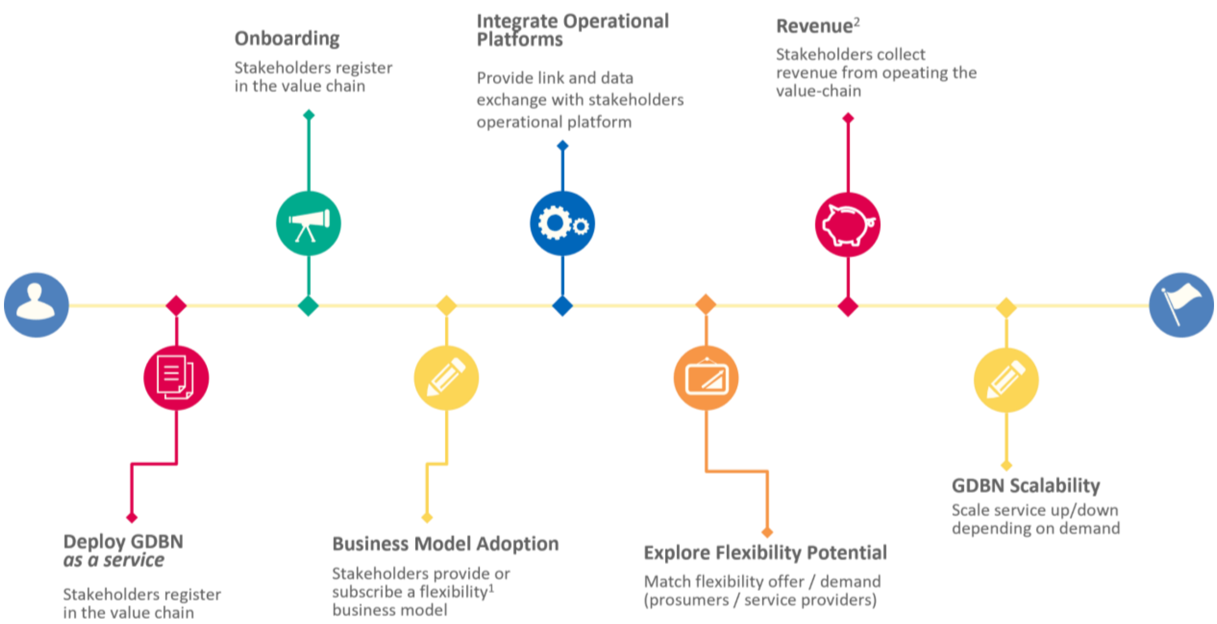

Figure 9.4 - VC roadmap

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According to the roadmap, the implementation of the VC starts with the deployment of the GDBN, which is available as a service, offering a solution for stakeholders to enhance their activities. Next, in the onboarding step, the stakeholders are invited to make their registration. Then, as members of the VC, stakeholders can either provide or subscribe to flexibility BMs. Since some of those stakeholders might already operate an own platform, it is necessary to guarantee a seamless link and data exchange between them and the GDBN. Once operational, the GDBN enables stakeholders to identify and match flexibility offers and requests from both Prosumers and service providers. From their participation in the GDBN, stakeholders can create value and be paid for it, fostering a sustainable and mutually beneficial ecosystem. The last stage of the roadmap is centred on guarantying the scalability of the GDBN, so it adapts to a variable demand.

9.3. Conclusions

The provided feedback led to the implementation of some changes on the VC, which are highlighted in Figure 9.5. These changes include the renaming of the "negotiation" stage to "negotiation preparation", Maintenance and support services are added to the Flex Capacitation and Integration/Enablement stages, the baseline is made more explicit in the Aggregation, Negotiation preparation and Activation & Settlement stages and TSO/DSO coordination is included in the Negotiation preparation stage.

	Flex capacitation	Integration /Enablement	Aggregation	Negotiation preparation	Market operation	Activation & Settlement
Main activities (regular operation)	-Asset provision & installation or Asset retrofit (PV, Bat + cross-sector assets: EV, HVAC, HPWH)	-Assets OM -HEMS/EMS (local aggr & cross-sector constraints) -(Sub)Metering	-Aggr/REC DP management -Bidding -Activation **-Verification (baseline)** -Settlement	-Flexibility needs -Flexibility zones -Bids preparation -**TSO-DSO coord**	-Market DP operation -Bids selection	-TSO-DSO coord -Activation -Monitoring -Verification **(baseline)** -Settlement -Billing
Main activities (once)	-Registration -Contracting support -Financing	-Aggr DP integration -Financing	-Market registration -Aggr/REC DP algm development -Aggr pre-qualification -Contracting support	-DSO pre-qualification -Market DP integration -**Baseline computation**	-Contracting support	
Secondary activities	-Energy services: sizing, efficiency, diagnostics, optimal aggregation, REC creation support, education **-Maintenance and support services**	-Links with cross-sector services (surveillance, health, mobility, etc) **-Maintenance and support services**	-Energy services: sizing, efficiency, diagnostics, optimal aggregation, REC creation support, education	-Market analysis -Market simulation -Bidding strategies -Forecasting -Grid analysis	-Market analysis and reporting	-Statistics
Main roles	-Consumer -DER Provider -ICT Provider -Manufacturer -ESCo, SCo	-DER Manager -Consumer	-Resource Aggregator -EC manager	-Resource Aggregator -BRP -DSO -TSO	-Flexibility Market Operator	-Resource Aggregator -DER Manager -Meter Data Collector -DSO and TSO -Billing Agent

Figure 9.5 - Structure of the VC after the workshop

The feedback received from the participants during and after the workshop led to the following conclusions:

- The VC suits the mapping of all Use Cases
- The VC includes all the necessary stages for boosting distributed flexibility

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10. Annex II – Business Use Cases template

1 Description of the use case

1.1 Name of the use case

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

1.2 Version management

Version Management			
Version No.	Date	Name of Author(s)	Changes

1.3 Scope and objectives of use case

Scope and Objectives of Use Case	
Scope	The scope defines the limits of the use case.
Objective(s)	List of objectives of the use case
Related business case(s)	Provides a description or reference with some rationale for the suggested use case. Usually the business case is related to several use cases. Therefore, an external reference or link to a business case/business requirements might be more efficient and can be added here.

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
Complete Description 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)

This information will be used in the remaining WP of BeFlexible, so it is crucial.

Business use cases should define KPI linked to specific objectives (and ad-hoc indicators) from the DoA, as well as business processes.

System use cases should define KPI linked to BeFlexible tools/services/platforms and respective performance.

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ID	Name	Description	Reference to mentioned use case objectives
		The description specifies the KPI and may include specific targets in relation to one of the objectives of the use case and the calculation of these targets.	Here is the link to one of the objective which are specified in the targets and the KPI before.

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
Known relations to other use cases can be provided here if e.g. the use case is a more detailed one related to a business level use case, or it is an alternative to an existing use case. Could be used to include the IDs of BeFlexible use cases related to this one, or even to refer to external Use Cases (from BRIDGE use cases repository: https://smart-grid-use-cases.github.io/docs/usecases/bridge/) from which the particular BeFlexible Use Case derives.
Level of depth
Defines the level of depth of the use case: **Business use case** (BUC) use case which describes a general requirement, idea or concept independently from a specific technical realization like an architectural solution **System use case** (SUC) use case which describes in detail the functionality/technological solutions of (a part of) a business process.
Prioritisation
Considering a larger number of use cases it might be interesting to cluster them according to priority. This prioritisation might be different from country to country. Nonetheless, in BeFlexible this field should indicate whether the solutions will be implemented in more than one demo and if replicability is a key objective.
Generic, regional or national relation
Generic, regional or national relation: On international level, the use case description might be generic enough to describe a use case in a more general way independently from the national or regional market design. But use cases might be used to describe regional or national specific circumstances like laws or even project-specific details. If the use case reflects those circumstances, it should be characterized accordingly. **Note: Use Cases demonstrated in more than one country should be classified and written as Generic.**
Nature of the use case

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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

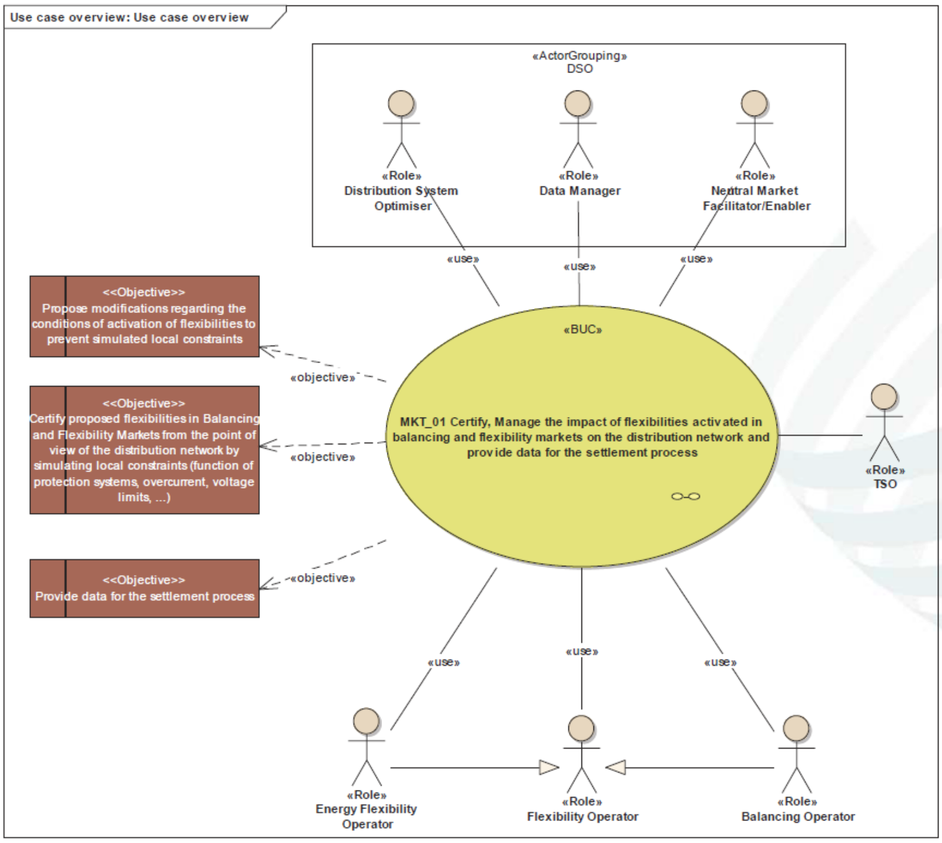
General Remarks
Is used for further comments which are not considered elsewhere.

2 Diagrams of use case

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

Diagram(s) of use case

Please paste below the *<u>Use Case Diagram</u>: shows how actors interact within the Use Case by participating in the technical functions*



Please paste below the <u>BUC-SUC Relations Diagram</u>: shows which system use cases (SUC) are used by the Business Use Case (BUC). <u>This is diagram is only included in BUC.</u>

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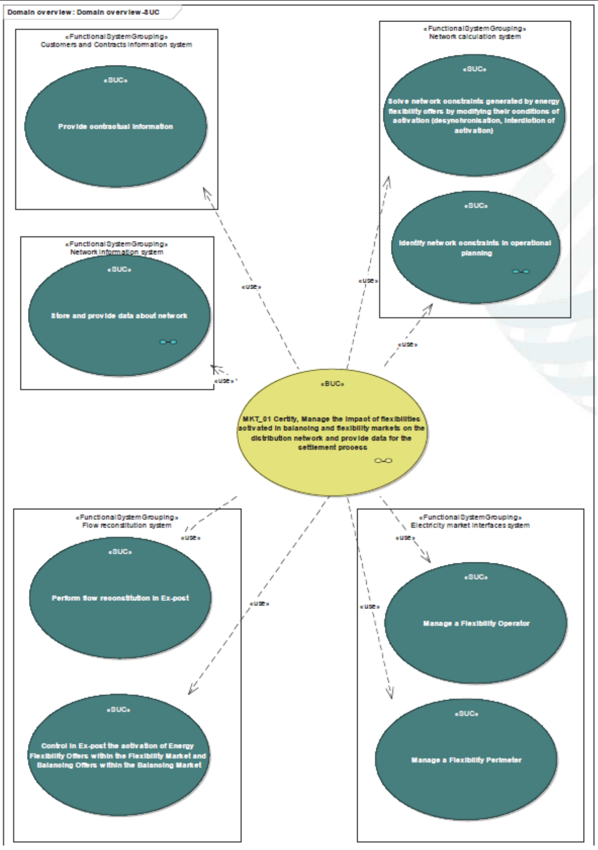
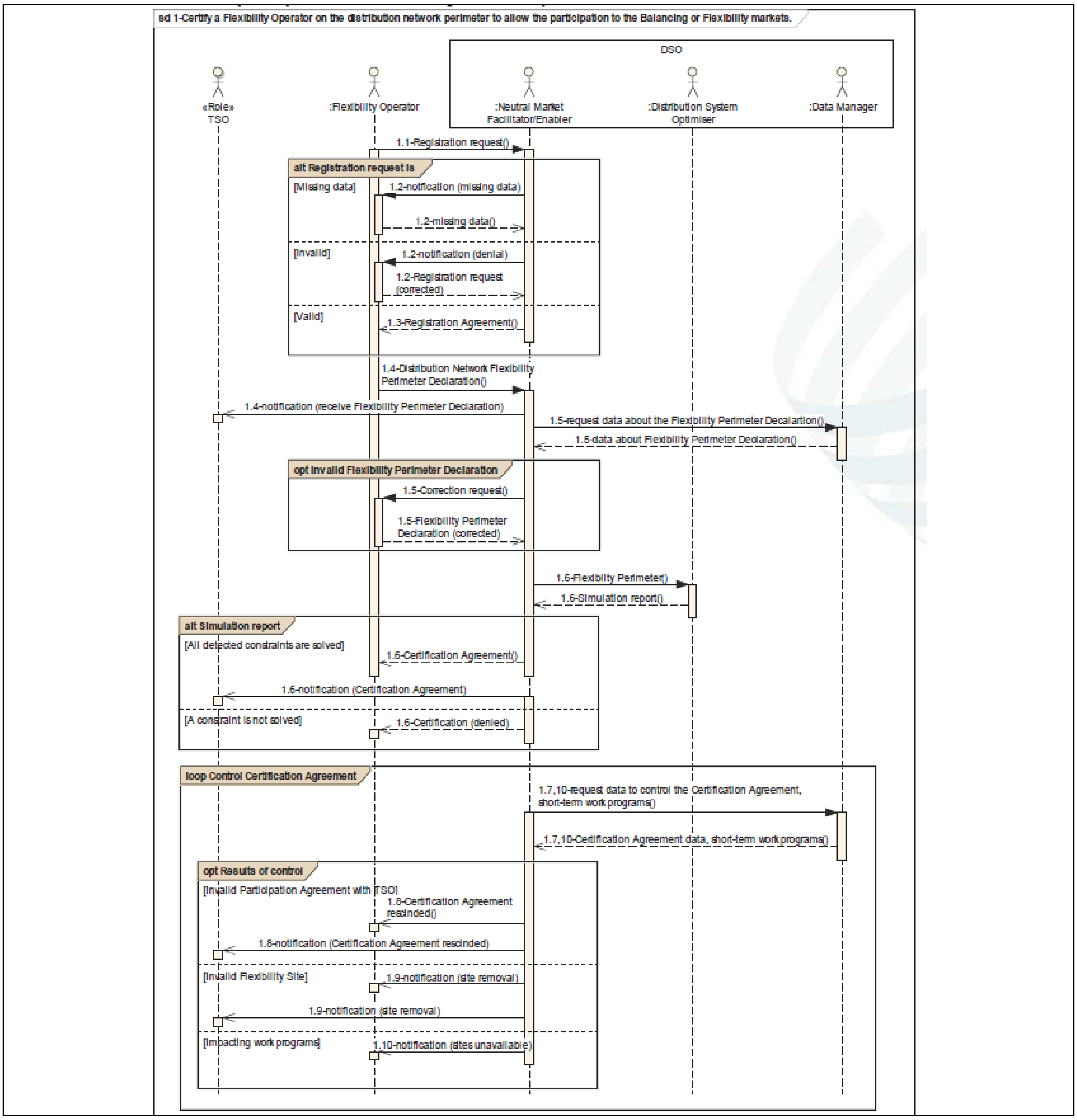


Please paste below the Sequence Diagram: shows the dynamic sequence of the activities (information exchanges/internal operations) required in the sub-functionality



3 Technical details

3.1 Actors

In this section 3.1, actors which are involved in the use case are listed and described. These can for instance include people, systems, applications, databases, devices, etc.

With the aim of improving consistency among Use Case descriptions, we shall use the BRIDGE "Harmonized Electricity Market Role Model" (HEMRM) - https://energy.ec.europa.eu/system/files/2021-06/bridge_wg_regulation_eu_bridge_hemrm_report_2020-2021_0.pdf - for actor names and description. Thus, the information included in the fields of the following table should be obtained from the Actors List defined in BRIDGE HEMRM. Nevertheless, it is possible to add new Actions.

Actors

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Actor Name	Actor Type	Actor Description

3.2 References

References (which are standards, reports, mandates and regulatory constraints) associated with the Use Case. The writers must identify the standards that should be used to realize the Use Case and improve the replicability of the solution.

Identify any legal issues that might affect the design and requirements of the function, including contracts, regulations, policies, financial considerations, engineering constraints, pollution constraints, and other environmental quality issues.

References						
No.	***References Type***	***Reference***	***Status***	***Impact on use case***	***Originator / organisation***	***Link***
			The status of the referenced document.	e.g. copy right, IPR		

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**
			Refers to the actor that triggers the scenario. For instance, a function called "Protection" would probably be triggered by an "Intelligent Electronic Device (IED)". 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.	Event that triggers the scenario. It can be a real event (such as, "a fault occurs in the grid"), or it is also possible to define scenarios that occur "periodically".	Describes the state of the system before the scenario starts.	Describes the expected state of the system after the scenario is realized.

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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 :		***No. 1 - Reference 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. This triggering event can be an event, such as "a fault that occurs in the grid", or it may refer to an activity that occurs "periodically".	Label that would appear in a process diagram. Action verbs should be used when naming activity. EXAMPLE: "Fault occurs in the grid".	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. When the activity is an internal process, the information producer is the actor that carries out the internal process. For instance, when the activity is an internal algorithm within an Intelligent Electronic Device	Name of the actor that receives the information. When the activity is an internal process, the information receiver is the same actor as the information producer.	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. These R-ID should be obtained from the BeFlexible Requirements List, which is based in the IEA PAS 62559 list of requirements/issues, and revised in the project. Refer to template Clause 7 "Definition of a list for requirements" for further details.

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					(IED), then the information producer is the actor “Intelligent Electronic Device (IED)”.			

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(*) 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.
- 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): EXAMPLE: Data protection class corresponding to this information object.

6 Requirements

This table summarizes the requirements of all steps in the use case and it is linked to template section 4 "Step by Step Analysis". The ID for requirements (R-ID) is a unique ID which identifies the requirement in all use cases (e.g. in a repository).

For Business Use Cases: Identify business requirements in the following potential categories:

- Social sciences and humanities: e.g., customer engagement, value proposition, etc. **[inputs from Tasks 2.1 and 2.2]**
- Legal and ethical implications for customers **[inputs for Task 2.3]**
- Regulatory changes / needs [inputs from Task 1.1]
- Economic (e.g., maximum price for flexibility)
- Temporal, e.g. associated to the flexibility market (gate closure, notification time, price structure) *see Valarezo, et al., Analysis of new flexibility market models in Europe. Energies, 14(12):3521, 2021. https://doi.org/10.3390/en14123521
- Flexibility perimeter, e.g., All sites belonging to the same remotely metered flexibility unit or entity have the same BRP **[inputs from Task 1.2]**
- Market structure **[inputs from Task 1.2]**

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For System Use Cases: A list of non-functional requirements was defined in BeFlexible to provide guidelines on possible values that could be given to each type of requirement. However, other values not included in the list could be used if necessary.

Requirements		
Categories ID	**Category name for requirements**	**Category description**
Unique identifier for the category.	Name for the category of requirements.	Description of the requirement category.
Requirement R-ID	**Requirement name**	**Requirement description**
Unique identifier which identifies the requirement within its category and which can link the requirement to an external requirement document.	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).

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. Using a database repository for the glossary, the definitions might be filled automatically based on existing information.

Common Terms and Definitions	
Term	**Definition**

11. Annex III – Business Use Cases Descriptions

11.1. BUC01 – Planning and sizing of energy communities considering customer flexibility

1 Description of the use case

1.1 Name of the use case

ID	*Area / Domain(s)*	*Name of Use Case*
BUC01	Consumer/Community-centric flexibility	Planning and sizing of energy communities considering customer flexibility

1.2 Version management

Version Management			
Version No.	*Date*	*Name of Author(s)*	*Changes*
0.1	21.04.2023	Ricardo Bessa	First draft version
0.2	09.05.2023	Pedro Macedo, Armando Moreno, Ricardo Bessa	KPIs, revision of the complete description
0.3	13.05.2023	Ricardo Bessa	Add of UML diagrams
0.4	29.09.2023	Diogo Faria, Luís Rodrigues	KPIs update

1.3 Scope and objectives of use case

Scope and Objectives of Use Case	
Scope	Planning and sizing of renewable energy communities (REC) – Article 2(16) Recast Renewable Energy Directive – and Citizen Energy Communities (CEC) – Article 2(11) Recast Internal Electricity Market Directive. Customer flexibility is estimated in the long-term and can be integrated with long-term flexibility tenders from Distribution System Operators (DSO).
Objective(s)	1. Conduct sizing and evaluation of REC and/or CEC business models, considering different assets ownership models and flexibility potential estimation.
Related business case(s)	REC and CEC emphasise participation and effective control by citizens, local authorities, and smaller businesses whose primary economic activity is not the energy sector. Moreover, their main purpose is to generate social and environmental benefits rather than focusing on financial profits.

1.4 Narrative of use case

Narrative of Use Case
Short description
The main actor of this use case is the Energy Community Manager (ECM) that will determine the optimal installed capacities in the REC /CEC, considering typical (or measured) consumption profiles, availability of renewable energy sources, and costs of technologies (both capital and operational cost).

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It consists in:

- Sizing of the distributed energy resources (DER) within the community, including the joint ownership of assets.
- Construction of flexibility models, using field and typical data, for flexible loads.
- Simulation of pricing mechanisms within the community, considering the retailers' tariffs and flexibility from DER.

This will enable economic feasibility analysis of energy communities, which can be identified by combining data collected from the residencies with external data (e.g., weather, average income, etc.), in energy trading / sharing activities under different business models. The benefit is to de-risk investment in shared energy resources, maximize the benefits of new local energy communities, and enable quantification of grid-centric flexibility for DSO (in particular for long-term flexibility procurement).

The Business Use Case includes the following steps.

1. Define community design data for sizing and economic evaluation of the community
2. Request historical community data
   2.1 Obtain consent from data owner
   2.2 Data shared with the ECM
   2.3 Complete dataset
3. Study different sizing options and business models
   3.1 Solve the resources sizing problem
   3.2 Analyse business model
   3.3 Communicate results to community members and third-party service providers
4. Estimate available flexibility for flexibility procurement stages

Complete description

The BUC is focused on determining the optimal installed capacities in the REC /CEC by combining metered and profile data and considering assets sharing between members of the community.

1. Define community design data for sizing and economic evaluation of the community

The ECM defines the following data that gives "degrees of freedom" in the design energy community: minimum size of the community, maximum distance between member of the communities, percentage of asset sharing, generation technologies and DER assets and capacity constraints, reference costs for technologies, consumers ID to consider (optional), type of community (REC /CEC), business model to be considered, that depends on the financing and energy sharing mechanisms selected and determines the objective function to optimize (e.g., total energy costs minimization, profit of specific members maximization, self-consumption maximization), the pricing mechanism for the internal transactions.

This pricing mechanism is part of the business model and can be, for example the mid-market rate or an intermediate market rate, a price computation based on the supply-demand ratio, or a price based on a post-delivery pool simulation, and can also be a constraint of the problem to be solved (e.g., minimum revenues based on a transaction fee).

2. Request historical community data

The ECM requests to the Data Hub Operator access to required data: typical consumption profiles or past consumption values of the consumers considered, investments costs of technologies, opportunity costs of the consumers (usually their full electricity tariffs, i.e. including the energy cost and access tariffs and any other charge, of buying energy from their retailers when they are consuming, or selling energy back to their retailers when they are generating), and weather conditions or typical generation profiles of renewable generators.

2.1 Obtain consent from data owner

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Data Hub Operator obtains or verifies explicit consent from the Data Owner for access to their electrical energy consumption / generation and electricity tariffs data in the context of this business case.

2.2 Data shared with the ECM

Data Hub Operator shares the historical data with the ECM. This data results from smart metering and sub-metering of total and partial electrical energy consumption, and it also includes economic information related to the electricity tariff scheme. The Data Owner can be the role of a Consumer, Producer or Data Hub Operator.

2.3 Complete dataset

The ECM conducts an analysis of the data available from step (2.2), and the missing data (i.e., variables) are completed by using typical profiles (e.g., load, generation) and by gathering data from public databases (e.g., PVGIS, Copernicus).

3. Study different sizing options and business models

3.1 Solve the resources sizing problem

Using the transferred data, a sizing problem is solved to find the optimal installed capacity in the REC / CEC considering an optimal operation with perfect information. The outputs are: a) size of the assets to be installed, b) schedules of the flexible assets, c) energies transacted and transaction prices, d) individual and collective investments, operation, and total costs.

System Use Case called by the step
SUC 1.1: DER sizing and economic evaluation of the LEC business model

3.2 Analyze business model

Using the results from step (3.1) the community business model is analyzed, and the parameters and assumptions from step (1) can be revised / further refined by the ECM.

3.3 Communicate results to community members and third-party service providers

The results in terms of KPI and benefits for the community members are communicated to consumers, producers, and third-party service providers (e.g., ESCO).

4. Estimate available flexibility for flexibility procurement stages

Considering the resources and capacities determined in step (3), the ECM estimates the available flexibility (from controllable loads, storage, PV, EV, among others) to be offered in TSO/DSO procurement processes, and can, for instance, be offered for long-term congestion management.

1.5 Key performance indicators (KPI)

ID	*Name*	*Description*	*Reference to mentioned use case objectives*
1.1	Electricity cost reduction	Energy cost reduction for the individual members of the EC due to belonging to the EC and due to the provision of flexibility	1
1.2	Payback period	Time to recover the investment cost	1
1.3	Energy sharing ratio	Energy shared between EC members as a percentage of total locally produced energy.	1
1.4	Emissions reduction	Aggregated members' emissions reduction from participating in the EC compared to trading only with their BRPs.	1

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1.6 Use case conditions

Use case conditions
Assumptions
In terms of geographical scope, we will consider two possibilities: CEC do not bind to immediate vicinity (according to Recast Internal Electricity Market Directive); REC must be in the vicinity of renewable energy projects owned/developed by that community (according to Recast Renewable Energy Directive).
Prerequisites
• Availability of smart meters or sub-metering in consumers premises • Data owner consent for data sharing • Operational Data Space where consumers share time series data about active power consumption (at least from the household meter, but sub-metering is also relevant) and static data about installed assets (PV, EV, etc.).

1.7 Further Information to the use case for classification / mapping

Classification Information
Relation to other use cases
GAIA-X use cases: • Local communities – Local communities of energy setting up and decentralization • Local communities – Stadtwerke/local open data for business models BRIDGE use cases: • Optimal sizing of a Local Energy System (E-LAND) • Optimization of operation of Local Energy System (E-LAND) • Procida Local energy community (GIFT) These use cases do not consider asset sharing (in particular of battery storage), or long-term estimation of flexibility. They are mainly focused on the optimal operation of the microgrid / local energy community.
BUC02 – Operation, energy sharing and flexibility boosting of local energy communities
BUC04 – Long-term distribution grid congestion management
Level of depth
Business use case (BUC)
Prioritisation
To be demonstrated in Spain (Pilots 3.1).
Generic, regional or national relation
Generic
Nature of the use case
Business case for a local energy community. The temporal scope if long-term (planning).
Further keywords for classification
Local energy community, renewable energy community, citizen energy community, storage, asset sharing, renewable energy, local flexibility, planning, long-term.

1.8 General Remarks

General Remarks

2 Diagrams of use case

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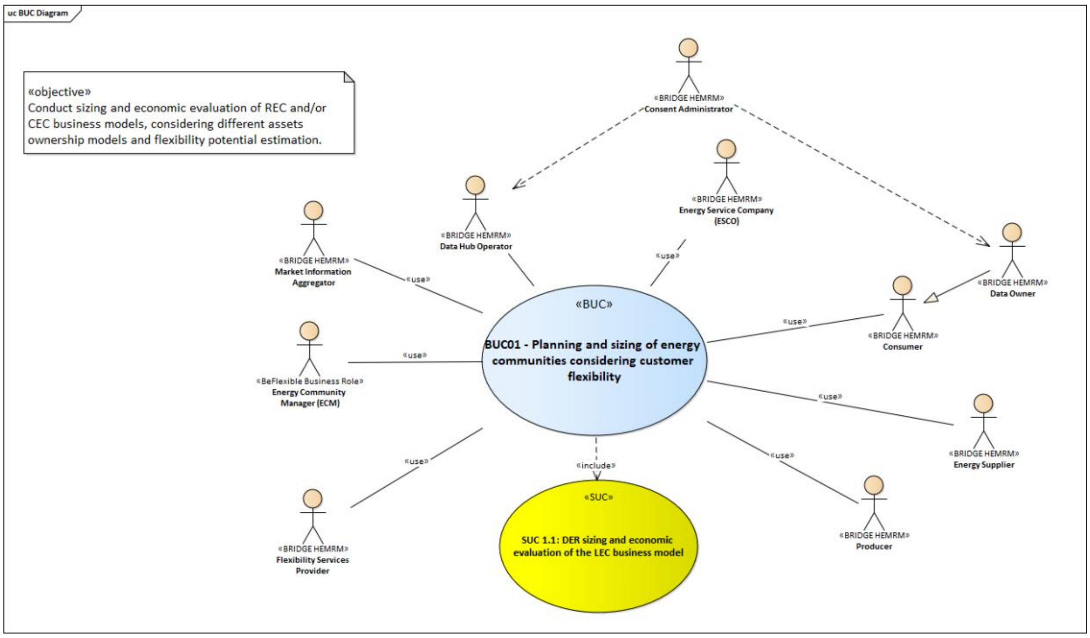
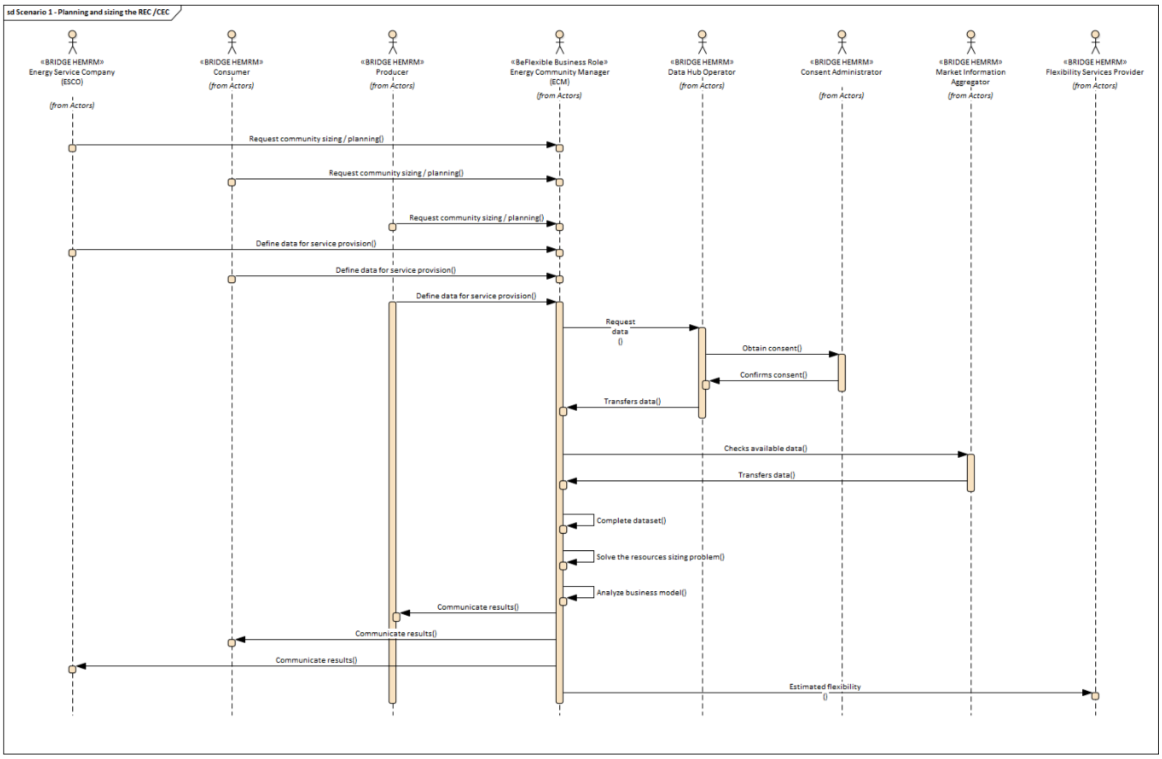
Diagram(s) of use case

Use Case Diagram



Sequence Diagram: Scenario 1 – Planning and sizing the REC /CEC



3 Technical details

3.1 Actors

Actors		
Actor Name	***Actor Type***	***Actor Description***
Consumer	Business Role (BRIDGE HEMRM)	A party that consumes electricity.
Energy Supplier	Business Role (BRIDGE HEMRM)	An Energy Supplier supplies electricity to or takes electricity from a Party Connected to the Grid at an Accounting Point.
Market Information Aggregator	Business Role (BRIDGE HEMRM)	A party that provides market related information that has been compiled from the figures supplied by different actors in the market. This information may also be published or distributed for general use.
Flexibility Services Provider	Business Role (BRIDGE HEMRM)	A party providing flexibility services to energy stakeholders via bilateral agreements or flexibility markets.
Consent Administrator	Business Role (BRIDGE HEMRM)	A party responsible for administrating a register of consents for a domain. The Consent Administrator makes this information available on request for entitled parties in the sector.
Data Hub Operator	Business Role (BRIDGE HEMRM)	Data Hub Operator owns and operates an information system whose main function is to store and make available electricity (also gas, heat) metering data and associated master data. In this BUC, it will be also submeter Data Hub Operator.
Producer	Business Role (BRIDGE HEMRM)	A party that generates electricity.
Data Owner	Business Role (BRIDGE HEMRM)	Any physical person or legal entity that owns data and can give authorization to other parties to access them.
Energy Community Manager (ECM)	Business Role (BeFlexible)	A party responsible for managing business activities within an energy community.
Energy Service Company (ESCO)	Business Role (BRIDGE HEMRM)	A party offering energy-related services to the Party Connected to Grid, but not directly active in the energy value chain or the physical infrastructure itself.

3.2 References

References						
No.	***References Type***	***Reference***	***Status***	***Impact on use case***	***Originator / organisation***	***Link***
1	Scientific paper	A. Moreno, J. Villar, C. S. Gouveia, J. Mello, and R. Rocha, “Investments and Governanc	Published.	Financing and energy sharing mechanisms	IEEE	https://doi.org/10.1109/EEM54602.2022.9921004

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		e Models for Renewable Energy Communities," in EEM 2022, Sep. 2022.				

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	Planning and sizing the REC /CEC	Determining the optimal installed capacities in the REC /CEC by combining metered and profile data and considering assets sharing between members of the community	Energy Community Manager (ECM)	Group of Consumers and/or ESCO request sizing and study of different community business models and assets	Consumption and generation profiles / time series available & tariff data	Information available about REC / CEC optimal sizing and benefits of the different business models

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4.2 Steps – Scenarios

Scenario								
Scenario name:		No. 1 - Reference 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
1	Triggering event	Request community sizing / planning	Request DER sizing and economic evaluation	CREATE	Consumer, Producer, ESCO, Energy Supplier	ECM	I-1, I-2, I-3, I-4, I-6, I-7, I-9, I-10	
2	1	Define data for service provision	Define community design data for sizing and economic evaluation of the community	CREATE	Consumer, Producer, ESCO	ECM	I-1, I-2, I-3, I-4, I-6, I-7, I-9, I-10	
3	1	Request data	Request historical consumer/producer data	CREATE	Data Hub Operator	ECM	I-6	
4	3	Obtain consent	Obtain consent for data sharing	CREATE	Data Hub Operator (Consent Administrator role)	Consumer, Producer (Data Owner role)	I-11	
5	3	Transfer data	Data transfer occurs	GET	Data Hub Operator	ECM	I-5, I-8, I-12, I-13, I-14	
6	3	Complete dataset	Analysis of the available data and missing data is completed with typical profiles and public databases.	CREATE	Market Information Aggregator, Data Hub Operator	ECM	I-15, I-16, I-17	
7	6	Solve the resources sizing problem	Sizing problem is solved to find the optimal installed capacity in the REC / CEC considering an optimal operation with perfect information	EXECUTE	ECM	ECM		
8	7	Analyze business	Community business model is analyzed, and the	REPEAT	ECM	ECM		

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		model	parameters and assumptions can be revised or further refined.					
9	8	Communicate results	KPI and benefits for the community members are communicated	CREATE	ECM	Producer, Consumer, ESCO, Energy Supplier	O-1, O-2, O-3, O-4	
10	9	Estimate flexibility	Estimates the available flexibility to be offered in TSO/DSO procurement processes	CREATE	ECM	Flexibility Services Provider	O-5	

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5 Information exchanged

Information exchanged			
Information exchanged (ID)	**Name of information**	**Description of information exchanged**	**Requirement, R-IDs**
I-1	Community size	Minimum size of the community	
I-2	Max distance	Maximum distance between member of the communities	
I-3	% asset sharing	Percentages of asset sharing	
I-4	DER technologies	Generation technologies and DER assets and capacity constraints	
I-5	DER OPEX	Reference costs for technologies	
I-6	Consumer ID	Consumers ID to consider	
I-7	Community type	Type of community (REC /CEC)	
I-8	Opportunity cost	Opportunity costs of the consumers (usually their full electricity tariffs)	
I-9	Business model	Business model that determines the objective function to optimize (e.g., total energy costs minimization, profit of specific members maximization, self-consumption maximization)	
I-10	Pricing mechanism	Pricing mechanism for the internal transactions and can be: 1) mid-market rate, 2) intermediate market rate, 3) based on the supply-demand ratio, 4) based on a post-delivery pool	
I-11	Consent	Explicit consent for data use	
I-12	Electrical energy consumption	Electrical energy consumption: past measurements or typical profile	
I-13	Weather-based generation	Weather conditions or typical generation profiles of renewable generators	
I-14	DER CAPEX	Investments costs of DER technologies	
I-15	Typical consumption profile	Electrical energy consumption profile obtained by client type (LV, MT), contracted power and annual total electrical energy consumed or from data clustering algorithms	
I-16	Simulated weather-based generation	Simulated generation obtained from software such as PVGIS	
I-17	Public electricity tariffs	Tariffs published by the electricity retailers	
O-1	DER size	Size of the DER assets to be installed	
O-2	Schedules	Schedules of the flexible assets	
O-3	Transactions	Energies transacted and transaction prices	
O-4	Investments	Individual and collective investments, operation, and total costs	

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O-5	Energy flexibility	Upward and downward flexibility potential of the community in the long-term horizon	

6 Requirements

Requirements		
Categories ID	**Category name for requirements**	**Category description**
GDPR	Regulatory obligation related to privacy	2016/679 (General Data Protection Regulation)
Requirement R-ID	**Requirement name**	**Requirement description**
GDPR-1	Data processing consent	Personal data may not be processed unless there is at least one legal basis to do so.
GDPR-2	Data retention policy	Data retention policy outlines the time period specific sensitive data can be retained, plus how it will be disposed of when the time to do so comes.
GDPR-3	Right to access, rectify, erasure, restriction	The data subject shall have the right to obtain from the controller without undue delay the access/rectification/erasure/restriction of inaccurate personal data concerning him or her.
GDPR-4	Data transfer consent	Personal data may not be transferred to a third-party if the data subject did not agree and the third party provide appropriate safeguard.
GDPR-X	All GDPR constraints also apply to this BUC.	e.g., proportional measures of protection, communication of data breach, among others

Requirements		
Categories ID	**Category name for requirements**	**Category description**
SOC	Social requirements for value addition and engagement	Inputs from 2.1 and 2.2
Requirement R-ID	**Requirement name**	**Requirement description**
SOC-1	Joint assets	Joint assets can be viewed as a cause of friction between the community and therefore has to be explained as contributing to the opposite
SOC-2	Data sharing	Mistrust from consumers regarding data sharing should be taken into account

Requirements		
Categories ID	**Category name for requirements**	**Category description**
RCR	Submetering regulations to be developed	Draft Proposal for Network Code on Demand Response

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	Regulations on energy community to be fully developed	Regulation 2018/1999 Directive 2018/2001 Directive 2019/944 Jefatura del Estado, "Real Decreto-ley 23/2020, de 23 de junio, por el que se aprueban medidas en materia de energía y en otros ámbitos para la reactivación económica," in Boletín Oficial del Estado número 175, de 24 de junio de 2020, Madrid, Agencia Estatal del Boletín Oficial del Estado, 2020, pp. 43879 - 43927.
Requirement R-ID	**Requirement name**	**Requirement description**
RCR-1	Submetering data regulations need to be implemented in Spain	The BUC considers Data Hub Operator shares the historical data with the ECM. This data results from smart metering and sub-metering. These requirements need to be regulated to guarantee privacy, accuracy and security. The BUC requires a prerequisite operational Data Space where consumers share time series data about active power consumption (at least from the household meter, but sub-metering is also relevant). The data-sharing agreements would be relevant to be defined.
RCR-2	Regulation for energy communities may establish minimum and maximum limits for design elements depending on the legal form adopted.	Aspects such as minimum size of the community, maximum distance between member of the communities, percentage of asset sharing (network coefficients) need to comply with the existing national regulation. National regulation experience different level of comprehensiveness. Spanish regulation may evolve in the near future.
RCR-3	The regulatory framework may restrict the participation in energy communities, with varying criteria across countries.	In Spain, the regulatory draft defines REC participants as physical persons, local authorities, small and medium enterprises, and associations of SMEs, local entities, and individuals, with a maximum 51% vote or control threshold. The draft specifies a minimum of five members or shareholders for both REC and CEC.

7 Common Terms and Definitions

Common Terms and Definitions	
Term	**Definition**

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Renewable Energy Community (REC)	A legal entity: (a) which, in accordance with the applicable national law, is based on open and voluntary participation, is autonomous, and is effectively controlled by shareholders or members that are located in the proximity of the renewable energy projects that are owned and developed by that legal entity. (b) the shareholders or members of which are natural persons, SMEs or local authorities, including municipalities. (c) the primary purpose of which is to provide environmental, economic or social community benefits for its shareholders or members or for the local areas where it operates, rather than financial profits.
Citizen Energy Community (CEC)	A legal entity that: (a) is based on voluntary and open participation and is effectively controlled by members or shareholders that are natural persons, local authorities, including municipalities, or small enterprises. (b) has for its primary purpose to provide environmental, economic or social community benefits to its members or shareholders or to the local areas where it operates rather than to generate financial profits. (c) may engage in generation, including from renewable sources, distribution, supply, consumption, aggregation, energy storage, energy efficiency services or charging services for electric vehicles or provide other energy services to its members or shareholders.
Mid market rate	Pricing mechanism based on computing the average between the price of buying price from the retailer and the price of selling energy back to the retailer. When different community members have different retailers and tariffs, we propose to use the maximum selling price and minimum buying price. It is necessary to determine, for each consumer, its net balance, to know if it is consuming, therefore buying, or generating, therefore selling energy.
Intermediate market rate	Based on the mid market rate, but instead of a simple average, we propose a weighted average to allow giving more weight to the buying or to the selling prices. It is again necessary to determine, for each consumer, its net balance, to know if it is consuming, therefore buying, or generating, therefore selling energy.
Supply-demand ration based price	This procedure provides a price probably closer to a real market outcome, since it takes into account the amount of supply available compared to the existing demand, providing a better economic signal. It is again necessary to determine, for each consumer, its net balance, to know if it is consuming, therefore buying and contributing to the aggregated demand, or generating, therefore selling energy and contributing to the aggregated supply.
Post-delivery pool based price	This price is the result of simulating a post-delivery pool, post-delivery local markets. In the simplest case, the simulation consists in crossing the aggregated supply and demand curves. To do so, for each consumer, its net balance is computed, to know if it is consuming, therefore buying energy and producing a buying bid at its opportunity cost (usually the integral tariff of buying energy from its retailer), or generating, therefore selling energy and producing a selling bid at its opportunity cost (usually the integral tariff of selling energy to its retailer). With these bids, the aggregated supply and demand curves of the pool can be computed. If there are no flexible resources, the price is computed by crossing these curves. In case there are flexible resources whose dispatch depends on the transactions price, an iterative procedure can be used to estimate the schedule, determining again the consuming or generating behaviour of the consumers, re-estimating the pool price, until prices and schedules convergence. Alternatively, it may be possible to maximize the welfare so as to determine, in one step optimization problem, the price and the flexible resources schedules.

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11.2. BUC02 – Operation, energy sharing and flexibility boosting of local energy communities

1 Description of the use case

1.1 Name of the use case

ID	*Area / Domain(s)*	*Name of Use Case*
BUC02	Consumer / Community-centric flexibility	Operation, energy sharing and flexibility boosting of local energy communities

1.2 Version management

Version Management			
Version No.	*Date*	*Name of Author(s)*	*Changes*
0.1	04.05.2023	J. Villar, L. Rodrigues, D. Faria, J. Mello	First draft version.
0.2	09.05.2023	J. Villar, L. Rodrigues, D. Faria, J. Mello	Second draft version.

1.3 Scope and objectives of use case

Scope and Objectives of Use Case	
Scope	Management and operation of energy communities (EC) with explicit flexibility provision. Different operation modes are considered: a) market-based, where decisions are totally or partially decentralized and therefore taken by the community members as market participants, and b) centralized, but complying with market principles, where the flexible assets schedules are computed with an optimization algorithm, and the collective benefits shared according to market-like principles based on a set of selected pricing mechanisms.
Objective(s)	1. Share energy among the community members for self-consumption. 2. Provide flexibility to third parties such as the local DSO.
Related business case(s)	BUC 1 – Planning and sizing of energy communities considering customer flexibility. BUC 11 – Operating a value chain enabler for flexibility-centric energy and non-energy services

1.4 Narrative of use case

Narrative of Use Case
Short description
The main actor of this Business Use Case (BUC) is the Energy Community Manager (ECM). Secondary but also essential actors are the prosumers, as they can become EC members of the community, and the DSO as the main flexibility procurer that will be considered. This BUC consists in: • Operate an energy community with flexible assets to improve its economic performance, considering the provision of local flexibility. • The energy community operation can be based on a market-based approach or be centrally managed but with market-like principles to share collective benefits among the members. Economics are based on the opportunity costs of the community members,

based on the buying and selling tariffs with their retailers, and on inputs estimating the amount and price of the flexibility that could be provided to third parties.

- Members can own assets behind the meter or connected to the grid. Assets can also be shared among members. Finally, business models with assets shared among the community members and the local DSO will be considered.
- Different business models in terms of sharing and pricing mechanisms will be considered.
- Provide, as main outputs, the allocation coefficients that define how the internal energy sharing must be performed (so that retailers can be informed on the energy supplied, surplus and self-consumed), the flexibility that can be provided and indicators of the energy community performance.

This BUC has the following steps:

1. Establish and organize the EC
   1.1. Define and upload EC structure
   1.2. Configure selected business model

2. Continuously operate the EC
   2.1. Get metered and forecasted energy data.
   2.2. Compute transactions or shared energy and internal price
   2.3. Compute the flexible asset transactions and schedules considering flexibility.
   2.4. Activate the flexibility required by the DSO and verify its delivery.
   2.5. Compute the allocation coefficients or energy sharing mechanisms
   2.6. Inform DSO and retailer on energy supplied, surplus and self-consumed by EC Members.
   2.7. Settle the financial compensations among the EC members and with third parties.
   2.8. Provide indicators for individual and community performances.

Complete description

The participation in collective self-consumption structures and EC needs tools to provide digital support to join the community, manage basic structural and dynamic data, operate the flexible assets according to predefined objectives (such as energy bill minimization and flexibility provision), support the energy sharing or transactions among the EC members, perform the corresponding financial compensations, and provide the economic indicators to assess community performance.

In addition, since EC are natural aggregators, this Business Use Case (BUC) intends to exploit this aggregation capability, in the case of renewable energy communities (REC), to provide flexibility to third parties, with the focus on the local DSO for local grid constraints solving. In the case of citizens energy communities (CEC), this aggregated flexibility could be provided, for example, to TSO for balancing purposes.

The operation of the energy community, which is described next, is presented in Figure 1.

1. Establish and organize the EC

The first step corresponds to the structural definition of the EC and configuration of the main options in terms of business model (BM) and static data (members, assets, assets ownership, grid usage, retail selling and buying tariffs, grid tariffs for self-consumption, etc) and configure the BM selected (operation mode and sharing mechanism, share assets operation rules, community objective, etc).

1.1 Define and upload EC structure

The ECM sets up the structure and fundamental components of the EC based on the EC structure and governance rules agreed among the EC members, as a facilitator of the process. EC members may be asked to verify the information or provide additional information. The EC structure includes members, assets, assets grid location (to compute the self-consumption access tariffs), assets ownerships, meters and assets metered, buying and selling tariffs of the EC members with their retailers or aggregators.

1.2 Configure selected Business Model

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The next step is to select the BM and operation mode according to the EC governance rules agreed by the members. This includes setting up rules for shared assets and creating operation guidelines that govern how EC members interact and/or benefit/profit from those assets. The selection and configuration of the BM defines the operation of the EC.

2. Continuously operate the EC

The second set of steps, which run continuously, corresponds to the operation of the EC.

2.1 Get metered and forecasted energy data

The ECM obtains accurate metering and/or forecasted energy data, depending on the operation mode selected. This step requires the existence of smart meters to monitor consumption and generation within the EC to be provided by the DSO (or Data Provider). Depending on the complexity, sub-metering may also be needed.

2.2 Compute the flexible asset transactions and schedules considering flexibility

The transactions (prices and quantities) are computed, either from the information provided by the EMS that centrally computes the optimal schedules of the assets and the optimal internal transactions, or from a market-based approach and the corresponding market clearing.

2.3 Activate the flexibility required by the DSO and verify its delivery

Flexibility provision is operated by the ECM, who aggregates the assets and offers the resulting flexibility to the DSO. There are two levels of operation:

- Upper level: the ECM offers flexibility to the DSO considering an aggregated set of assets previously procured within the EC members. The flexibility availability to the DSO is computed using an agreed baseline methodology between all parties. Next, the DSO acquires the flexibility capacity needed a day before and requires the amount needed just prior to the delivery period. The, the ECM sends the activation signals to the selected assets. Since the DSO is not monitoring specific assets, the delivered flexibility is computed and checked by the DSO considering the whole ECM portfolio delivery using the baseline methodology.
- The lower level, where the EC Members negotiate with the ECM the aggregation of their assets' flexibility. In this level, the ECM assesses the EC Members flexibility to be offered to the DSO. EC members that offer flexibility to the ECM are subject to be activated if the flexibility is required by the DSO. The activated flexibility must be settled by the EC Manager considering its delivery and its difference from the commitment.

2.4 Compute the allocation coefficients or energy sharing mechanisms

The dynamic allocation coefficients (AC) are computed to reflect the transactions of the previous step, both for energy trades and flexibility delivery. These coefficients are the way to inform DSO and retailers of the energy allocated to the EC members.

2.5 Inform DSO and retailer on the energy supplied, surplus and self-consumed by the EC Members

- The DSO uses the AC to compute the energies supplied, self-consumed and surplus of each meter. In the simplest case, an EC Member can correspond to a meter. In more complex structures, an EC Member could own and be responsible for several meters, which has an impact on how the AC and the final compensations are computed.

2.6 Settle the financial compensations among the EC members and with third parties

- With the energy data (supplied, self-consumed and surplus) provided by the DSO to the community, after verification of the AC, the ECM, using the assets ownerships and BM, the transactions both for energy and flexibility, and corresponding prices, can proceed to the computation of the internal financial compensations for the energies shared.

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2.7 Provide indicators for individual and community performances

At any time, ECM and EC members can access the service to obtain indicators for the individual and collective performance for a set of interval settlement periods, provided they have already been settled.

Figure 1: definition and operation of an energy community

The main/sole system use case (SUC) is:

- SUC2.1: Operation of the energy community
-

System Use Case
SUC 2.1: Operation of the energy community

This SUC has the following set of functions:

1. Structural definition of the EC: allow to insert the definition of the energy community and the configuration of its main options.
2. Transactions and pricing: compute the internal transaction and prices corresponding to the energy shared.

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3. Settlement: computes the allocation coefficients and the compensations among the community members. 4. KPI computation: computation of individual and collective performance indicators of the community. 5. HMI: interfaces for ECM and prosumers members of the community. 6. EMS: energy management system to determine the optimal schedules of the flexible assets and internal energy exchanges. •

1.5 Key performance indicators (KPI)

ID	Name	Description	Reference to mentioned use case objectives
2.1	Electricity cost reduction	Energy cost reduction for the individual members of the EC due to belonging to the EC and due to the provision of flexibility	1
2.2	Energy sharing ratio	Energy shared between EC members as a percentage of total locally produced energy.	1
2.3	Self-sufficiency	Energy consumed locally compared to the total energy consumed	1
2.4	Average buying price reduction	Average price of buying the energy within the EC.	1
2.5	Flexibility provision	Flexibility provided by the EC to the DSO compared to the flexibility required.	2

1.6 Use case conditions

Use case conditions
Assumptions
• A set of prosumers have decided to constitute an energy community (EC).
Prerequisites
• All agreements and rules of the EC have already been defined according to the available options of the EC management service. • Members consent data sharing with the ECM. • Members give access to the ECM to control their flexibility assets or make their own control of this assets according to their flexibility commitments. • ECM has access to flexibility electricity markets. • Common baseline methodology agreed between DSO, EC and the DER's owner members to compute delivered flexibility.

1.7 Further Information to the use case for classification / mapping

Classification Information
Relation to other use cases
BUC 1 – Planning and sizing of energy communities considering customer flexibility
BUC 11 – Operating a value chain enabler for flexibility-centric energy and non-energy services Comments: This use case focus on the operation of the digital platform where the services will be implemented.
Level of depth
Business use case (BUC)
Prioritisation

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To be demonstrated in Spain (pilots 3.1)
Generic, regional or national relation
Generic
Nature of the use case
Business use case
Further keywords for classification
Energy community operation, self-consumption, storage, asset sharing, renewable energy, local flexibility

1.8 General Remarks

General Remarks

2 Diagrams of use case

Diagram(s) of use case

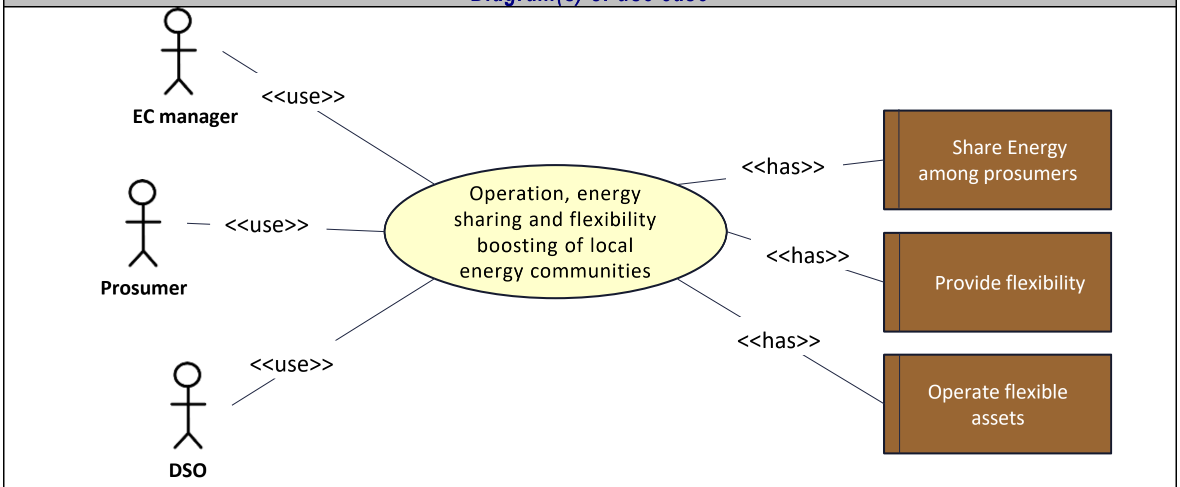

Figure 2: BUC overview: operation, energy sharing and flexibility boosting of local energy communities

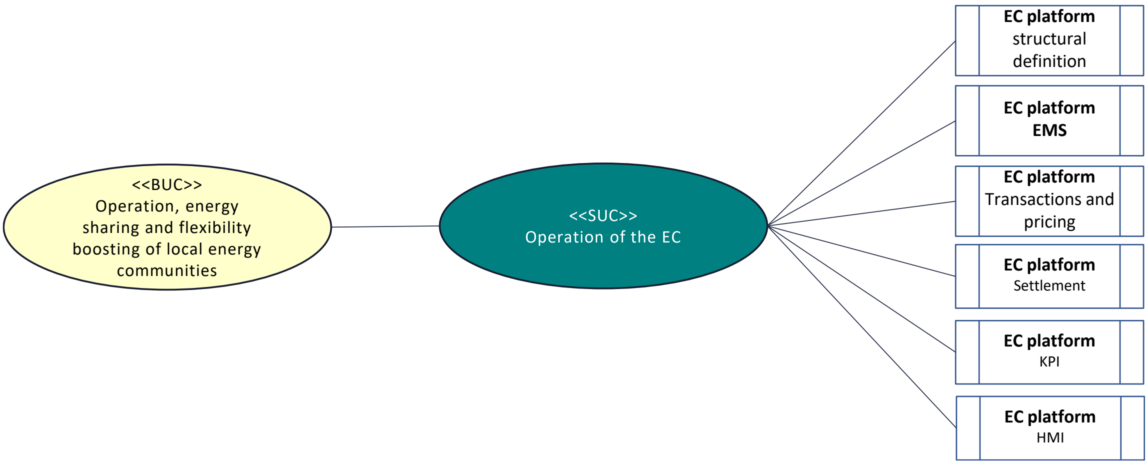

Figure 3: SUC and functions overview

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3 Technical details

3.1 Actors

Actors		
Actor Name	*Actor Type*	*Actor Description*
Energy Community Manager (ECM)	Business Role (BeFlexible role model)	Responsible for managing business activities within an Energy Community. In this BUC the ECM is rather and actor that also performs the role of aggregator.
Prosumer	Business Role (BeFlexible role model, BRIDGE HEMRM)	The Prosumer is a Consumer who can also produce electricity. In BeFlexible role model (T1.3) it is assumed that a prosumer also adopts an active role in the energy chain, by, for example, be willing to joint self-consumption structures or provide flexibility (sometimes Flexumer is also used). The EC members are assumed to be prosumers.
Resource Aggregator	Business Role (BeFlexible role model, BRIDGE HEMRM)	Aggregates (i.e., collects and combines) multiple resources for usage by a service provider for energy market services. In this BUC the ECM assumes the role of aggregator.
DSO	Business Role (BeFlexible role model, BRIDGE HEMRM)	Responsible for the security of supply and reliability of the distribution network. It continuously monitors the grid to detect potential issues and, whenever necessary, it uses multiple resources to solve such problems, including network reconfiguration and/or requesting assistance from market operators or directly from contracted customers. In this BUC the DSO is the main procurer of flexibility.
Not explicitly addressed, the actors below are also related to this BUC		
TSO	Business Role (BeFlexible role model, BRIDGE HEMRM)	Responsible for security of supply and reliability of a transmission network and also real time operation and monitoring, building, expanding, and maintaining the transmission system. Could be a flexibility procurer although it is not explicitly been addressed in this BUC.
Market Operator	Business Role (BRIDGE HEMRM)	Provides a service whereby the offers to sell electricity are matched with the bids to buy it. In this case this actor could manage the DSO flexibility market where the ECM negotiates the EC aggregated flexibility.
Billing Agent	Business Role (BRIDGE HEMRM)	Responsible for invoicing a concerned party. Not explicitly considered, the billing agent would be responsible for the final billing to the EC members.
Retailer	Business Actor (BRIDGE HEMRM)	Supplies or takes electricity from a party connected to the grid. It is the actor that has the role of Energy Supplier (Bridge)
DER Provider	BeFlexible role model	Responsible for installing and/or maintaining assets related with distributed energy equipment, which are provided/sold to other market agents.
ESCo	Business Role (BeFlexible role model, BRIDGE HEMRM)	Offers energy related services. Can provide insights and energy management services as well as implementing energy efficiency and renewable energy projects.

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Manufacturer	Business Role (BeFlexible role model)	Manufactures specific products which are later supplied to other market agents

3.2 References

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

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	EC centralized operation	Based on a centralized optimization to determine the schedules of the flexible assets, the energy shared internally, and the flexibility provided	Energy Community Manager	Occurs periodically	Structural configuration of the energy community.	Optimal schedules of the flexible assets, billing guide for internal settlement, performance indicators.
2	EC market-based operation	Based on market approaches (such as post-delivery pool) with the flexibility provision integrated.	Energy Community Manager	Occurs periodically	Structural configuration of the energy community.	Optimal schedules of the flexible assets, billing guide for internal settlement, performance indicators.

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4.2 Steps – Scenarios

Scenario								
Scenario name :		**No. 1 - EC centralized operation**						
Step No.	**Event**	**Name of process/ activity**	**Description of process/ activity**	**Service**	**Information producer (actor)**	**Information receiver (actor)**	**Information Exchanged (IDs)**	**Requirement, R-IDs**
1.1	Occurs once	EC definition	Access the service, register, and define and upload the energy community structure (members, assets, assets ownerships, grid usage, retail selling and buying tariffs, grid tariffs for self-consumption, etc) and configure the business model selected (operation mode and sharing mechanism, share assets operation rules, community objective, etc).	CREATE	ECM	ECM	ECStructID	EC-MEMB
1.2	Occurs periodically (daily)	Get Operation Data	Get metered or forecasted energy data at the smart meters (SM)	GET	DSO	ECM	SMEneProfilesID	EC-MEMB
1.3	Occurs periodically (daily)	Get Operation Data	Get metered or forecasted energy data of internal EC assets	GET	Prosumer	ECM	IntEneProfilesID	EC-MEMB
1.4	Occurs periodically (daily)	Share AC and flexibility bids with DSO	Optimize transactions and flexible asset schedules and provide allocation coefficients (AC) and flexibility bids to DSO.	CREATE	ECM	DSO	ACFlexID	EC-MEMB
1.5	Occurs periodically (daily)	Share internal settlement	Compute the financial compensations (settlement)	CREATE	ECM	Prosumers	SettlementID	EC-MEMB

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		with members	among the community members					
1.6	Prosumers request	Share performance indicators	Provide indicators to show the individual and community performances.	CREATE	ECM	Prosumers	PerformanceID	EC-MEMB
Scenario								
Scenario name :		***No. 1 - EC market-based operation***						
Step No.	***Event***	***Name of process/ activity***	***Description of process/ activity***	***Service***	***Information producer (actor)***	***Information receiver (actor)***	***Information Exchanged (IDs)***	***Requirement, R-IDs***
2.1	Occurs once	EC definition	Access the service, register, and define and upload the energy community structure (members, assets, assets ownerships, grid usage, retail selling and buying tariffs, grid tariffs for self-consumption, etc) and configure the business model selected (operation mode and sharing mechanism, share assets operation rules, community objective, etc).	CREATE	ECM	ECM	ECStructID	EC-MEMB
2.2	Occurs periodically (daily)	Get Operation Data	Get metered or forecasted energy data at the smart meters (SM)	GET	DSO	ECM	SMEneProfilesID	EC-MEMB
2.3	Occurs periodically (daily)	Get Operation Data	Get metered or forecasted energy data of internal EC assets	GET	Prosumer	ECM	IntEneProfilesID	EC-MEMB
2.4	Occurs periodically (daily)	Share AC and flexibility bids with DSO	Determine market-based transactions and flexible asset schedules and provide	CREATE	ECM	DSO	ACFlexID	EC-MEMB

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			allocation coefficients (AC) and flexibility bids to DSO.					
2.5	Occurs periodically (daily)	Share internal settlement with members	Compute the financial compensations (settlement) among the community members.	CREATE	ECM	Prosumers	SettlementID	EC-MEMB
2.6	Prosumers request	Share performance indicators	Provide indicators to show the individual and community performances.	CREATE	ECM	Prosumers	PerformanceID	EC-MEMB

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5 Information exchanged

Information exchanged			
Information exchanged (ID)	***Name of information***	***Description of information exchanged***	***Requirement, R-IDs***
ECStructID	Community structure	Structural definition of the energy community and configuration of the main options in terms of business models and static data: members, assets, assets ownerships, grid usage, retail selling and buying tariffs, grid tariffs for self-consumption, etc) and configure the business model selected (operation mode and sharing mechanism, share assets operation rules, community objective, etc	
SMEneProfilesID	Energy measurements or forecasts at the EC members smart meters	Consumption or generation measured for the day whose operation is being addressed with the resolution corresponding to the regulation applicable	
IntEneProfilesID	Energy measurements or forecasts at the EC members smart meters	Consumption or generation measured for the day whose operation is being addressed with the resolution corresponding to the regulation applicable. In addition, storage systems may provide additional energy measures such as initial SOC	
ACFlexID	Allocation coefficients and flexibility bids	Allocation coefficients that specify how the energy is shared withing the EC and flexibility bids to provide the DSO flexibility requirements	
SettlementID	Internal energy share settlement	Financial compensations that must be performed among the members according to the energy shared, the ownership of the energy shared, the internal transactions and the internal energy price, according to the EC governance rules pre-defined.	
PerformanceID	Performance indicators	Indicators related to the savings for belonging to the community and to the global EC performance.	

6 Requirements

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

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EC-MEMB	Contractual agreement to belong to the EC.	Contractual agreement to belong to the EC and explicit acceptance of the EC governance rules, including data sharing consent, willingness to provide flexibility services and access to flexible resources.
Requirements		
Categories ID	**Category name for requirements**	**Category description**
GDPR	Regulatory obligation related to privacy	2016/679 (General Data Protection Regulation)
Requirement R-ID	**Requirement name**	**Requirement description**
GDPR-1	Data processing consent	Personal data may not be processed unless there is at least one legal basis to do so.
GDPR-2	Data retention policy	Data retention policy outlines the time period specific sensitive data can be retained, plus how it will be disposed of when the time to do so comes.
GDPR-3	Right to access, rectify, erasure, restriction	The data subject shall have the right to obtain from the controller without undue delay the access/rectification/erasure/restriction of inaccurate personal data concerning him or her.
GDPR-4	Data transfer consent	Personal data may not be transferred to a third-party if the data subject did not agree and the third party provide appropriate safeguard.
GDPR-X	All GDPR constraints also apply to this BUC.	e.g., proportional measures of protection, communication of data breach, among others
Requirements		
Categories ID	**Category name for requirements**	**Category description**
SOC	Social requirements for value addition and engagement	Inputs from 2.1 and 2.2
Requirement R-ID	**Requirement name**	**Requirement description**
SOC-1	Flexible assets	Assets should be easy to handle. Except adopters, users are avoiding new technology as a consequence of being overwhelmed when they do not understand it.
SOC-2	Flexible assets (connection)	Control for users to trust in their participation in the community
SOC-3	Energy sharing	Transparency and public information specifically for the coefficient distribution (possible sense of injustice)
SOC-4	Flexibility participation in EC	It implies installation, sharing and management from users so if the value is not clear (economic, comfort, environmental, social) value is destroyed and participation declines.

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

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RCR	Submetering and baseline regulations to be developed Regulations on energy community to be fully developed Regulations on aggregators to be fully developed	Draft Proposal for Network Code on Demand Response Regulation 2018/1999 Directive 2018/2001 Directive 2019/944 Jefatura del Estado, "Real Decreto-ley 23/2020, de 23 de junio, por el que se aprueban medidas en materia de energía y en otros ámbitos para la reactivación económica," in Boletín Oficial del Estado número 175, de 24 de junio de 2020, Madrid, Agencia Estatal del Boletín Oficial del Estado, 2020, pp. 43879 - 43927. Royal Decree 23/2020
AM	Regulation for flexibility provision mechanism to be developed	Draft Proposal for Network Code on Demand Response
Requirement R-ID	**Requirement name**	**Requirement description**
RCR-1	Submetering data regulations need to be implemented in Spain	The BUC requires ECM to obtain accurate metering and/or forecasted energy data using submeters. Depending on the exact usage of submeters data the regulation regarding submeters needs to be defined and implemented.
RCR-2	Definition of baseline methodology	The BUC requires that the flexibility availability to the DSO is computed using an agreed baseline methodology between DSO, EC and the DER's owner members. The used baseline methodology as stated in the draft Network Code will depend on the aggregation models applied, the national market design, the type of service and the type of technical resource, different baselining methods can be nationally implemented and applied.
RCR-3	Regulation for energy communities may establish rules for benefit distribution among members.	In Spain, consumers may either use *fixed* or *variable* coefficients **Invalid source specified.**. Using the former, the energy is distributed always using a fixed set of coefficients between the different members of the community **Invalid source specified.**. Using the latter, the energy is distributed using a set of defined *ex-ante* for each of the hours of the year **Invalid source specified.**. Dynamic coefficients have not been implemented yet, but are mentioned in the legislation, and other documents as the *Self-consumption Roadmap* **Invalid source specified.**.

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RCR-4	Regulation for the activities of aggregators may apply to ECs when aggregating members to participate to markets	ECs may be subject to rules defined for aggregators when acting as aggregators for market participation.
AM-1	Regulation for local flexibility markets need to be implemented in Spain	The BUC considers that energy communities equipped with flexible assets can adopt a market-based approach like local markets, or centralized but aligned with market principles for system services provision. There is a necessity to formulate strategies in Spain for integrating energy communities into local marketplaces and also schedules for assets according optimization algorithms.

7 Common Terms and Definitions

Common Terms and Definitions	
Term	**Definition**
Renewable Energy Community (REC)	A legal entity: (a) which, in accordance with the applicable national law, is based on open and voluntary participation, is autonomous, and is effectively controlled by shareholders or members that are located in the proximity of the renewable energy projects that are owned and developed by that legal entity. (b) the shareholders or members of which are natural persons, SMEs or local authorities, including municipalities. (c) the primary purpose of which is to provide environmental, economic or social community benefits for its shareholders or members or for the local areas where it operates, rather than financial profits.
Citizen Energy Community (CEC)	A legal entity that: (a) is based on voluntary and open participation and is effectively controlled by members or shareholders that are natural persons, local authorities, including municipalities, or small enterprises. (b) has for its primary purpose to provide environmental, economic or social community benefits to its members or shareholders or to the local areas where it operates rather than to generate financial profits. (c) may engage in generation, including from renewable sources, distribution, supply, consumption, aggregation, energy storage, energy efficiency services or charging services for electric vehicles or provide other energy services to its members or shareholders.
Mid market rate	Pricing mechanism based on computing the average between the price of buying price from the retailer and the price of selling energy back to the retailer. When different community members have different retailers and tariffs, we propose to use the maximum selling price and minimum buying price. It is necessary to determine, for each consumer, its net balance, to know if it is consuming, therefore buying, or generating, therefore selling energy.
Intermediate market rate	Based on the mid market rate, but instead of a simple average, we propose a weighted average to allow giving more weight to the buying or to the selling prices. It is again necessary to determine, for each consumer, its net balance, to know if it is consuming, therefore buying, or generating, therefore selling energy.
Supply-demand ration based price	This procedure provides a price probably closer to a real market outcome, since it takes into account the amount of supply available compared to the existing demand, providing a better economic signal. It is again necessary to determine, for each consumer, its

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	net balance, to know if it is consuming, therefore buying and contributing to the aggregated demand, or generating, therefore selling energy and contributing to the aggregated supply.
Post-delivery pool based price	This price is the result of simulating a post-delivery pool, post-delivery local markets. In the simplest case, the simulation consists in crossing the aggregated supply and demand curves. To do so, for each consumer, its net balance is computed, to know if it is consuming, therefore buying energy and producing a buying bid at its opportunity cost (usualy the integral tariff of buying energy from its retailer), or generating, therefore selling energy and producing a selling bid at its opportunity cost (usually the integral tariff of selling energy to its retailer). With these bids, the aggregated supply and demand curves of the pool can be computed. If there are no flexible resources, the price is computed by crossing these curves. In case there are flexible resources whose dispatch depends on the transactions price, an iterative procedure can be used to estimate the schedule, determining again the consuming or generating behaviour of the consumers, re-estimating the pool price, until prices and schedules convergence. Alternatively, it may be possible to maximize the welfare so as to determine, in one step optimization problem, the price and the flexible resources schedules.

11.3. BUC03 – Optimize domestic thermal loads to reduce costs and boost flexibility

1 Description of the use case

1.1 Name of the use case

ID	*Area / Domain(s)*	*Name of Use Case*
BUC03	Consumer/Community-centric flexibility	Optimize domestic thermal loads to reduce costs and boost flexibility

1.2 Version management

Version Management			
Version No.	*Date*	*Name of Author(s)*	*Changes*
0.1	25.04.2023	Pau Lloret	First draft version
0.2	15.05.2023	Pau Lloret	Complete description update
0.3	23.05.2023	Pau Lloret	Modification of the Complete description section

1.3 Scope and objectives of use case

Scope and Objectives of Use Case	
Scope	Optimal control of thermal loads to reduce energy consumption and costs.
Objective(s)	• Increase the controllability of thermal loads to enable the provision of flexibility services • Reduce the energy consumption of the controlled thermal loads • Reduce the energy bill associated with the consumption of the controlled thermal loads

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Related business case(s)	It is a pre-requisite for the aggregation of thermal loads for TSO and DSO grid services. • BUC 05 - Aggregation for TSO and DSO grid services

1.4 Narrative of use case

Narrative of Use Case
Short description
Optimal control of domestic thermal loads refers to the application of advanced technology and data analytics to manage energy consumption to optimize the usage of domestic thermal loads, such as electric water heaters, to reduce costs and increase flexibility. By leveraging advanced technology and data analytics, thermal loads can be controlled to reduce their energy usage and reduce energy costs by combining several services like: • Increasing self-consumption (SC) • Peak-shaving (PS) • Dynamic tariff (DT) or Time-of-use (ToU) tariff optimization It may also include the retrofit of devices to enable energy efficiency and demand response services on already installed devices.
Complete description
The BUC is focused on increasing the controllability of domestic thermal loads to improve its efficiency, reduce its associated energy costs, and to enable the provision of flexibility services. This Use Case is mainly focused on the use of electrical storage water heaters as the controlled thermal loads, but other thermal devices that have thermal inertia can be considered as well, like storage space heaters or heat pumps. The Use Case has the following steps: 1. Enabling thermal load controllability. This can be achieved by either: a. Using or installing new demand response factory-ready thermal loads b. retrofitting already installed devices with the installation of a non-intrusive controller to be able to control thermal loads and monitor their performance (SUC03.1. Retrofit of electric storage water heaters is called by this step). 2. Optimize energy consumption. 2.1. Monitoring Once the thermal load can be remotely controlled, the local controller sends monitoring and performance data to the EMS. In some cases, it may also include feedback or constraints from the end-user, although in other cases it is also possible to ensure the comfort with no interaction from the end-user. SUC03.2. Optimize thermal loads to reduce energy use and costs is called by this step. 2.2. Optimization Based on the received monitored data, and combining machine learning prediction algorithms and consumption optimization, the EMS can provide energy efficiency (EE) by optimizing thermal loads' energy consumption. The EMS optimization can be virtually located in the cloud, embedded into the local controller or a combination of both. Tested savings of around 20% of energy consumption can be achieved in the case of retrofitted water heaters. In addition to energy efficiency, the following services can be combined to reduce the energy bill costs: • Increased self-consumption (SC) includes the decision of concentrating consumption during sunny hours and reducing the cost of electricity and the CO2 emissions in the case of behind-the-meter renewable energy sources. This service could also be used in local energy communities with shared generation.

- Peak-shaving (PS). It includes the capability of limiting thermal loads consumption in case of detecting excessive consumption in the smart meter. The definition of power limitation could vary, and the service must be adapted to each regulatory framework.
- Dynamic tariff (DT) or Time-of-use (ToU) tariff optimization for electricity bill reduction without comfort loss. It adapts the consumption to the hourly electricity prices to reduce the heating cost. This service needs to know the tariff of each customer.

SUC03.2. Optimize thermal loads to reduce energy use and costs is called by this step.

2.3. Activation
As a result of the optimization carried out by the EMS, control signals are sent to control the thermal device following the optimization results. Depending on the kind of thermal assets and its control capabilities, these control signals can be ON/OFF signals, temperature setpoints, or other kind of setpoints or control signals.

SUC03.2. Optimize thermal loads to reduce energy use and costs is called by this step.

3. Settlement
Optionally, the FSP in charge of the EMS can also send periodic reports about the achieved savings in the energy bill to the social housing company, building manager or end user.

1.5 Key performance indicators (KPI)

ID	*Name*	*Description*	*Reference to mentioned use case objectives*
3.1	Controllable thermal loads [#]	Enable the control of thermal loads for an efficient use and enable flexibility services. Target: 90 in all pilots	Increase the controllability of thermal loads to enable the provision of flexibility services.
3.2	Reduction of energy consumption [%]	Reduce the energy consumption of thermal loads by applying an efficient control. Target: reduction of around 15% of the energy consumption.	Reduce the energy consumption of the controlled thermal loads.
3.3	Reduction of energy costs [%]	Reduce the energy associated cost of thermal loads by applying an efficient control. Target: reduction of around 20% of energy bill.	Reduce the energy bill associated with the consumption of the controlled thermal loads.

1.6 Use case conditions

Use case conditions
Assumptions
The installed thermal load can be externally controlled, either with a retrofit controller or with a factory ready thermal device.
Prerequisites
End-users give permission for controlling their thermal loads and collect their consumption data.

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For the DT or ToU service, knowing the tariff of each customer is needed. For the SC service, installed individual or shared PV panels are needed.

1.7 Further Information to the use case for classification / mapping

Classification Information
Relation to other use cases
It has the following SUCs: • SUC03.1. Retrofit of electric storage water heaters • SUC03.2. Optimize thermal loads to reduce energy use and costs It can be complemented by: • BUC05. Aggregation for TSO and DSO grid services.
Level of depth
Business use case (BUC).
Prioritisation
To be demonstrated in France (pilots 3.5 and 3.6) and Spain (pilots 3.1 or 3.2 and 3.4).
Generic, regional or national relation
Generic.
Nature of the use case
Business use case.
Further keywords for classification
Thermal loads, energy efficiency, optimization, flexibility.

1.8 General Remarks

General Remarks

2 Diagrams of use case

Diagram(s) of use case
Use Case Diagram:

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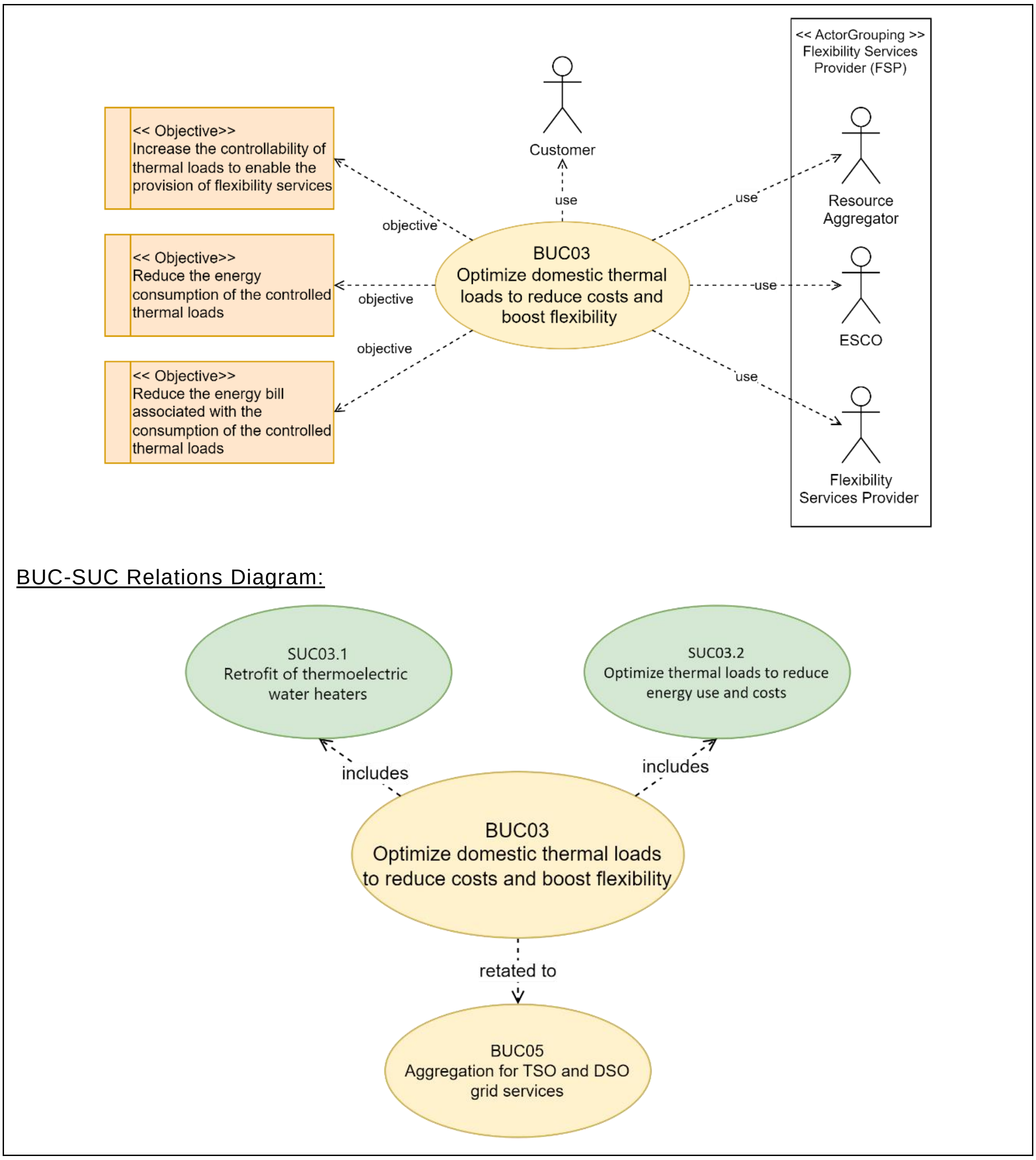

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3 Technical details

3.1 Actors

Actors		
Actor Name	***Actor Type***	***Actor Description***
Consumer	Business Role (BRIDGE HEMRM)	A party that consumes electricity.
Energy Service Company (ESCO)	Business Role (BRIDGE HEMRM)	A party offering energy-related services to the Party Connected to Grid, but not directly active in the energy value chain or the physical infrastructure itself.
Flexibility Services Provider	Business Role (BRIDGE HEMRM)	A party providing flexibility services to energy stakeholders via bilateral agreements or flexibility markets.
Resource Aggregator	Business Role (BRIDGE HEMRM)	A party that aggregates resources for usage by a service provider for energy market services.

3.2 References

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

4 Requirements

Requirements		
Categories ID	**Category name for requirements**	**Category description**
GDPR	Regulatory obligation related to privacy	2016/679 (General Data Protection Regulation)
Requirement R-ID	**Requirement name**	**Requirement description**
GDPR-1	Data processing consent	Personal data may not be processed unless there is at least one legal basis to do so.
GDPR-2	Data retention policy	Data retention policy outlines the time period specific sensitive data can be retained, plus how it will be disposed of when the time to do so comes.
GDPR-3	Right to access, rectify, erasure, restriction	The data subject shall have the right to obtain from the controller without undue delay the access/rectification/erasure/restriction of inaccurate personal data concerning him or her.
GDPR-4	Data transfer consent	Personal data may not be transferred to a third-party if the data subject did not agree and the third party provide appropriate safeguard.

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GDPR-X	All GDPR constraints also apply to this BUC.	e.g., proportional measures of protection, communication of data breach, among others
Categories ID	**Category name for requirements**	**Category description**
FLEX-VOL	Consent to participate in flexibility services	The customer gives consent to participate in flexibility services.
Requirement R-ID	**Requirement name**	**Requirement description**
SOC	Social requirements for value addition and engagement	Inputs from 2.1 and 2.2
Requirement R-ID	**Requirement name**	**Requirement description**
SOC-1	Installation & devices	Anything capable of being installed should be smooth and easy to install. Economic constraints exist from user's side as the economic benefit from their efficiency is not high.
SOC-2	Automation	Users need a sense of control when automation happens.
SOC-3	Change behavior	For users to change their habits or behavior of energy consumption a value beyond efficiency should be explained and comfort should be safe and never sacrificed.

Requirements		
Categories ID	**Category name for requirements**	**Category description**
RCR	Submetering regulations to be developed	Draft Proposal for Network Code on Demand Response
Requirement R-ID	**Requirement name**	**Requirement description**
RCR-1	Submetering data regulations	The BUC requires ECM to obtain accurate metering and/or forecasted energy data using submeters. Depending on the exact usage of submeters data the regulation regarding submeters needs to be defined and implemented.

5 Common Terms and Definitions

Common Terms and Definitions	
Term	**Definition**
ESCO	Energy Service Company
FSP	Flexibility Service Provider
SC	Self-consumption
PS	Peak shaving
DT	Dynamic tariff
ToU	Time of use tariff

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11.4. BUC04 – Long-term distribution grid congestion (and voltage constraints) management

1 Description of the use case

1.1 Name of the use case

ID	*Area / Domain(s)*	*Name of Use Case*
BUC04	Grid-centric flexibility	Long-term distribution grid congestion (and voltage constraints) management

1.2 Version management

Version Management			
Version No.	*Date*	*Name of Author(s)*	*Changes*
0.1	28.04.2023	Maja Johansson	First draft version
0.2	05.05.2023	Rebecca Samuelsson, David Bjarup, Maja Johansson	Second draft version
0.3	10.05.2023	Maja Johansson	Third draft version
0.4	30.05.2023	Maja Johansson	Added text under complete description
0.5	02.06.2023	Rebecca Samuelsson, David Bjarup, Maja Johansson	Revised text under complete description
0.6	27.06.2023	Rebecca Samuelsson, Maja Johansson	Inclusion of comments from partners.
0.7	14.11.2023	Carolina Manaresi	Added Voltage constraints management

1.3 Scope and objectives of use case

Scope and Objectives of Use Case	
Scope	Long-term congestion (and voltage constraints) management in the distribution grid.
Objective(s)	• Integrate flexibility into DSO grid planning processes and tools to properly assess its value and its potential to contribute to a smarter grid planning and operation, based on an analysis of its reliability to reach a cost-effective and reliable planning. • Procurement of local flexibility products by the DSO to manage long term congestions (and voltage constraints) thus deferring/eliminating the need of traditional system investments.
Related business case(s)	BUC05 Aggregation for TSO and DSO grid services, BUC06 Short-term congestion constraints forecasting and management for local flexibility service activation, BUC07 Short-term voltage constraints forecasting and management for local flexibility service activation BUC09 Local and global market coordination.

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1.4 Narrative of use case

Narrative of Use Case
Short description
This BUC will demonstrate long-term congestion management including procurement of local flexibility products by the DSO. Only for DEMO1 this BUC will consider also the long-term management of voltage constraints through active power modulation, since the activities and the systems involved are the same to detect both congestions and voltage constraints. This BUC describes the exchanges of information and the processes that should be established between DSO, forecast provider, FSP/aggregator and DER to solve long-term local distribution grid congestions (and voltage constraints) using flexibility thus deferring/eliminating the need of traditional system investments. The objective is to integrate flexibility into DSO grid planning processes and tools to properly assess its value and its potential to contribute to a smarter grid planning and operation, based on an analysis of its reliability to reach a cost-effective and reliable planning. It consists of the following steps: 1. Determine flexibility demand and value • 1.1 Perform long-term electricity load forecasts • 1.2 Assess congestion and voltage problems and quantify flexibility needs in a constrained grid point • 1.3 Determine the expected cost and value for the DSO to manage the constraint with flexibility • 2. Acquire flexibility capital 2.1 Procure availability contracts 2.2 Sign non-firm connection agreements 2.3 Prequalify DERs to market • 3. Operate flexibility market 3.1 Perform short-term load forecasts 3.2 Activate market-based and non-market based availability contracts 3.3 Validate delivered flexibility 3.4 Settle with FSP • 4. Evaluation of flexibility and improvement of grid planning 4.1 Evaluate delivered flexibility and its reliability 4.2 Improve the integration of flexibility into DSO grid planning processes and tools
Complete description
This BUC describes the integration of flexibility into DSO grid planning processes and tools to properly assess its value and its potential to contribute to a smarter grid planning and operation. This should be based on an analysis of its reliability to reach a cost-effective and reliable planning. It consists of the following steps: **1. Determine flexibility demand and value** • • To be able to create a liquid flexibility market for long-term grid constraints, the DSO needs to start with assess the amount of flexibility needed in a grid point and how much it is worth for the DSO to be able to solve the constraint with flexibility. • **1.1 Perform long-term electricity load forecasts** • • The DSO performs long-term load forecasts for its grid, based on prognosis of user consumption, electricity production, growth and electrification, and identify network constraints based on applicable planning criteria.

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1.2 Assess congestion problem and quantify flexibility needs in a constrained grid point.

For identified constrained points in the grid, the DSO investigates the specific flexibility demand in that grid point, based on for example the temperature dependency of the load and the forecast from 1.1. Different scenarios such as "worst case", "likely" and "best case" can be calculated for each constrained grid point and the demand quantified according to a common methodology taking into consideration expected growth in the selected time period. Development of these tools is done iteratively to benefit from learnings made when actively operating flexibility markets and performing the grid planning.

System Use Case called by the step
SUC 04.1: Load forecasts for long-term grid demand **and quantification of flexibility needs.**

1.3 Determine the expected cost and value for the DSO to manage the constraint with flexibility

Based on the specific characteristics of the constraint in the grid, the value of managing the constraint with flexibility should be determined. The value can consist of value for delaying a traditional grid reinforcement, value for lowering the risk of grid components breaking, value of being able to connect a new customer faster, value of reduced climate impact and value of public relations etc. The value of the flexibility determines what the DSO is willing to pay for procurement of flexibility service providers. Based on this budget, a strategy for procurement of different products should be developed.

2. Acquire flexibility capital

The flexibility market needs resources that the DSO can buy different flexibility products from. Resources can either be procured (market-based) or contracted through non-firm connection agreements (non-market based).

2.1 Procure availability contracts

The DSO procures the availability from FSPs/aggregators in a long-term time scale (years to weeks ahead of delivery) for a fixed price. The procurement should be designed in a way that if more flexibility volumes than requested are offered, flexibility volumes with the lowest total cost of the service (availability and activation costs) should be chosen.

System Use Case called by the step
SUC 04.2: Procure availability contracts

2.2 Sign non-firm connection agreements

The flexibility platform can also contain resources that are connected to the grid through non-firm connection agreements, where the DSO can request a temporary reduction of the resource's outtake or injection to/from the grid under certain circumstances during the operation of the grid when activating these agreements.

2.3 Prequalify DERs to market

This process serves to ensure that a particular FSP/aggregator is capable of delivering a given product and not risk the operational security of the grid. This has to be ensured from two perspectives, namely the grid pre-qualification and product pre-qualification. The objective of the grid pre-qualification is to ensure that the network is capable to cope with the flexibility provision by a particular FSP/aggregator. The grid pre-qualification may involve both internal simulations by the DSO and/or specific field tests with the FSP/aggregator. The product pre-qualification ensures that the resource fulfils the technical requirements to be able to deliver the product and participate in a particular market. In principle, the product pre-qualification should be done by the requesting DSO. Whenever possible, the pre-qualification processes (grid and product) will be combined or coordinate, aiming at having the simplest possible process for the FSP/aggregator.

3. Operate flexibility market

- The flexibility market is open when needed by the DSO during the identified months of constraints in the grid.

3.1 Perform short-term load forecasts

- The DSO utilises short-term load forecasts based on applicable input data which is modelled by a forecast provider. The forecast can be custom made for a specific grid point or produced with a generic method. Typical inputs are historic load data (production and consumption), historic weather data, real-time grid and weather data, as well as weather forecasts of temperature and wind. Models for predictions may vary but will generally employ a trained neural network such as LSTM (Long Short-Term Memory) that is suited for time-series forecasting.

3.2 Activate market-based and non-market-based availability contracts

- The available flexibility will be activated by the DSO when needed or as scheduled, one or more times during the life of the availability contract. In the case of an aggregator as FSP, the aggregator activates the flexibility from relevant DERs. Non-firm connection agreements may also be activated during this phase, but only if the flexibility demand persists after all market-based flexibility is activated, there is a risk for gaming in the market, if there is not enough resources that can secure a competitive market or that it has not been possible to establish a market-based solution.

System Use Case called by the step
SUC 04.3 Activate market-based and non-market-based availability contracts

3.3 Validate delivered flexibility

- The delivered flexibility is calculated by comparing real-time measurements of electricity outtakes or injections with provided baseline for the DER. Baseline methodology may differ depending on type of resource but will typically either be calculated by the flexibility market platform or sent by the FSP/aggregator as a plan/nomination. If the flexibility of an FSP/aggregator is delivered as contracted, the DSO proceeds with the settlement as agreed in the contract.

3.4 Settle with FSP

- Delivered flexibility of FSP/aggregator receives a payment for the availability during the life of the contract and if activation is needed, the FSP/aggregator may receive an additional utilisation payment or not (to be defined in the contract). If the activation is not delivered, penalties may be applied to the FSP/aggregator.

4. Evaluation of flexibility and improvement of grid planning

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-
- The grid planning processes within the DSO organization will use the flexibility in future planning of the grid.
-

4.1 Evaluate delivered flexibility and its reliability

-
- The DSO evaluates how well the flexibility solves the specific grid challenge and estimates the reliability of the flexibility.
-

4.2 Improve the integration of flexibility into DSO grid planning processes and tools

-
- The DSO integrates the flexibility volumes and its reliability in grid planning tools, making flexibility an alternative to traditional grid reinforcement in the grid planning processes.
-

System Use Case called by the step
SUC 04.4: Integrate flexibility into DSO grid planning processes and tools

1.5 Key performance indicators (KPI)

ID	***Name***	***Description***	***Reference to mentioned use case objectives***
1	*Value of flexibility*	Compare cost for flexibility and its management with cost if flexibility was not available, e.g., cost deferral or avoidance of network reinforcement.	All
2	*Available Flexibility*	Available power flexibility in a defined period (e.g., per day) that can be allocated by the DSO at a specific grid perimeter. Measured in MW. This in relation with the total amount of power in the specific grid perimeter in the same period.	Integrate flexibility into DSO grid planning processes and tools
3	*Congestion Forecast Accuracy*	Degree of accuracy in predicting the occurrence and severity of grid congestions.	Integrate flexibility into DSO grid planning processes and tools
5	*Activated Flexibility*	This indicator measures the amount of activated flexibility. This indicator will be used in order to measure the amount of purchased flexibility.	All
6	*Delivered Flexibility*	This indicator measures the amount of delivered flexibility in comparison with requested activated flexibility (%)	All
7	*Quality of Flexibility Delivery per FSP*	This indicator measures how well each FSP delivers the flexibility that was activated by the DSO.	All
8	*Active Flexibility Service Providers*	This indicator measures the number of flexibility service provider that participate actively in the market.	Procurement of local flexibility products by the DSO to manage long term congestions thus deferring/eliminating the need of traditional system investments.

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9	*Flexibility Accountability*	This indicator measures how well flexibility solves the long-term grid challenges based on the KPIs 2, 5 and 6.	

1.6 Use case conditions

Use case conditions
Assumptions
The DSO has grid areas with long-term congestion challenges. There are flexibility service providers that are willing to provide flexibility. Individual DERs, aggregators, and independent aggregators are allowed by regulation to provide flexibility to the DSO, which receive a remuneration.
Prerequisites
The DSO has started to develop a methodology for long-term grid development, where future flexibility need is included.

1.7 Further Information to the use case for classification / mapping

Classification Information
Relation to other use cases
It has the following SUCs: • SUC04.1 Load forecasts for long-term grid demand and quantification of flexibility needs • SUC04.2 Procure availability contracts • SUC04.3 Activate market-based and non-market-based availability contracts • SUC04.4 Integrate flexibility into DSO grid planning processes and tools It can be complemented by: • BUC05 Aggregation for TSO and DSO grid services • BUC06 Short-term congestion constraints forecasting and management for local flexibility service activation • BUC07 Short-term voltage constraints forecasting and management for local flexibility service activation • BUC 09 Local and global market coordination for distributed resources system service provision
Level of depth
Business Use Case (BUC)
Prioritisation
To be demonstrated in Italy (pilots 1.2 and 1.3), Sweden (pilots 2.1 and 2.2) and Spain (pilots 3.1 and 3.4).
Generic, regional or national relation
Generic
Nature of the use case
Business Use Case
Further keywords for classification
Local congestion management, grid constraints, distributed energy resources, flexibility service providers, aggregators, long-term, flexibility, availability, grid planning, demand response, distribution system operator.

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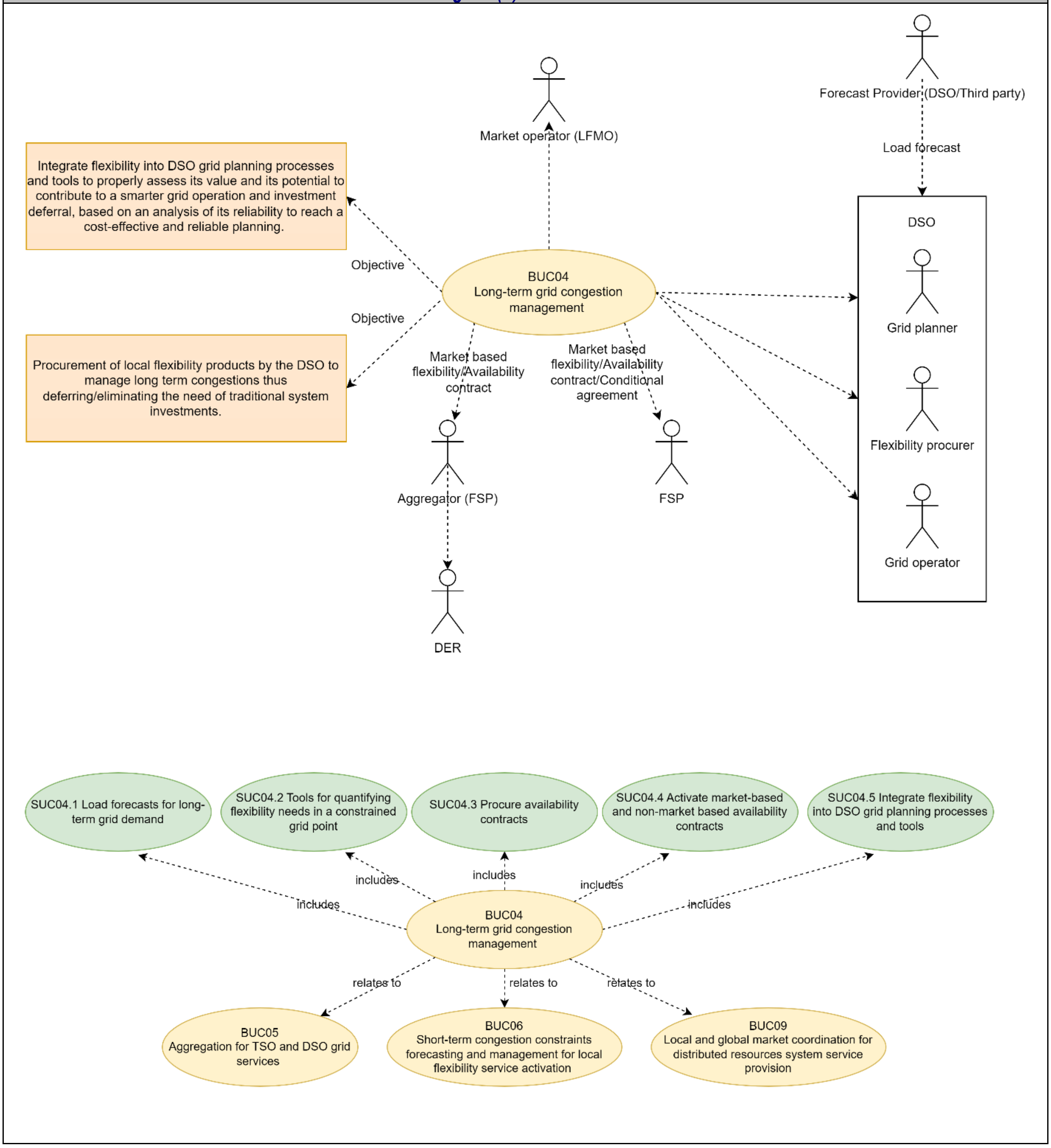
1.8 General Remarks

General Remarks
No general remarks.

2 Diagrams of use case

Diagram(s) of use case


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3 Technical details

3.1 Actors

Actors		
Actor Name	***Actor Type***	***Actor Description***
Distribution System Operator (DSO)	Role (HEMRM)	A DSO is a System Operator. DSO is responsible for security of supply and reliability of the distribution grid. For this reason, it monitors the grid in order to identify possible arising issues and, if there is a need, it makes use of resources to solve such problems, by network reconfiguration and/or by requests to market operators or directly to properly contracted customers. In addition to the above and more in detail: • is responsible for the access of the customers to the grid; • operates, maintains, develops and is fully responsible of the part of the electricity system, named “Distribution Network”, typically starting from the HV/MV transformers (or vHV/HV transformers depending upon Member State Regulation) down to the customer’s POD; • acts on Local Flexibility Market requiring Local Flexibility Services to solve distribution grids issues; • ensures a transparent and non-discriminatory access to the distribution network for each users; • assess network status of the distribution grid and broadcasts selected information of the network status to eligible actors (e.g. aggregators, other system operators); • in critical situations, implements dedicated actions and deliver alerts during stress events If necessary, implement emergency measures including load shedding and DER curtailment; cooperates with the Transmission System Operator in carrying out their responsibilities (e.g. load shedding).
Flexibility Services Provider (FSP)	Role (HEMRM)	A party providing flexibility services to energy stakeholders via bilateral agreements or flexibility markets. An FSP can also be a BSP if enabled to the LFC services. In the Bridge HEMRM, FSP is an extension of FBSP. FSP offer services potentially to all the system operators, directly or through market operators.
Distributed Energy Resource (DER)	Device	Resources connected at the distribution grid capable of providing active power flexibility, either upward/downward or both. It can include several different roles and devices such as demand response (actor/role), distributed generation, electric vehicles, and storage systems.
(Resource) Aggregator	Role	A party that aggregates resources for usage by a service provider for energy market services.
Local Flexibility Market Operator (LFMO)	Role (HEMRM)	Responsible for the local flexibility market services. Responsible for calling, clearing, communicating results and possibly settling the provision of distributed flexibility. This role can be taken by an Independent Market Operator, an existing one (e.g. a NEMO) or a system operator (e.g. DSO, TSO)

3.2 References

References

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

4 Requirements

Requirements		
Categories ID	**Category name for requirements**	**Category description**
GDPR	Regulatory obligation related to privacy	2016/679 (General Data Protection Regulation)
Requirement R-ID	**Requirement name**	**Requirement description**
GDPR-1	Data processing consent	Personal data may not be processed unless there is at least one legal basis to do so.
GDPR-2	Data retention policy	Data retention policy outlines the time period specific sensitive data can be retained, plus how it will be disposed of when the time to do so comes.
GDPR-3	Right to access, rectify, erasure, restriction	The data subject shall have the right to obtain from the controller without undue delay the access/rectification/erasure/restriction of inaccurate personal data concerning him or her.
GDPR-4	Data transfer consent	Personal data may not be transferred to a third-party if the data subject did not agree and the third party provide appropriate safeguard.
GDPR-X	All GDPR constraints also apply to this BUC.	e.g., proportional measures of protection, communication of data breach, among others
Categories ID	**Category name for requirements**	**Category description**
FLEX-VOL	Consent to participate in flexibility services	The customer gives consent to participate in flexibility services.
Requirement R-ID	**Requirement name**	**Requirement description**
FLEX-VOL1	Opt in	The customer should opt in to participate in flexibility services.

Requirements		
Categories ID	**Category name for requirements**	**Category description**
RCR	Regulatory changes/needs related to DSO remuneration and network development plans	European Electricity Market Directive 944/2019
AM	Regulation for flexibility provision mechanism to be developed	Draft Proposal for Network Code on Demand Response CEER Paper on Alternative Connection Agreements
Requirement R-ID	**Requirement name**	**Requirement description**
RCR-1	Scenario definition for grid planning	As noted in [275], creating a comprehensive and reasonably accurate set of all potential future

		scenarios is a challenging endeavour and one can end up justifying large amounts to be spent on contingencies most of which will never be realized. Scenarios for long-term electricity load forecasts need to be carefully addressed, close collaboration with the regulatory authority is recommended.
RCR-2	Analysis of incentives in DSO remuneration schemes	There are many European countries with a Capex biased regulatory framework for DSO remuneration [276]. This may lead to a situation where a flexibility solution (e.g. use of a flexibility solution to delay network reinforcement), while efficient from a system perspective, is not well incentivized and DSO earnings are reduced compared to the alternative of not delaying the grid reinforcement. This topic should be addressed in the BUC.
AM-1	Regulation for local flexibility markets need to be implemented in Spain, while also regulation for non-firm connection agreements need to be implemented in Italy and Spain	The BUC considers long-term congestion management using local flexibility acquisition mechanisms non-market-based availability contracts like non-firm connection agreements, and market-based like local flexibility markets. To enable more efficient operation of different acquisition mechanisms, regulatory frameworks should be considered that allow for the selection of the most suitable mechanisms or a combination of them, based on their design characteristics.

11.5. BUC05 – Aggregation for TSO and DSO grid services

1 Description of the use case

1.1 Name of the use case

ID	Area / Domain(s)	Name of Use Case
BUC 05	Grid-centric flexibility	Aggregation for TSO and DSO grid services

1.2 Version management

Version Management			
Version No.	***Date***	***Name of Author(s)***	***Changes***
0.1	16.05.2023	Ione Lopez	First draft version

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0.2	13/06/2023	Ione Lopez	Final version

1.3 Scope and objectives of use case

Scope and Objectives of Use Case	
Scope	Aggregation of flexibility from household thermal assets, battery energy systems, and building energy management systems.
Objective(s)	Use aggregation services to offer flexibility in the local flexibility market to the DSO aiming to solve short and long-term congestion issues (DSO services procurement), and also offer flexibility to the TSO for different purposes.
Related business case(s)	BUC 04: Long-term distribution grid congestion management. BUC 06: Short-term congestion constraints forecasting and management for local flexibility service activation.

1.4 Narrative of use case

Narrative of Use Case
Short description
As the main actor of this Business Use Case (BUC) is the Resource Aggregator (VPP) aiming to aggregate different flexible assets (e.g., controllable loads, electric vehicle chargers, storage, distributed generation) located in different areas to offer local flexibility services to both TSO and DSO, considering short-term flexibility markets and long-term flexibility tenders for congestion management. Balancing services for TSO are also considered and its potential is evaluated against local flexibility services in terms of cost, technical requirements, and opportunity. The aggregation target is small-scale consumers (i.e., households and buildings) considering manual control from users. The participation in aggregation needs tools to provide digital support. A Virtual Power Plant manages structural and dynamic data in order operate asset flexibility to solve DSO & TSO constraints. VPP is a software placed in the cloud which uses Internet-of-things, Artificial Intelligence and digitalization to communicate, aggregate and optimize distributed energy resources in different markets. It consists in: - Engage with DSO and TSO flexibility procurement processes in the short and long-term and offer flexibility potential (amount, location, and price). - Incentivize final users to provide flexibility when requested by the Resources Aggregator, targeting their most flexibility (and cost-effective) assets, including the manual/automatic control of the resources. - Decide the best flexibility products/mechanisms participate in, covering different time horizons and both TSOs/DSOs. Quantify and bid the aggregated flexibility in the selected markets and products. - Settlement of the flexibility provision, e.g., division of benefits with the consumers.
Complete description
Congestion management is a critical task for DSOs and TSOs as it ensures the smooth flow of electricity across the grid. In recent years, the integration of renewable energy sources such as solar and wind power has led to an increase in congestion levels, making it challenging for DSOs\TSOs to manage the grid effectively. To address this issue, aggregations through Virtual Power Plants (VPPs) have emerged as a powerful solution that can help DSOs\ TSOs mitigate congestion and optimize grid performance.

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The participation in aggregation structures needs tools (as VPPs) to provide digital support for stablish communications among all flexibility actors. In addition, managing basic structural and dynamic data as to operate the flexible assets according to predefined constrains (such as congestion management). Finally supporting energy flows and transactions among aggregated VPP members and DSO and/or TSO.

This BUC objective is to extract all the flexibility of the systems to solve congestions on DSO and/or TSO. With this aggregation platform (VPP) we are able to provide congestion management solutions with the integration and aggregation of demand assets, capable of providing flexibility to solve the needs of the systems.

The BUC includes the following steps.

Short Term

1. Receive at VPP information from TSO and/or DSO about short-term flexibility needs in different network areas: The first step in utilizing a VPP for congestion management is to receive information from the Transmission System Operator (TSO) and/or DSO about short-term flexibility needs in different network areas. This information will help VPP and distributed energy resources (DERs) determine where congestion may occur and where flexibility is needed to alleviate it.

    1.1 Check if this flexibility request corresponds to any flexibility products contracted in the short-term: The TSO and/or DSO will then check if the requested flexibility corresponds to any flexibility products that have been contracted in the short-term. If so, the TSO and/or DSO can utilize these resources to provide the necessary flexibility.

    1.2 Submit short-term flexibility offer: The TSO and/or DSO will then submit a short-term flexibility offer, through the VPP, to distributed energy resources (DERs).

2. Estimate flexibility potential: In order to forecast flexibility potential. The VPP will aggregate data (volumes, prices, time horizon) from distributed energy resources (DERs) in each area under procurement. This will help the aggregator determine how much flexibility capacity can be offered in the short-term.

    2.1 Estimate flexibility potential per areas under procurement: The VPP will estimate the flexibility potential per area under procurement by analyzing data from distributed energy resources (DERs) such as solar panels, demand response, and battery storage systems baselines.
    2.2 Decide how much flexibility capacity can be offered in the short-term: Based on the estimated flexibility potential, the VPP will decide how much flexibility capacity can be offered in the short-term.

3 Receive information about accepted flexibility offers: The VPP will aggregate distributed energy resources (DERs) flexibility capacity and accept the flexibility offer (by bidding on the flexibility offer). The TSO and/or DSO will receive information about the accepted offers.

    3.1 The VPP will communicate this information to the distributed energy resources (DERs) associated with the flexibility provision: The TSO and/or DSO will then communicate market clear information to the clients associated with the flexibility provision.

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4 Through the VPP receive notification signal for flexibility activation by the TSO and DSO to the distributed energy resources (DERs): When a notification signal for flexibility activation is received from the TSO and DSO, will take the following steps:

4.1 Notify consumers (flexibility providers): The VPP will notify consumers (flexibility providers) that their resources are needed for congestion management.
4.2 Implement activation signals to provide requested flexibility: The TSO and/or DSO will implement the activation signal to provide the requested flexibility. VPP will aggregate distributed energy resources (DERs).
4.3 Monitor provision of the flexibility per resource/point-of-delivery: The VPP will monitor the provision of the flexibility per resource/point-of-delivery to ensure that it is meeting the requested amount.
4.4 Apply remedial actions in case of flexibility shortage: If there is a shortage of flexibility, the TSO and/or DSO will apply remedial actions to sure that congestion is still managed effectively. VPP can activate additional DERS if first ones in merit order are failing to provide service.
4.5 Manual control will be activated by DER's: In case of emergency, manual control can be activated by DERs to ensure that congestion is managed effectively.

5 Settlement of flexibility provision: Once the congestion has been managed and resolved, settlement of the flexibility provision must occur.

5.1 Settlement with consumers: The TSO and/or DSO will also settle with distributed energy resources (DERs) who provided the necessary resources for congestion management.

Long Term

6 Receive at VPP information from TSO and/or DSO about long-term flexibility needs in different network areas: The first step in utilizing a VPP for congestion management is to receive information from the Transmission System Operator (TSO) and/or DSO about long-term flexibility needs in different network areas. This information will help VPP and distributed energy resources (DERs) determine where congestion may occur and where flexibility is needed to alleviate it.

6.1 Check if this flexibility request corresponds to any flexibility products contracted in the long-term: The TSO and/or DSO will then check if the requested flexibility corresponds to any flexibility products that have been contracted in the long-term. If so, the TSO and/or DSO can utilize these resources to provide the necessary flexibility.

6.2 Submit long-term flexibility offer: The TSO and/or DSO will then submit a long-term flexibility offer, through the VPP, to distributed energy resources (DERs).

7 Estimate flexibility potential: In order to forecast flexibility potential. The VPP will aggregate data (volumes, prices, time horizon) from distributed energy resources (DERs) in each area under procurement. This will help the aggregator determine how much flexibility capacity can be offered in the long-term.

7.1 Estimate flexibility potential per areas under procurement: The VPP will estimate the flexibility potential per area under procurement by analyzing

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data from distributed energy resources (DERs) such as solar panels, demand response, and battery storage systems baselines.

7.2 Decide how much flexibility capacity can be offered in the long-term: Based on the estimated flexibility potential, the VPP will decide how much flexibility capacity can be offered in the long-term.

8 Receive information about accepted flexibility offers: The VPP will aggregate distributed energy resources (DERs) flexibility capacity and accept the flexibility offer (by bidding on the flexibility offer). The TSO and/or DSO will receive information about the accepted offers.

8.1 The VPP will communicate this information to the distributed energy resources (DERs) associated with the flexibility provision: The TSO and/or DSO will then communicate market clear information to the clients associated with the flexibility provision.

9 Through the VPP receive notification signal for flexibility activation by the TSO and DSO to the distributed energy resources (DERs): When a notification signal for flexibility activation is received from the TSO and DSO, will take the following steps:

9.1 Notify consumers (flexibility providers): The VPP will notify consumers (flexibility providers) that their resources are needed for congestion management.

9.2 Implement activation signals to provide requested flexibility: The TSO and/or DSO will implement the activation signal to provide the requested flexibility. VPP will aggregate distributed energy resources (DERs).

9.3 Monitor provision of the flexibility per resource/point-of-delivery: The VPP will monitor the provision of the flexibility per resource/point-of-delivery to ensure that it is meeting the requested amount.

9.4 Apply remedial actions in case of flexibility shortage: If there is a shortage of flexibility, the TSO and/or DSO will apply remedial actions to sure that congestion is still managed effectively. VPP can activate additional DERS if first ones in merit order are failing to provide service.

9.5 Manual control will be activated by DER's: In case of emergency, manual control can be activated by DERs to ensure that congestion is managed effectively.

10 Settlement of flexibility provision: Once the congestion has been managed and resolved, settlement of the flexibility provision must occur.

10.1 Settlement with consumers: The TSO and/or DSO will also settle with distributed energy resources (DERs) who provided the necessary resources for congestion management.

In conclusion, Virtual power plants are an effective solution for TSO and/or DSO to manage congestion and optimize grid performance. By aggregating distributed energy resources, VPPs provide flexibility, demand response, energy storage, energy trading, and grid stability services that can help TSO and/or DSO address congestion management challenges. As renewable energy sources continue to grow, VPPs will become an essential tool for TSO and/or DSO to manage the grid effectively.

1.5 Key performance indicators (KPI)

ID	Name	Description	Reference to mentioned use case objectives

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5.1	Reduction of asset energy load consumption.	Baseline: forecasted baseline vs flexibility activation.	Maximize the use of local and grid RES.
5.2	Reduction of asset energy wholesale value consumption.	Baseline: forecasted baseline cost in day ahead market vs flexibility activation price.	Solving congestion Management DSO issues.
5.3	DER's participants in aggregation	Number of flexibility providers.	Solving congestion Management DSO issues.

1.6 Use case conditions

Use case conditions
Assumptions
TSO-DSO will need to provide local markets, specific congestion management constraints regarding volume, time horizon, baseload and price.
Prerequisites
Local market participation, VPP. DSO market platform communication.

1.7 Further Information to the use case for classification / mapping

Classification Information
Relation to other use cases
COORDINET BUC SE-1a/b + ES-1 + GR-2a/b https://private.coordinet-project.eu//files/documentos/5d724207ca982Coordinet_Deliverable_1.5.pdf BUC03: Long-term distribution grid congestion management. BUC05: Short-term congestion constraints forecasting and management for local flexibility service activation.
Level of depth
Business use case (BUC).
Prioritisation
To be demonstrated in South- Western Europe.
Generic, regional or national relation
Regional
Nature of the use case
Asset aggregation flexibility focused on solving Congestion Management.
Further keywords for classification
Electricity metering, storage, flexibility and aggregation.

1.8 General Remarks

General Remarks

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We are planning to test services or components unless complex and unique communications or real measurements requirements.

2 Diagrams of use case

Diagram(s) of use case


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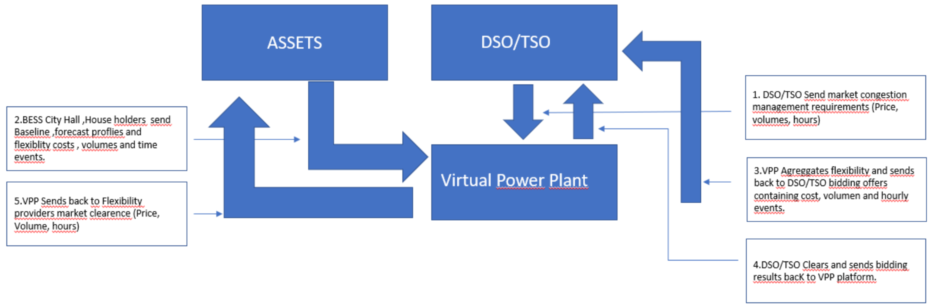

3 Technical details

3.1 Actors

A

Actors		
Actor Name	***Actor Type***	***Actor Description***
VPP owner Resource Aggregator	IBERDROLA Business Role (BRIDGE HEMRM)	Aggregates (i.e., collects and combines) multiple resources for usage by a service provider for energy market services. In this BUC the VPP assumes the role of aggregator. A party that aggregates resources for usage by a service provider for energy market services.
Consumer	Guadalix Business Role (BRIDGE HEMRM)	The Prosumer is a Consumer who can also produce electricity. In BeFlexible role model (T1.3) it is assumed that a prosumer also adopts an active role in the energy chain, by, for example, be willing to joint self-consumption structures or provide flexibility (sometimes Flexumer is also used).
Consumer	Benidorm Business Role (BRIDGE HEMRM)	The Prosumer is a Consumer who can also produce electricity. In BeFlexible role model (T1.3) it is assumed that a prosumer also adopts an active role in the energy chain, by, for example, be willing to joint self-consumption structures or provide flexibility (sometimes Flexumer is also used).
Consumer	Bilbao City Hall Business Role (BRIDGE HEMRM)	The Prosumer is a Consumer who can also produce electricity. In BeFlexible role model (T1.3) it is assumed that a prosumer also adopts an active role in the energy chain, by, for example, be willing to joint self-consumption structures or provide flexibility (sometimes Flexumer is also used).
Data User	Ilnestec	Any person who uses data. Can be a Data Owner or a Data Delegated Third party. He has the right to use the data of a Data Owner as specified by a contract policy.
DSO- Data Owner & Market place owner	I-DE Business Role (BeFlexible role model, BRIDGE HEMRM)	Responsible for the security of supply and reliability of the distribution network. It continuously monitors the grid to detect potential issues and, whenever necessary, it uses multiple resources to solve such problems, including network reconfiguration and/or

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		requesting assistance from market operators or directly from contracted customers. In this BUC the DSO is the main procurer of flexibility. In addition to the above and more in detail: - is responsible for the access of the customers to the grid; - operates, maintains, develops and is fully responsible of the part of the electricity system, named “Distribution Network”, typically starting from the HV/MV transformers (or vHV/HV transformers depending upon Member State Regulation) down to the customer’s POD; - acts on Local Flexibility Market requiring Local Flexibility Services to solve distribution grids issues; - ensures a transparent and non-discriminatory access to the distribution network for each users; - assess network status of the distribution grid and broadcasts selected information
TSO	Business Role (BeFlexible role model, BRIDGE HEMRM)	Responsible for security of supply and reliability of a transmission network and al so real time operation and monitoring, building, expanding, and maintaining the transmission system. Could be a flexibility procurer although it is not explicitly been addressed in this BUC.

3.2 References

References						
No.	***References Type***	***Reference***	***Status***	***Impact on use case***	***Originator / organisation***	***Link***
1	Protocol	Modbus TCP /API / IEC 104	Private	Data Exhange and format	Consumer /I-DE / Iberdrola Clientes	

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	Aggregation for short-term DSO markets.	Concerns the comfort constrains and consumption management at the location, as well as data sharing with third-party service providers.	DERs (distributed energy resource	Aggregation for solving short-term DSO congestion management.	Communication for sharing data, activations, and feedback.	Baseline vs flexibility.

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Scenario conditions						
No.	**Scenario name**	**Scenario description**	**Primary actor**	**Triggering event**	**Pre-condition**	**Post-condition**
2	Aggregation for long-term DSO markets.	Concerns the comfort constrains and consumption management at the location, as well as data sharing with third-party service providers.	DERs (distributed energy resource)	Aggregation for solving long-term DSO congestion management.	Communication for sharing data, activations, and feedback.	Baseline vs flexibility

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4.2 Steps – Scenarios

Scenario								
Scenario name :		No. 1 - Reference 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
1	Occurs periodically (daily).	Inform flexibility providers about the best flexibility periods at the office.	Inform flexibility providers for the next hours and day about the best charging periods considering near real-time and/or forecasted availability of RES; local market electricity price; grid technical constraints.	CREATE	Energy Facility Manager	Flexibility provider	VPP communication	GDPR
2	Occurs periodically (daily)	Obtain / verify consent for data sharing.	Obtain / verify explicit consent from the Data Owner to share charging point data (real-time and/or historical).	GET	Energy Facility Manager (Consent Administrator role)	Flexibility provider (Data Owner role)	User Consent ProfileID	GDPR-[1-4]
3	Flexibility provider unable to modify load.	Notify flexibility providers faults.	Notifies the maintenance service provider of the faulty equipment.	CREATE	Energy Facility Manager	Maintenance Service Provider	Notification ID	GDPR
4	Occurs periodically (daily).	Provide RES generation / Energy storage usage.	The Energy Facility Manager collects the information related to RES generation and Energy storage usage. It can be purchased within a community.	CREATE	M Metered Data Administrator	Energy Facility Manager / Producer	Asset Compsumption ID	GDPR

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5 Information exchanged

Information exchanged				
Information exchanged (ID)	***Name of information***	***Description of information exchanged***	***Requirement, R-IDs***	
1	Load profile	Consumption profile	Define for a period of time.	
2	UserConsentProfileID	Consent profile (extension)	Define for each data dimension (e.g., location, energy, price, time), the consent to exchange the data with different stakeholders, for each stakeholders the granularity, the first time of acceptance, the duration.	
3	CDRTransactionID	Transaction	Define the energy exchanged, duration per time interval	
4	SitesID	Flexibility point data with energy and non-energy service providers (extension)	Extension of the current sites API to include non-energy service providers	
5	FLexID	Flexibility capacity (new)	A list of energy requirement per period of time per flexibility location (data structure similar to Load Profile)	
6	NotificationID	Notification (extension)	Notification binding different objects (eg. assets, userID), a distribution channel and an informative message	
7	AssetCompsumptionID	Asset consumption / production (extension)	Retrieve consumption / production / battery SoC for an asset during a time period including some meta data	

			(geoloc, siteID, etc).	
8	If necessary to calculate baseline	Energy availability forecast	Forecast & Refresh	

6 Requirements

Requirements		
Categories ID	**Category name for requirements**	**Category description**
GDPR	Regulatory obligation related to privacy	2016/679 (General Data Protection Regulation)
Requirement R-ID	**Requirement name**	**Requirement description**
GDPR-1	Data processing consent	Personal data may not be processed unless there is at least one legal basis to do so.
GDPR-2	Data retention policy	Data retention policy outlines the time period specific sensitive data can be retained, plus how it will be disposed of when the time to do so comes.
GDPR-3	Right to access, rectify, erasure, restriction	The data subject shall have the right to obtain from the controller without undue delay the access/rectification/erasure/restriction of inaccurate personal data concerning him or her.
GDPR-4	Data transfer consent	Personal data may not be transferred to a third-party if the data subject did not agree and the third party provide appropriate safeguard.
GDPR-X	All GDPR constraints also apply to this BUC.	e.g., proportional measures of protection, communication of data breach, among others.
Categories ID	**Category name for requirements**	**Category description**
LAB-REG	Regulatory obligation related to labor law	National labour law regulates the scheme related to benefit in kind such as cars or energy, but also protect the fairness in employee management.
Requirement R-ID	**Requirement name**	**Requirement description**
LAB-REG1	Energy price and benefit in kind	As of today, there is no clear regulation with respect to the reimbursement of energy at home especially in the case of local production (usually the price is based on the energy contract) soon we may expect more regulation and the duty to reintegrate it as benefit in kind (after end 2024).
LAB-REG2	Employee fairness	All employees should be equally treated, in this respect we may be careful that the charge prioritization does not discriminate certain population especially if their usage pattern is bound to extra-work constraints (e.g.,

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		parents with young children, people with disabilities).
Categories ID	**Category name for requirements**	**Category description**
FLEX-VOL	Free will to participate to flexibility	The participation to flexibility program, especially at home, should be done in a voluntary basis.
Requirement R-ID	**Requirement name**	**Requirement description**
FLEX-VOL1	Opt in	The consumer should opt in to participate to the flexibility program.
FLEX-VOL2	Reasonable penalties	The penalties for opting out should not exceed the extra cost generated to the company (e.g., energy price, carbon footprint, usage of flexibility).

Requirements		
Categories ID	**Category name for requirements**	**Category description**
RCR	Baseline regulation to be developed Regulations on aggregators to be fully developed	Draft Proposal for Network Code on Demand Response
Requirement R-ID	**Requirement name**	**Requirement description**
RCR-1	Definition of baseline methodology	In this BUC, the VPP will estimate the flexibility potential per area under procurement by analysing data from distributed energy resources (DERs) such as solar panels, demand response, and battery storage systems baselines. National methodologies need to be implemented for such purposes as stated in the Draft Proposal for Network Code on Demand Response.
RCR-2	Regulations on aggregators may outline boundaries for the aggregation and market participation practices.	National regulations prescribe for aggregation activities rules concerning data exchange and confidentiality, market access and compensation for aggregated entities. Moreover, the relation with the retailer considering unbalance responsibility and transfer of energy requires bilateral agreements whether not regulated.

7 Common Terms and Definitions

Common Terms and Definitions	
Term	**Definition**
VPP	Virtual Power Plant

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11.6. BUC06 – Short-term congestion constraints forecasting and management for local flexibility service activation

1 Description of the use case

1.1 Name of the use case

ID	Area / Domain(s)	Name of Use Case
BUC06	Grid-centric flexibility	Short-term congestion constraints forecasting and management for local flexibility service activation

1.2 Version management

Version Management			
Version No.	Date	Name of Author(s)	Changes
0.1	03.05.2023	Marco Rossi, Giorgia Lattanzio, Giacomo Viganò, Daniele Clerici	First draft version
0.2	30.05.2023	Marco Rossi, Giorgia Lattanzio, Giacomo Viganò, Daniele Clerici	Final draft
0.3	04/07/2023	Marco Rossi, Giorgia Lattanzio, Giacomo Viganò, Daniele Clerici	Final review, includes comments resolution

1.3 Scope and objectives of use case

Scope and Objectives of Use Case	
Scope	Forecast of congestions and subsequent management of local flexibility.
Objective(s)	1-Integrate flexibility into DSO grid operation processes and tools to exploit its potential in solving possible congestions. 2-Demonstrates business potential of demand-side products for DERs 3- Demonstrates the ability of the system operator in procuring the right amount of flexibility for occurring congestions. 4- Demonstrates the ability of FSP in respecting the received activation signal.
Related business case(s)	BUC 04: Long-term distribution grid congestion management (The use of long-term availability contracts (including flexible connection agreements) affects the short-term congestion as results from previous markets has to be considered to quantify the available flexibility. Furthermore, short-term procurement supports the long-term one increasing the amount of usable flexibility.) BUC 05: Aggregation for TSO and DSO grid services (The aggregator created virtual units which aggregate flexibility resources to contribute to congestion management) BUC 08: Crowd Balancing: Interoperable data exchange between stakeholders (The platform is necessary to communicate to TSO the local activation of resources so to

	develop a coordination between local and global markets. It also enables data registering on the Flexibility Register) BUC 09: Local and global market coordination for distributed resources system service provision (The results of the local markets could affect the constraints for TSO to use distributed resources in the global market)

1.4 Narrative of use case

Narrative of Use Case
Short description
Short term congestion management considers every condition where the loading state of the grid overcomes a given threshold, determined according to physical limits, operational limits criteria. The analysed Business Use Case (BUC) considers all congestions that might be predicted by SOs by means of available information approximately up to M-1 (month ahead); every condition which cannot be forecasted, such as equipment failure, is instead excluded because outside the scope of the BUC. Activation signal may be sent in tighter timing based on the most updated information, even if grid power flows and flexibility service needs were calculated in advance.
Complete description
This BUC will analyse the short-term congestion management by means of the procurement of local flexibility products by the DSO. This BUC describes the exchanges of information and the processes that should be established between DSO, LFMO and FSP to solve distribution network local congestions. Single or multiple timeframe markets are considered: a day-ahead market and possibly different following market sessions nearest to real time (such as intraday markets). Both “day-ahead” and “intra-day” markets will be used for short-term procurement of flexibility availability to support the network operational planning. The DSO will procure flexibility that could be activated one or more times during the life of the contract. The product will be usually set as an energy product, because of the necessity of short term activation, but it could be set also as an availability and energy (activation) product, depending on the timeframe and characteristics of the problem to be solved. In both cases, the DSO procures flexibility with predefined activation characteristics (e.g., time of activation, duration, ramping periods etc). At activation time, the DSO monitors the delivery of the service. In the case of availability contract, the flexibility providers will receive a payment for the availability during the life of the contract. If activation is needed, the flexibility provider may receive an additional utilisation payment or not (to be defined in the product specifications). If activation is needed and the flexibility provider is not able to deliver it as contracted, a penalty may apply. **Possible scenario:** <u>Prepare/Pre-qualification:</u> The pre-qualification process should start after a flexibility service provider (formally FSP) expresses interest in entering the flexibility market. This process serves to ensure that a particular flexibility service provider is capable of delivering a given product. This has to be ensured from two perspective, namely the grid pre-qualification and product pre-qualification. The former ensures that the resource contains the technical requirements to be able to deliver the product and proceed to the market phase and possibly be selected by a system operator. In principle, the grid pre-qualification will be done by the DSO, as FSP in this BUC are connected to MV and LV grids. The objective of the grid pre-qualification is to ensure that the network is capable to cope with the flexibility provision by a particular FSP. The grid pre-qualification may involve both internal simulations by the DSO and/or specific field tests with the FSP. The product pre-qualification aims at ensuring that the FSP can participate in a particular market and can provide a particular service considering market and product design aspects. In principle, the product pre-qualification should be done by LFMO. If the results of the two types of pre-qualifications are approved, the entry of the FSP into the flexibility market is allowed. The validity of the pre-qualification can be indefinite, limited to a certain period of time or conditioned to predefined aspects (e.g., grid conditions). Whenever possible, the pre-qualification processes (grid and product) will be combined or coordinated, aiming at having the simplest possible process for the FSP. <u>Plan/Forecast:</u>

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In this service phase, the DSO carries internal analysis (e.g., forecasts, power flows) to detect structural congestions in the grid, which could be solved by the short-term procurement of flexibility. This service phase may happen sufficiently in advance. Potential already procured long-term products are also considered to quantify the available flexibility. Market Phase: Based on the flexibility needs identified in the operational planning phase, the DSO is able to attend a market through the auction/market platform. On this market the DSO will procure either availability or activation products. The availability means a capacity band (product defined in MW) with a start and finish times defined, in which the FSP is expected to provide the flexibility upon the DSO's call. Activation is predefined in terms of day, time, capacity and duration of activations (product defined in MWh). In principle, the day -ahead market will be open for availability and activation procurement only. The Intraday market or the following market phases can support both activation products and the activation of an availability product up to a predefined time. This market phase can be classified as a **local market model**. During this phase there is a qualification process to check if the FSP is able to provide the demand service in terms of quality and cost. The results of the auction will be published to market participants. In addition, the scheduling of FSPs could be integrated into to the notification sent to the TSO. Monitoring and Activation: This service phase takes place close to real-time and in real-time. The DSO will monitor the conditions of the grid in real time, notify the activation to the FSPs committed in the market phase and, possibly, send the related signal to DERs in accordance with the type of product procured. When activating the FSPs, the DSO will consider the actual state of the grid, thus taking into account the final state of the network according to the selected activations. Emergency situations in which the necessary flexibility cannot be forecasted are outside the scope of this BUC. Metering Phase and Settlement Phase: In this final service phase, the LFMO and/or DSO will verify if the flexibility was provided in accordance to the product procured in the market phase. This phase can take place in real-time and/or after the delivery period. For metering of flexibility, a baseline has to be previously defined, to which the actual metered data of the FSP can be compared with. If the FSP is not able to deliver the flexibility in accordance with the predefined market conditions and agreed baseline, penalties may apply, which would decrease the remuneration received by FSP.

1.5 Key performance indicators (KPI)

ID	Name	Description	Reference to mentioned use case objectives
6.1	*Cost Value/ Economic value of short-term flexibility*	Compare cost for flexibility and its management with avoided cost if flexibility was not available, e.g., cost deferral or avoidance of network traditional solution which in case of short-term management are represented by the maximum price the pilot owner is willing to pay.	All
6.2	*Available short-term Flexibility*	Available power flexibility in a defined period (e.g., per day) that can be allocated by the DSO at a specific grid perimeter. Measured in MW.	Demonstrates business potential of demand-side products for DERs.
6.3	*Short-term Congestion forecast accuracy*	Degree of accuracy in predicting the occurrence and severity of grid congestions.	Demonstrates the ability of the system operator to forecast the flexibility need and procure the right amount of flexibility for occurring congestions.
6.5	*Delivered Short -Term Flexibility*	This indicator measures the amount of delivered flexibility in comparison with requested activated flexibility (%)	All

1.6 Use case conditions

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Use case conditions
Assumptions
Within the situations in which this BUC can be applied/tested, it is assumed that • Flexibility is a cost effective- solution (with respect to network traditional solutions), at least in the short term timeframe. • There is a pool of flexibility large enough to avoid market liquidity problems, thus flexibility market are an efficient strategy to procure flexibility. • FSP, within the timeframe requested for providing services to the DSO, has no other flexibility provision contracts except the one with the DSO itself. • There is TSO/DSO coordination for what concerns- flexibility activations for local services. • DSO is allowed and remunerated for the procurement of flexibility services by regulation. • Individual DERs and aggregators are allowed by regulation to provide flexibility to the DSO
Prerequisites
• DSO forecasts congestions before the market phases • FSPs effectively control the contracted resources to respect requested activations • DSO and FSPs agree on a defined baseline power profile

1.7 Further Information to the use case for classification / mapping

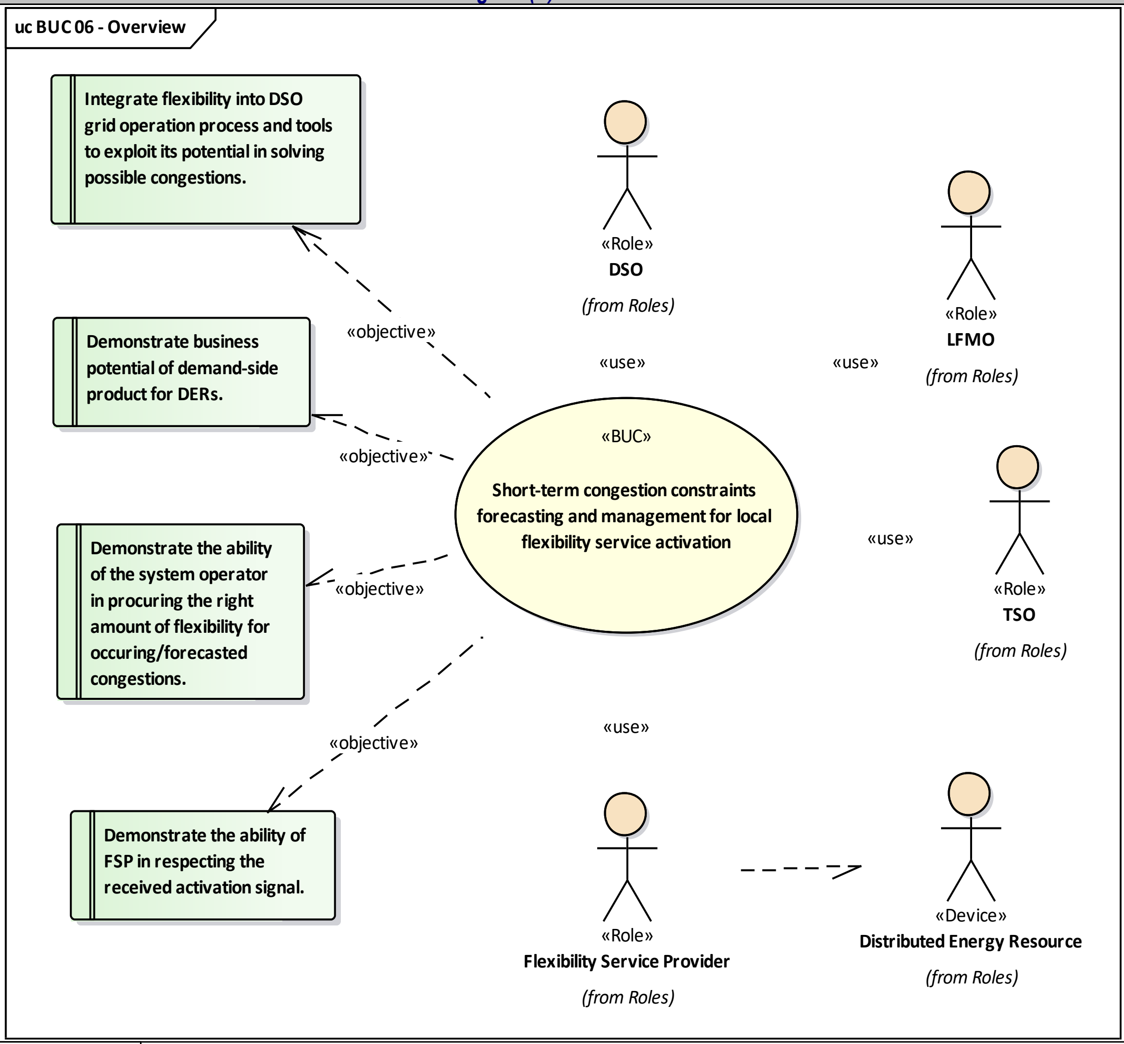
Classification Information
Relation to other use cases
Known relations to system use cases: • SUC06.1 – Short-term flexibility procurement based on congestion forecasting • SUC06.2 – Short-term Flexibility activation for DSO congestion management • SUC06.3 - Settlement of flexibility services from distributed resources participating on local market • SUC 8.1 – Flexibility Register
Level of depth
Business use case (BUC) use case which describes a general requirement, idea or concept independently from a specific technical realization like an architectural solution
Prioritisation
Demos in which the BUC will be implemented: • Italy - Pilot 1.1 ARETI • Spain - I-DE/EDE • Sweden - EON
Generic, regional or national relation
Generic
Nature of the use case
Business use cases
Further keywords for classification
Local market, short-term congestion management, DSO, DER flexibility, FSP, TSO-DSO coordination

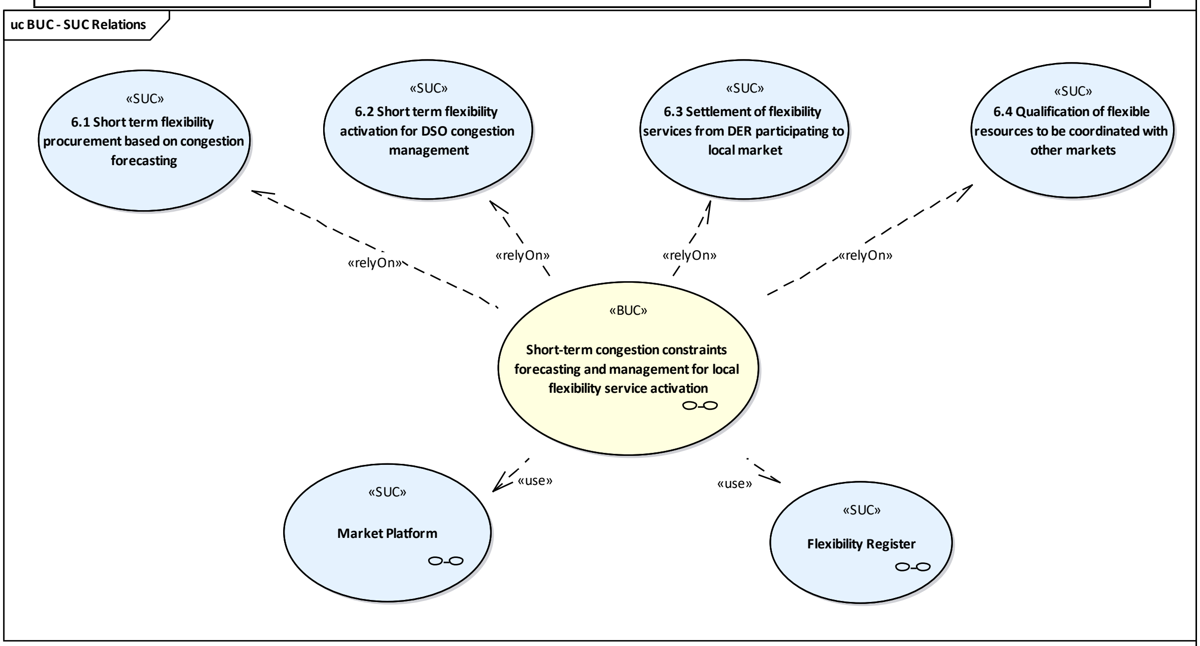
1.8 General Remarks

General Remarks
No further comments which are not considered elsewhere.

2 Diagrams of use case

Diagram(s) of use case





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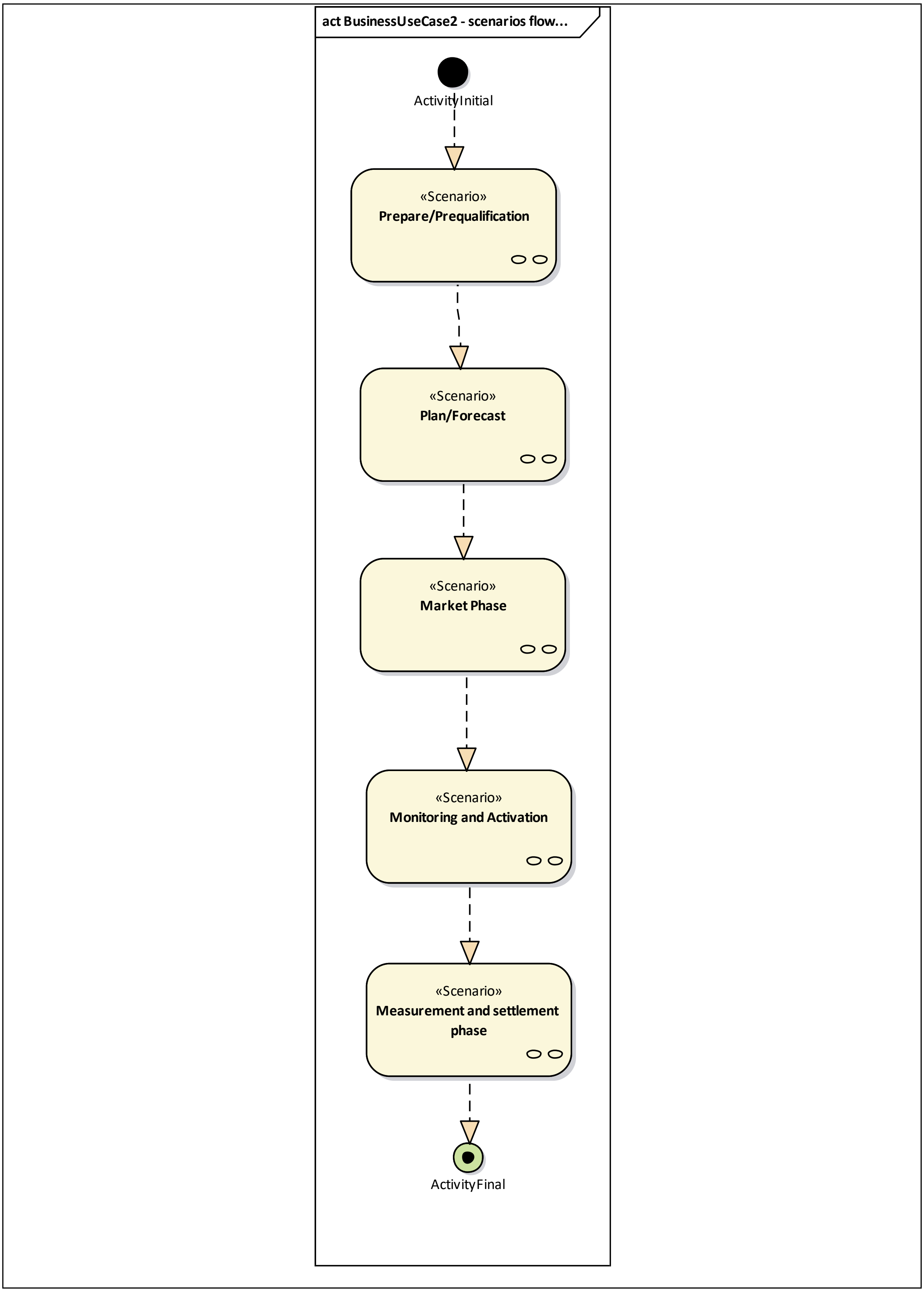

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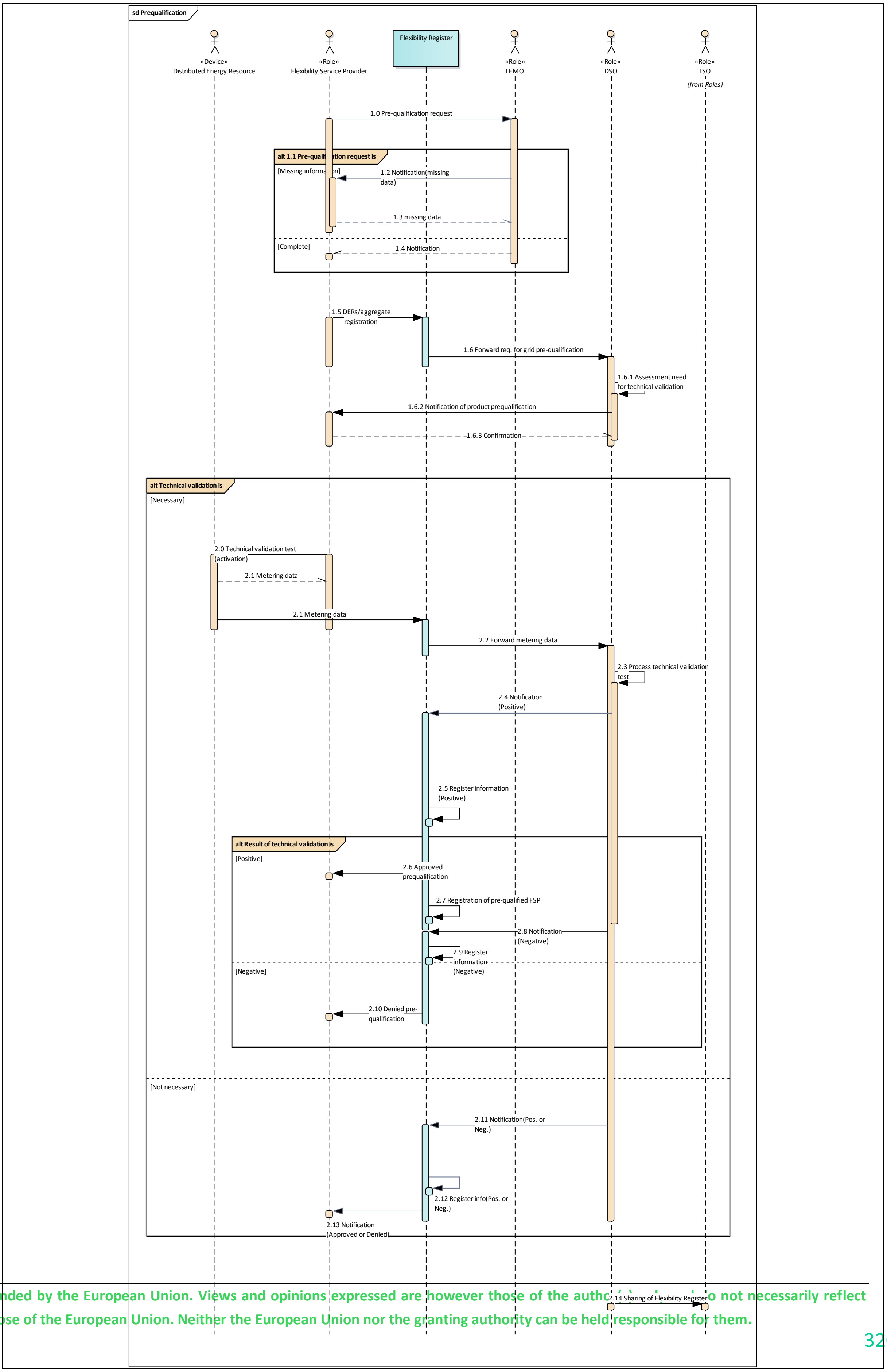

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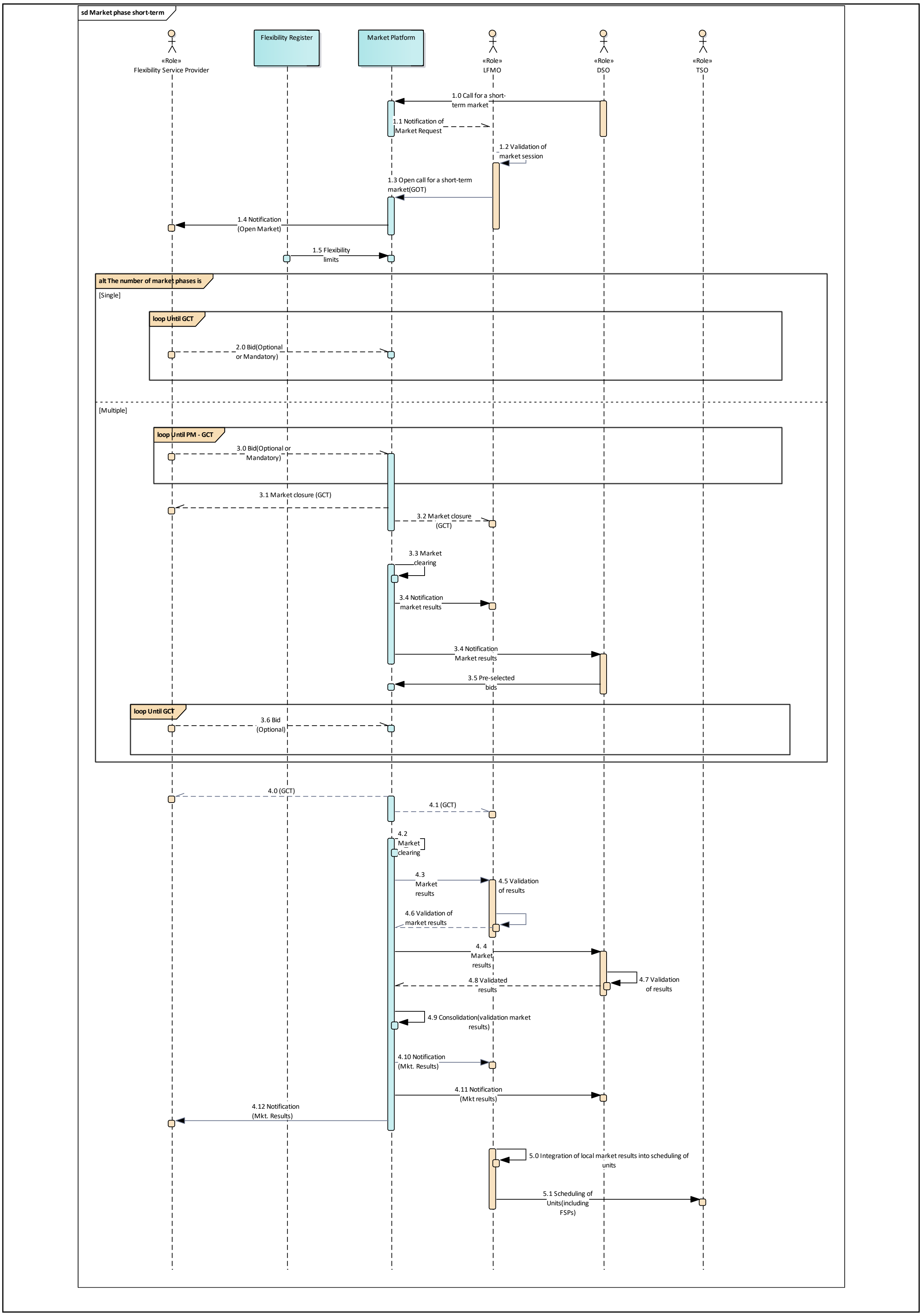

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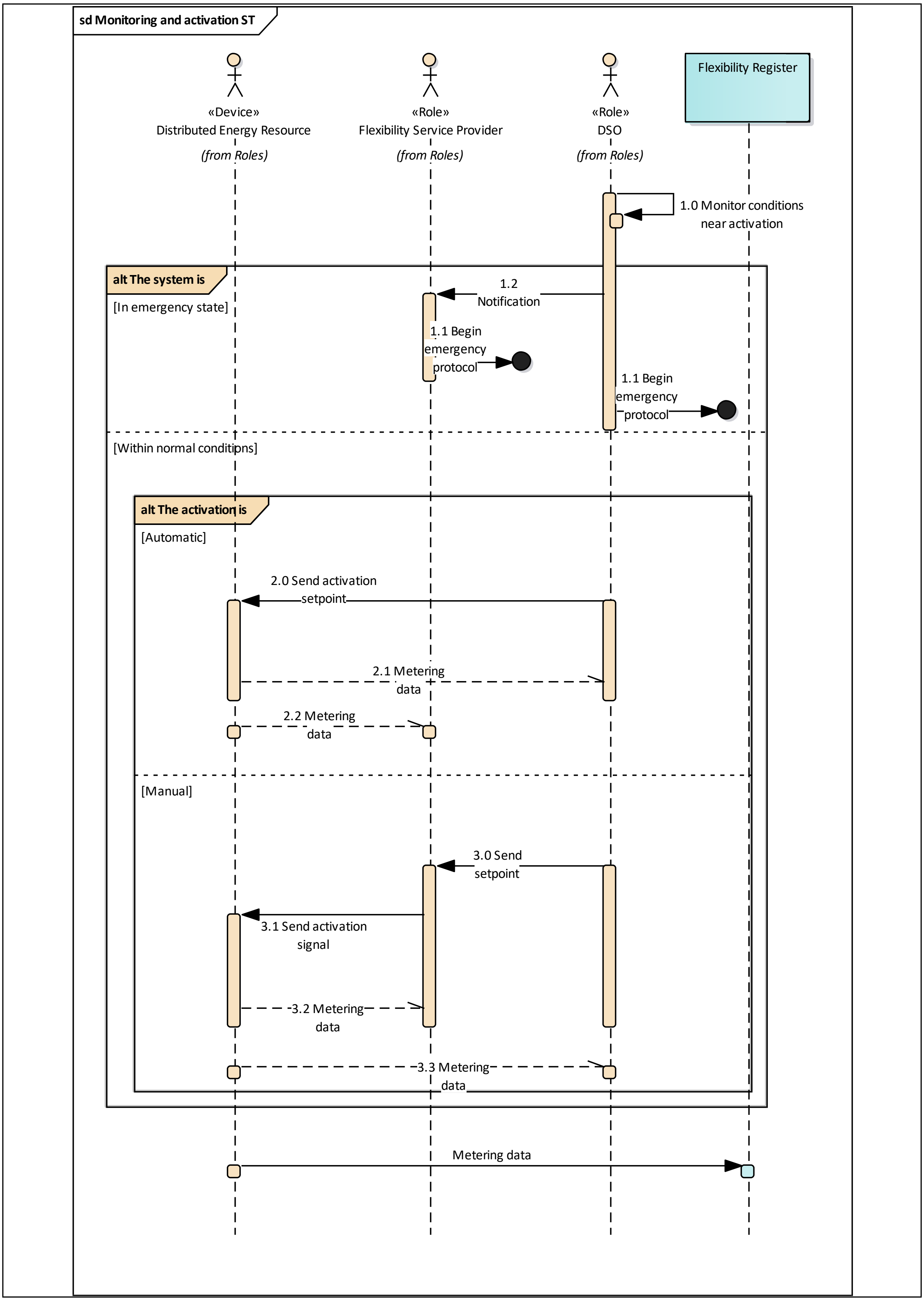

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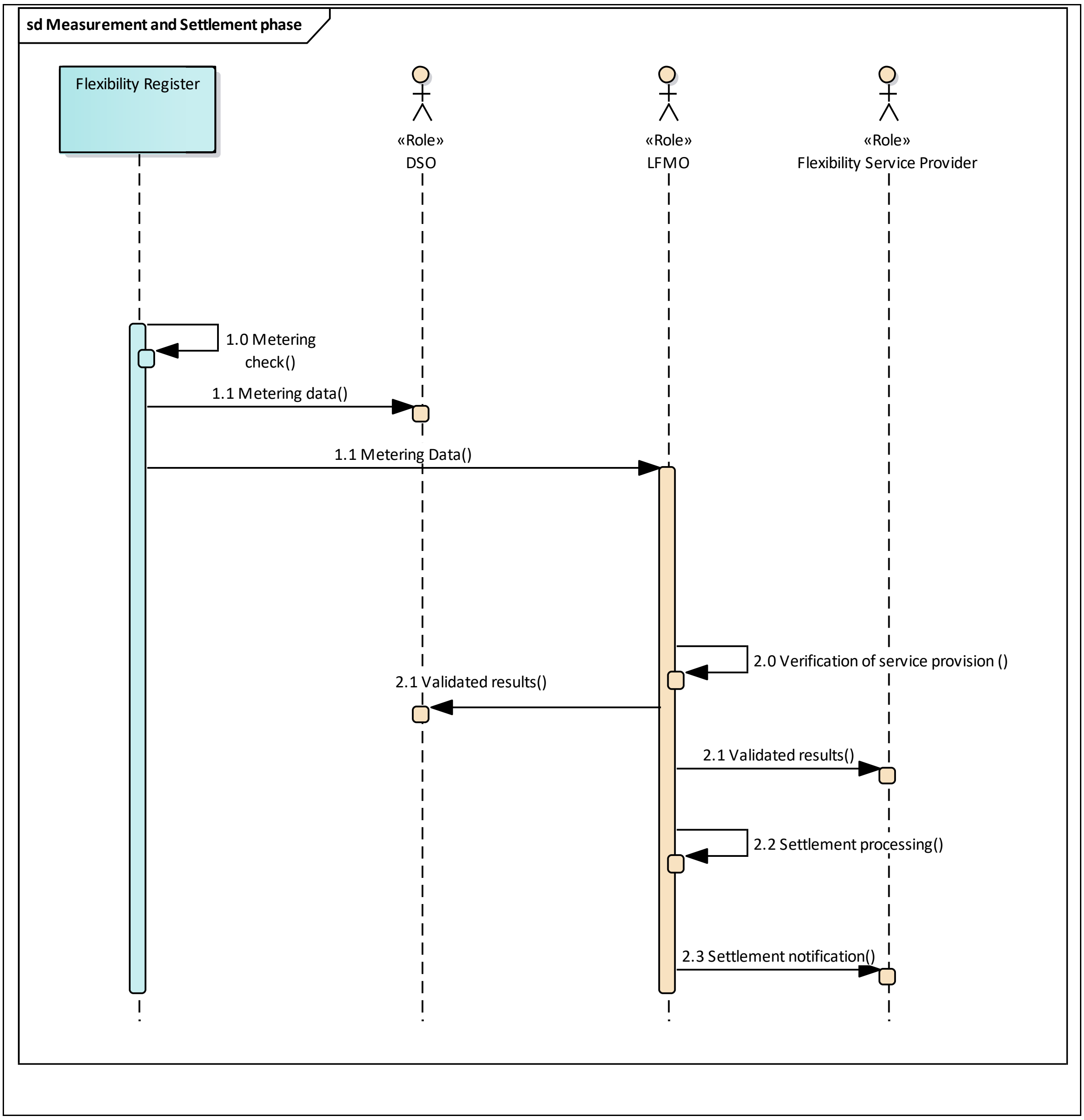

3 Technical details

3.1 Actors

Actors		
Actor Name	***Actor Type***	***Actor Description***
Distribution System Operator (DSO)	Role (HEMRM)	A DSO is a System Operator. DSO is responsible for security of supply and reliability of the distribution grid. For this reason, it monitors the grid in order to identify possible arising issues and, if there is a need, it makes use of resources to solve such problems, by network reconfiguration and/or by requests to market operators or directly to

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		properly contracted customers. In addition to the above and more in detail: • is responsible for the access of the customers to the grid; • operates, maintains, develops and is fully responsible of the part of the electricity system, named "Distribution Network", typically starting from the HV/MV transformers (or vHV/HV transformers depending upon Member State Regulation) down to the customer's POD; • acts on Local Flexibility Market requiring Local Flexibility Services to solve distribution grids issues; • ensures a transparent and non-discriminatory access to the distribution network for each users; • assess network status of the distribution grid and broadcasts selected information of the network status to eligible actors (e.g. aggregators, other system operators); • in critical situations, implements dedicated actions and deliver alerts during stress events If necessary, implement emergency measures including load shedding and DER curtailment; • cooperates with the Transmission System Operator in carrying out their responsibilities (e.g. load shedding).
Transmission System Operator (TSO)	Role (HEMRM)	TSO is a System Operator. TSO is responsible for security of supply and reliability of the transmission grid. It monitors the grid in order to identify possible arising issues and, if there is a need, it solves such problems by means of network reconfiguration and/or by requests to market operators or directly to properly contracted customers. In addition to the above and more in detail: • is responsible for real time physical generation-consumption balance on a geographical perimeter, including ensuring the frequency control service; • operates, maintains, develops and is fully responsible of the part of the electricity system, named "Transmission Network", typically starting from producers connected to the HV grid up to the DSOs' HV/MV transformers (or vHV/HV transformers depending upon the Member State Regulation); • acts on Markets contracting services useful to solve transmission grids issues; • ensures a transparent and non-discriminatory access to the transmission network for each user; • assess network status of the transmission grid and broadcasts selected information of the network status to eligible actors (e.g. aggregators, other system operators); • provides data to the interconnection capacity market operator for the management of cross border transactions;

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		• in critical situations, implements dedicated actions and deliver alerts during stressful events. If necessary, implement emergency measures (e.g. system defence plan) including load shedding; • cooperates with the Distribution System Operators in carrying out their responsibilities (e.g. load shedding).
Local Flexibility Market Operator (LFMO)	Role (HEMRM)	Responsible for the local flexibility market services. Responsible for calling, clearing, communicating results and possibly settling the provision of distributed flexibility. This role can be taken by an Independent Market Operator, an existing one (e.g. a NEMO) or a system operator (e.g. DSO, TSO)
Flexibility Services Provider (FSP)	Role (HEMRM)	A party providing flexibility services to energy stakeholders via bilateral agreements or flexibility markets. An FSP can also be a BSP if enabled to the LFC services. In the Bridge HEMRM, FSP is an extension of FBSP. FSP offer services potentially to all the system operators, directly or through market operators. The role could be taken by many stakeholders, such as an aggregator or individual distributed energy resources.
Distributed Energy Resource (DER)	Device	Resources connected at the distribution grid capable of providing active power flexibility, either upward/downward or both. It can include several different roles and devices such as demand response (actor/role), distributed generation, electric vehicles, and storage systems.

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

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	Prepare / Pre-qualification	The process in which it is checked whether a unit can deliver the	DSO	The DSO and/or the LFMO receives a request from	The DER/Aggregation complies with the prerequisites	The DER/Aggregation is successfully verified and

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		type of resources it intends to sell.		a FSP asking to prequalify DER able to offer short-term local congestion management resources	publicly made available by the DSO/LFMO	tested, receiving the permission to offer the products? (type of resources?) to which the prequalification was aimed at.
2	Plan/Forecast	Planning of grid utilization and identifying potential congestions.	DSO	The distribution system optimizer quantifies the amount of flexibility needed	The DSO identifies a situation in which congestion is expected in the short term.	The DSO computes the amount of flexibility needed for the different types of products in the different timesteps and calls a market.
3	Market phase	Market opening, qualification, bids collection, market clearing and communication of results	LFMO	The DSO calls a market for the procurement of flexibility calculated in scenario 2.	FSPs offer flexibility services by means of pre-qualified DERs/Aggregates.	Markets are cleared and FSPs are nominated to provide the product. Please clarify this section?
4	Monitoring and activation	Grid monitoring and flexibility bids activation to solve the forecasted congestion management	DSO	The real-time for the provision of a service procured in scenario 3 approached.	The FSP and the DSO have the necessary communication infrastructure for the activation order to be sent	The FSP successfully receives the order to provide the flexibility.
5	Metering phase	Validation of service delivery	DSO	The service is being provided in real-time or it has been already provided	Metering data is successfully received by the DSO with the necessary granularity and a baseline method was determined	The DSO compares the metered data with the baseline previously computed or sent by the FSP.

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4.2 Steps – Scenarios

Scenario								
Scenario name :		No. 1 - Prepare/Pre-qualification						
Step No.	Event	Name of process/ activity	Description of process/ activity	Service	Information producer (actor)	Information receiver (actor)	Information Exchanged (IDs)	Requirement, R-IDs
1.0	FSP requests to be pre-qualified	Pre-qualification request	The FSP requests to the LFMO to be prequalified to operate in flexibility markets providing flexibility services	CREATE	FSP	LFMO	I.E.01 I.E.02 I.E.03 I.E.04	
1.1	LFMO processes market pre-qualification	Product pre-qualification	The LFMO processes the market pre-qualification.	EXECUTE	LFMO	LFMO		
1.2	FSP is notified if information provided is incomplete	Notification (missing data)	The LFMO requests missing data	GET	LFMO	FSP	I.E.03 I.E.04	
1.3	FSP reports back missing data	Missing data	The FSP reports back missing data	REPORT	FSP	LFMO	I.E.03 I.E.04	
1.4	LFMO notifies the completion of data collection	Notification (complete)	The notifies the completion on data collection process for the purpose of pre-qualification	CLOSE	LFMO	FSP		
1.5	FSP subscribe DERs to Flexibility Register	DERs/Aggregate registration	The FSP subscribes on the Flexibility Register each DERs with which flexibility services will be provided. Products are indicated in the Flexibility Register.	CREATE	FSP	Flexibility Register		

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1.6	Flexibility Register notifies prequalification request	Forward req. for grid pre-qualification	The product prequalification request for technical validation is forwarded to the DSO. The request is analyzed to understand the impact on the grid of the product to be prequalified.	REPORT	Flexibility Register	DSO	I.E.03 I.E.04	
1.6.1	DSO assess the need for a technical validation	Assessment of need for technical validation	The DSO may decide that spot-checks are necessary to ensure that flexibility can be provided by the applicant FSP. In this step, the DSO assess internally the need for spot-checks .	EXECUTE	DSO	DSO		
1.6.2	DSO communicates the need for a technical validation	Notification of product pre-qualification	If a technical validation is necessary, the FSP is informed about the new requirement, as well as the details for the technical validation.	REPORT	DSO	FSP		
1.6.3	FSP acknowledges the technical validation need	Confirmation	The FSP acknowledges the technical validation need	REPORT	FSP	DSO		
2.0	Technical validation test	Technical validation test (activation)	The FSP activate the DERs to perform the technical validation test at the moment of activation	GET	FSP	DER		
2.1	DER sends metering data	Metering data	The DER sends metering data regarding the technical prequalification directly to the DSO and to FSP.	REPORT	DER	FSP, Flexibility Register		
2.2	Information flow	Forward metering data	Flexibility Register forward the metering data to the DSO	REPORT	Flexibility Register	DSO		

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2.3	DSO processes the results from technical validation	Process technical validation	The DSO internally processes the results of the technical validation test	EXECUTE	DER	DSO; FSP		
2.4	DSO notifies on successful technical validation	Notification (positive)	The DSO notifies the LFMO on the result of the technical validation	REPORT	DSO	DSO	I.E.06	
2.5	The LFMO registers internally the FSP as pre-qualified	Register information (positive)	The LFMO registers internally the FSP as pre-qualified	CREATE	DSO	LFMO		
2.6	The FSP is informed about the successful prequalification	Approved pre-qualification	The FSP is informed about the successful prequalification	GET	Flexibility Register	FSP		
2.7	Resource is registered on Flexibility Register	Registration of pre-qualified FSP	The successful prequalification activate the registration of the resource/aggregate to the Flexibility Register	CREATE	Flexibility Register	Flexibility Register		
2.8	DSO notifies on unsuccessful technical validation	Notification (negative)	The DSO notifies the LFMO on the result of the technical validation	REPORT	DSO	Flexibility Register		
2.9	The LFMO registers internally the FSP as not pre-qualified	Register information (negative)	The LFMO registers internally the FSP as not pre-qualified	CREATE	Flexibility Register	Flexibility Register		

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2.10	The FSP is communicated on the unsuccessful pre-qualification	Denied pre-qualification	The FSP is communicated on the unsuccessful pre-qualification	GET	Flexibility Register	FSP		
2.11	If no technical validation is necessary, DSO informs no technical prequalification result	Notification (positive or negative)	If no technical validation is necessary, DSO informs no technical pre-qualification result	REPORT	Flexibility Register	FSP		
2.12	The LFMO registers internally the result of the prequalification process (positive or negative)	Register information (positive or negative)	The LFMO registers the result of the pre-qualification process (positive or negative). All the resources which succeeded the prequalification process are inserted inside the flexibility register.	CREATE	DSO	Flexibility Register		
2.13	The FSP is communicated on the prequalification result (positive or negative)	Notification (Approved or Denied)	The FSP is communicated on the pre-qualification result (positive or negative)	REPORT	LFMO	LFMO		
2.14	The Flexibility Register is shared	Sharing of flexibility register	The DSO shared the pool flexibility available for service provision	REPORT	DSO	TS		

Scenario	
Scenario name :	***No. 1 - Plan/Forecast***

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Step No.	Event	Name of process/ activity	Description of process/ activity	Service	Information producer (actor)	Information receiver (actor)	Information Exchanged (IDs)	Requirement, R-IDs
1.0	DSO evaluates the short term market need and promotes a product to be used for short term market flexibility	DSO evaluates the need for short-term market flexibility	The DSO evaluates internally the need for a short-term market for flexibility. This step is an internal activity exclusive to the DSO, and therefore no information exchanges with other actors . Therefore, the internal steps carried out by the DSO are not modelled in detail.	EXECUTE	DSO	DSO		

Scenario								
Scenario name :	No. 1 - Market phase							
Step No.	Event	Name of process/ activity	Description of process/ activity	Service	Information producer (actor)	Information receiver (actor)	Information Exchanged (IDs)	Requirement, R-IDs
1.0	DSO requests a short-term market	Call for a short -term market	DSO requests a short-term market based on the results of scenario 2 (plan and forecast). At this request, several parameters will have to be informed by the DSO. These parameters are grouped into (i) generic attributes and (ii) product parameters and they determine the requirements and characteristics of prequalified DER which is able to provide a specific service.	CREATE	DSO	Market Platform	I.E.07 (generic attributes) I.E.08 (product parameters)	

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1.1	Notification of market request	Notification of market request	The LFMO is notified that a market request was created by the DSO	REPORT	Market platform	LFMO		
1.2	LFMO validates and prepares a market session	Preparation of market session	The LFMO validates the information provided by the DSO (IE07 and IE08). Intermediated steps in which the LFMO may identify missing information, request completion from the DSO, and final completion by the DSO are omitted for the sake of simplicity.	EXECUTE	LFMO	LFMO		
1.3	LFMO opens call for a short -term market	Open call for a short -term market	The LFMO, after validating the market session, opens the market session in the Market Platform	EXECUTE	LFMO	Market Platform		
1.4	FSPs are notified of a market opening	Notification (Open Market)	The Market Platform notifies the FSP about a market opening.	REPORT	Market Platform	FSP	I.E.08 (not all parameters)	
1.5	Flexibility Register forward flexibility limits	Flexibility limits	The Flexibility Register informs the Market platform concerning the flexibility limits of the different resources/aggregate	REPORT	Flexibility Register	Market Platform		
2.0	If the market phase is characterized by a single market, the FSP bids to market session	Bid	Qualified FSPs may bid to the market session as long as market session is open (before the Gate Close Time [GCT])	CREATE	FSP	Market Platform	I.E.11	
3.0	If the market phase is characterized by a	Bid	Qualified FSPs may bid to the preliminary market session as long as market session is open (before the	CREATE	FSP	Market Platform	IE 11	

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	multiple number of markets, the FSP bids to Preliminary market session		Preliminary Market Gate Closer Time [PM-GCT])					
3.1; 3.2	Market platform notified the GCT	Market closure (GCT)	Market Platform notified the PM-GCT	REPORT	Market Platform	FSP; LFMO		
3.3	Market Platform clears the market	Market clearing	Market Platform reports the market results and so the pre-selected bid	EXECUT E	Market Platform	Market Platform		
3.4	Market Platform notifies the Market results to the DSO	Notification market results	Market results are notified to the DSO and LFMO	REPORT	Market Platform	DSO; LFMO	IE 12	
3.5	The pre-selected bids are collected in the market platform	Pre-selected bids	The Market platform considers the pre-selected bid for the following market sessions	REPORT	DSO	Market Platform		
3.6	The FSP bids in the market session	Bid	The FSP bid in the last market session	CREATE	FSP	Market Platform	IE 11	
4.0; 4.1	Market platform notifies the GCT	Market closure (GCT)	Market platform notifies the GCT	REPORT	Market Platform	FSP; LFMO		
4.2	Market Platform clears the market	Market clearing	Market Platform clears the market taking into account DSO specific needs	EXECUT E	Market Platform	Market Platform		

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4.3; 4.4	Market Platform reports market results	Market results	Market Platform reports market results	REPORT	Market Platform	LFMO; DSO		
4.5	LFMO validates the market results	Validation of results	The LFMO checks the market results for inconsistences. After that, results are validated	EXECUTE	LFMO	LFMO		
4.6	LFMO registers the validated market results	Validated market results	LFMO registers the validated market results	REPORT	LFMO	Market platform	I.E.12 (market)	
4.7	DSO validates the market results		The DSO checks the market results for inconsistences (from a technical perspective)	EXECUTE	DSO	DSO	I.E.12 (technical)	
4.8	DSO registers the validated market results	Validated market results	DSO registers the validated market results	REPORT	DSO	Market platform	I.E.12 (technical)	
4.9	The Market Platform consolidates the market results	Consolidation (market results)	The Market Platform consolidates the market results based on the validation by the LFMO and the DSO	CREATE	Market Platform	Market Platform	I.E.12 (consolidated)	
4.10; 4.11; 4.12	Market participants and LFMO are informed of final market results	Notification (market results)	Market participants (DSO, FSPs) and LFMO are informed of final market results	REPORT	Market Platform	DSO; FSP; LFMO	I.E.12 (consolidated)	
5.0	The LFMO integrates the market	Integration of local market results into	The LFMO integrates the market results in the short	CREATE	LFMO	LFMO		

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	results in the short term with all other market results	scheduling of units	term with all other market results					
5.1	The LFMO reports the scheduling of units, including the results of local flexibility markets, to the TSO	Scheduling of Units	The LFMO reports the scheduling of units, including the results of local flexibility markets, to the TSO	REPORT	LFMO	TSO	I.E.13	

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Scenario								
Scenario name :		***No. 1 - Monitoring and 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***
1.0	The DSO monitors the state of the grid near real-time (activation)	Monitoring conditions near activation	The DSO monitor the state of the grid near activation in order to ensure the security of the grid	EXECUTE	DSO	DSO		
1.1	If the grid is an emergency state, the DSO starts the emergency protocol, and the BUC is terminated	Beginning emergency state	If the grid is an emergency state, the DSO starts the emergency protocol and the BUC is terminated, as this situation lays outside the scope of this BUC.	EXECUTE; CLOSE	DSO	DSO		
1.2	If the grid is an emergency state, the DSO notifies the FSP to proceed according to the emergency protocol (outside the scope of the BUC)	Notification	If the grid is an emergency state, the DSO notifies the FSP to proceed according to the emergency protocol (outside the scope of the BUC). For example, the FSP may be requested to proceed on a previously agreed way, may be exempted from providing flexibility, or may not be notified at all. This situation is outside the scope of this BUC.	REPORT	DSO	FSP		

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2.0	If the state is within normal conditions and the activation type is automatic, the DSO sends the setpoint directly to the DER	Send activation setpoint	If the state is within normal conditions and the activation type is automatic, the DSO sends the setpoint directly to the DER	REPORT; EXECUTE	DSO	DER		
2.1 2.2	DER reports metering data	Metering data	DER reports metering data directly to the DSO	REPORT	DER	DSO	I.E.06	
3.0	If the state is within normal condition s and the activation type is manual, the DSO sends the setpoint to the FSP	Activation setpoint	If the state is within normal conditions and the activation type is manual, the DSO sends the setpoint to the FSP	REPORT	DSO	FSP		
3.1	The FSP proceeds with the activation in real-time according to the market results.	Activation	If the state is within normal conditions, the FSP proceeds with the activation in real-time according to the market results.	EXECUTE	FSP	DER		
3.2 3.3	DER reports metering data	Metering data	DER reports metering data directly to the DSO and to FSP	REPORT	DER	DSO; FSP	I.E.06	

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3.4	DER reports metering data	Metering data	DER reports metering data directly to Flexibility Register	REPOR T	DER	Flexibility Register	I.E.06	

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Scenario								
Scenario name :		No. 1 - Measurement phase Metering phase						
Step No.	Event	Name of process/ activity	Description of process/ activity	Service	Information producer (actor)	Information receiver (actor)	Information Exchanged (IDs)	Requirement, R-IDs
1.0	Check reliability of metering data	Flexibility Register	GFlexibility Register verifies that metering data are coherent with technical data	EXECUTE	Flexibility Register	Flexibility Register		
1.1	DSO receives metering data	Metering data	DSO/LFMO receives metering data (step 3.1 of scenario 4)	GET	DER	DSO,LFMO	I.E.06	
2.0	The LFMO validates the service provision	Verification of service provision	The LFMO validates the service provision. To do so, the LFMO compares the metered data with the service procured and the baseline predefined.	EXECUTE	LFMO	LFMO		
2.1	Results are communicated to stakeholders	Validated Results	Results of the validation are communicated to stakeholders.	REPORT	LFMO	DSO,FSP		
2.2	LFMO proceeds with the settlement processing	Settlement processing	The LFMO proceeds with the settlement processing. According to the level of service provision, penalties (reduction of agreed price/payment) may occur.	EXECUTE	LFSMO	LFSMO		
2.3	The FSP is notified on the final settlement	Settlement notification	The FSP is notified on the final settlement	REPORT	LFSMO	FSP		

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5 Information exchanged

Information exchanged			
Information exchanged (ID)	***Name of information***	***Description of information exchanged***	***Requirement, R-IDs***
I.E.01	Basic Participant Information	Register and basic information about the market participant such as username and password	
I.E.02	Market participant prequalification information	Contact information; Fiscal data; Access contract; bank details; power of representation; confidentiality agreement; declaration of non-collusion	
I.E.03	Market resource pre-qualification information	Market participants provide information on the resources they want to prequalify: Facility/resource name; Type of technology; Location; Market participant; etc.	
I.E.04	Technical resource pre-qualification information	Verification of the installed capacity to provide the service: Power; Maximum quantity; Response time, etc.	
I.E.05	Technical validation for pre-qualification	In case of the need of a technical validation for prequalification, the FSP receives the information on the when and how the test will be conducted: day; time; power to reduce/increase; duration of the test; etc.	
I.E.06	Metering data	Metering data from DER	
I.E.07	Generic attributes	Composed of generic parameters concerning the market session being requested. E.g.: • Auction identifier • Associated DSO • Product Type: Flexibility Product • Type of negotiation: Auction • Area: Basic or aggregated.	
I.E.08	Product parameters	Composed of product parameters concerning the market session being requested. E.g.: • Service window: Selection of the required date and duration of the service • Availability: Selection of the capacity, the direction, and the estimated hours of activation. • Activation window (in case of activation product): Specific subperiod in an activation window when a particular DER could be activated and thus it must be available. Multiple sets of activation windows can be defined. • Local area: Selection of the trading area. Choice by postal code, connection point, lines… (to be determined). • Activation Announcement: Time in advance that a DSO informs a	

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		DER that its activation is programmed confirmed. • Form of Remuneration: It establishes form of payment to winner DERs Two different terms are defined availability and activation (depending on the product).	
I.E.09	List of pre-qualified units	List of pre-qualified units for a given market. List of a portfolio with assets registered for a specific market session.	
I.E.10	List of qualified units (market, technical or consolidated)	List of qualified units for a given market session. The list can refer to the market qualification, technical qualification or the consolidated list.	
I.E.11	Bid	Composed of bidding information • General attributes (FSP identifier) • Availability: Selection of the capacity, the direction and the estimated hours of activation (period of availability and price).	
I.E.12	Validate market results	Validated market results by either the LFMO (market), the DSO (technical) or the consolidated market results.	
I.E.13	Scheduling of FSPs	Scheduling of FSPs	

4 Requirements

Requirements		
Categories ID	**Category name for requirements**	**Category description**
GDPR	Regulatory obligation related to privacy	2016/679 (General Data Protection Regulation)
Requirement R-ID	**Requirement name**	**Requirement description**
GDPR-1	Data processing consent	Personal data may not be processed unless there is at least one legal basis to do so.
GDPR-2	Data retention policy	Data retention policy outlines the time period specific sensitive data can be retained, plus how it will be disposed of when the time to do so comes.
GDPR-3	Right to access, rectify, erasure, restriction	The data subject shall have the right to obtain from the controller without undue delay the access/rectification/erasure/restriction of inaccurate personal data concerning him or her.
GDPR-4	Data transfer consent	Personal data may not be transferred to a third-party if the data subject did not agree and the third party provide appropriate safeguard.
GDPR-X	All GDPR constraints also apply to this BUC.	e.g., proportional measures of protection, communication of data breach, among others
Categories ID	**Category name for requirements**	**Category description**

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LAB-REG	Regulatory obligation related to labor law	National labour law regulates the scheme related to benefit in kind such as cars or energy, but also protect the fairness in employee management.
Requirement R-ID	**Requirement name**	**Requirement description**
LAB-REG1	Energy price and benefit in kind	As of today, there is no clear regulation with respect to the reimbursement of energy at home especially in the case of local production (usually the price is based on the energy contract) soon we may expect more regulation and the duty to reintegrate it as benefit in kind (after end 2024).
LAB-REG2	Employee fairness	All employees should be equally treated, in this respect we may be careful that the charge prioritization does not discriminate certain population especially if their usage pattern is bound to extra-work constraints (e.g., parents with young children, people with disabilities)
Categories ID	**Category name for requirements**	**Category description**
FLEX-VOL	Free will to participate to flexibility	The participation to flexibility program, especially at home, should be done in a voluntary basis.
Requirement R-ID	**Requirement name**	**Requirement description**
FLEX-VOL1	Opt in	The employee should opt in to participate to the flexibility program.
FLEX-VOL2	Reasonable penalties	The penalties for opting out should not exceed the extra cost generated to the company (e.g., energy price, carbon footprint, usage of EVSE).

Requirements		
Categories ID	**Category name for requirements**	**Category description**
RCR	Regulatory changes/needs related to DSO remuneration and network development plans Baseline regulation to be developed	European Electricity Market Directive 944/2019 Draft Proposal for Network Code on Demand Response
AM	Regulation for flexibility provision mechanism to be developed	Draft Proposal for Network Code on Demand Response
Requirement R-ID	**Requirement name**	**Requirement description**
RCR-1	Analysis of incentives in DSO remuneration schemes	Regarding operational expenditures, most of the countries studied in deliverable D1.1 establish an ex-ante allowance for operational expenditures with an incentive rate. This type of regulatory framework incentivizes DSO to reduce OPEX. If the regulatory framework does not incentivize the DSO to reduce OPEX, the objectives of this BUC may not be

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		aligned with current regulation introducing distorting incentives that may not lead to overall cost-efficiency in short-term congestion management.
RCR-2	Definition of baseline methodology	This BUC requires that DSO and FSPs agree on a defined baseline power profile. The definition of national methodologies needs to be defined as stated in the Draft Proposal for Network Code on Demand Response.
AM-1	Regulation for local flexibility markets need to be implemented in Spain and Italy	The BUC considers the integration of flexibility can effectively exploit its potential in addressing potential congestion issues, using market-based mechanism like flexibility markets. Availability or activation products can be procured.
AM-2	Coherency with other electricity markets.	Local market timing has to be coordinated with the existing electricity markets to foster the efficient allocation of resources, avoid distortions, and prevent gaming. Possible unbalances should be adequately considered to avoid system level impacts.

5 Common Terms and Definitions

Common Terms and Definitions	
Term	**Definition**
BSP	Balance Service Provider
BUC	Business Use Case
D-1	Day Ahead
DER	Distribution Energy Resource
DSO	Distribution System Operator
FSP	Flexibility Service Provider
GDPR	General Data Protection Regulation
GCT	Gate Closure Time
HEMRM	Harmonized Electricity Market Role Model
HV	High Voltage
LFC	Load Frequency Control
LFMO	Local Flexibility Market Operator
MV	Medium Voltage
M-1	Month Ahead
POD	Point Of Delivery
SO	System Operator
TSO	Transmission System Operator
vHV	Very High Voltage

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11.7. BUC07 – Short-term congestion constraints forecasting and management for local flexibility service activation

1 Description of the use case

1.1 Name of the use case

ID	Area / Domain(s)	Name of Use Case
BUC07	Grid-centric flexibility	Short-term voltage constraints forecasting and management for local flexibility service activation

1.2 Version management

Version Management			
Version No.	Date	Name of Author(s)	Changes
0.1	02.05.2023	Edoardo De Din	First draft version

1.3 Scope and objectives of use case

Scope and Objectives of Use Case	
Scope	Short-term voltage constraint forecasting and management in the distribution grid.
Objective(s)	Compensate for local voltage violations using the available flexibility from the resources installed in the grid.
Related business case(s)	BUC06 and BUC08 consider the short management of the distribution grid, therefore, timescales and objectives are very similar. SUC06.1 and SUC08.1 both consider the flexibility procurement and SUC06.3 and SUC08.2 both consider the settlement of flexibility. SUC06.4 and SOC08.3 represent the same system use case.

1.4 Narrative of use case

Narrative of Use Case
Short description
The short-term voltage constraints forecasting and management can be used by the DSO to compensate for local voltage violations using the available resources installed in the grid. The main actors involved are the DSO and the Market. The problem to be solved is local, meaning that the resources installed in the vicinity of the voltage would have a higher impact in solving the voltage violations. The result of the control algorithm is formulated as flexibility demand for the Market, which then interacts with the Flexibility Service providers. The short-term control is performed on a day-ahead basis considering the predicted voltage violations. The resulting activation signal is sent on the same day using the latest information and eventually modified based on the updated forecasts and grid conditions. Monitoring devices installed in the electrical grid are required to enhance the grid observability, together with the knowledge of the electrical grid model. The BUC includes the following steps. 1. Prepare/Pre-qualification 1.1 Grid pre-qualification 1.2 Product pre-qualification 2. Plan/Forecast

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3. Market Phase 4. Monitoring and Activation 5. Measurement phase
Complete description
The BUC will analyse the short-term voltage constraints forecasting and management, using local flexibility activated by the DSO. The document describes the relationships and the exchanges between the different actors (DSO, MO, FSP) involved in the solution of voltage issues in the distribution grid. Although congestion and voltage management can be considered complementary for many distribution grid topology and conditions, there might be situations, particularly for long feeders located in rural areas, where voltage problems appear to be more relevant. When considering the hosting capacity (HC), which describes the maximum Distributed Energy Resources (DER)s penetration for which the power system operates satisfactorily, voltage and thermal limits can be encountered. Simulations have demonstrated that long feeders can reach the voltage limits when the loading is well below the 100% loading limit, due to the fact that voltage increase or decrease along the feeder proportionally with the values of the line impedances. Moreover, DSO can make use of additional assets to perform the control the voltage within the operational limits. The use of assets' flexibility, however, contributes positively in keeping the voltage within the limits, particularly by reducing the injection or absorption of reactive power into the grid, resulting in a better outcome for primarily resistive networks. The coordination of flexibility procurement for voltage and congestion management results in an optimal grid operation, while engaging the market and the Flexibility Service Provider (FSP) in the support of the grid. For this reason, some of the scenarios and related SUC are in common with the BUC06, which considers the flexibility for the congestion management. As for BUC06, the short-term management of the voltage constraints and the interaction with the market is performed in two timeframes, the day-ahead and the intraday. The DSO will obtain flexibility that may be used once or more throughout the duration of the contract. The item will be designated as an energy item. The DSO obtains flexibility in this product with the help of predetermined activation features (such as activation time, length, ramping intervals, etc.). The procurement and successively the activation of the flexibility is based on the forecasting of possible voltage violations on a day-ahead basis. In the day-ahead and intra-day markets the DSO procures and activates the flexibility interacting with the FSP. During the activation of the flexibility the DSO monitors the grid to and applies the signals. In case of activation of flexibility, the FSP receives remuneration proportional to the utilization time. In case the FSP is not able to provide the flexibility as by contract, a penalty may apply. **1. Prepare/Pre-qualification:** 1. After a flexibility service provider (FSP) indicates interest in entering the flexibility market, the pre-qualification procedure should be performed. This procedure aims to confirm that a specific flexibility service provider is qualified to supply a specific good. Both the grid pre-qualification and the product pre-qualification must be considered in order to guarantee this. **1.1 Grid pre-qualification** 2. It makes sure that the resource has the technical requirements needed to provide the product, move on to the marketing phase, and potentially be chosen by a system operator. As the FSP in this BUC are connected to MV and LV grids, the DSO will do the grid pre-qualification. The goal of the grid pre-qualification is to make sure the network can handle the flexibility offered by a specific FSP. Both internal simulations by the DSO and/or particular field tests with the FSP may be used for the grid pre-qualification. **1.2 Product pre-qualification** 3. The market or product pre-qualification, performed by the LFMO, aims at ensuring that the FSP can participate in a particular market. The FSP may enter the flexibility market if the outcomes of the two pre-qualification methods are accepted. The pre-qualification's validity may be limitless, time-limited, or subject to particular criteria (such as grid conditions). **2. Plan/Forecast:** The DSO performs simulation analysis based on forecasted data to detect possible voltage constraints violations in the grid that could be solved using local flexibility. This service could be applied in the day-ahead or intra-day.

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System Use Case called by the step
SUC06.1 – Short-term flexibility procurement based on congestion and voltage constraints forecasting

3. Market Phase:
Based on the need for flexibility determined during the operational planning stage, the DSO can call the market via the auction/market platform. This market either sources availability, or availability and activation.
Availability refers to a capacity band (product in kW) with defined start and end times, and the FSP should provide flexibility as required by the DSO. Activations are predefined in terms of days, hours, capacities, and activation periods (products are defined in kWh). The day-ahead market is open to sourcing availability and activations, while the intraday market is used to procure activations.

SUC08.3 – Settlement of flexibility services from DER participating to local market

System Use Case called by the step
SUC06.3 – Settlement of flexibility services from DER participating to local market

4. Monitoring and Activation:
The DSO monitors in real-time the status of the grid combining measurement devices with the result of the state estimation. The DSO send the activation signal to the FSP in accordance to the auction performed in the market phase.

System Use Case called by the step
SUC06.2 – Short term flexibility activation for DSO congestion and voltage constraints management

System Use Case called by the step
SUC07.1 – Online monitoring and observability enhancement to quantify the actual voltage condition

5. Measurement phase:
In this last service phase, the MO and/or the DSO check whether flexibility has been achieved with respect to the product delivered in the market phase. This service phase can be in real time and/or in post-real time. For the resilience measurement, a baseline must be defined beforehand, with which the actual measurement data of the FSP can be compared. If the FSP is unable to provide flexibility under the predefined market conditions and agreed basis, penalties may be imposed to reduce the fees charged to the FSP.

1.5 Key performance indicators (KPI)

ID	Name	Description	Reference to mentioned use case objectives
1	*Voltage violations forecasting accuracy*	Degree of accuracy (Mean Absolute error) in predicting the voltage violations.	Demonstrates the ability of the forecasting methods to identify possibile grid issues in advance.
2	*State estimation accuracy*	Degree of accuracy (Mean Absolute Error) in estimating voltage values in the grid based on a limited number of measuring points.	Demonstrates the ability of the state estimation to provide accurate values of voltage of the grid nodes.

1.6 Use case conditions

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Use case conditions
Assumptions
In the BUC it is assumed that • Flexibility is a cost-effective solution (with respect to network reinforcement), at least in the short-term. • There are no market liquidity problems. • FSP has only a flexibility provision contract with the DSO within the timeframe requested. • DSO is remunerated for the procurement of flexibility services.
Prerequisites
• DSO owns a grid state estimation tool. • Voltage constraints forecast is performed before the market phase

1.7 Further Information to the use case for classification / mapping

Classification Information
Relation to other use cases
BeFlexible project: BUC06 Short-term congestion constraints forecasting and management for local flexibility service activation Bridge use cases: UC-IT-1 Voltage Management
Level of depth
Business use case (BUC) use case which describes a general requirement, idea or concept independently from a specific technical realization like an architectural solution
Prioritisation
To be demonstrated in Italy (pilots 1.1)
Generic, regional or national relation
Generic
Nature of the use case
Business Use Case
Further keywords for classification
Voltage Control, grid constraints, distributed energy resources, flexibility service providers, aggregators, short-term, flexibility, distribution system operator. observability

1.8 General Remarks

General Remarks

2 Diagrams of use case

Diagram(s) of use case

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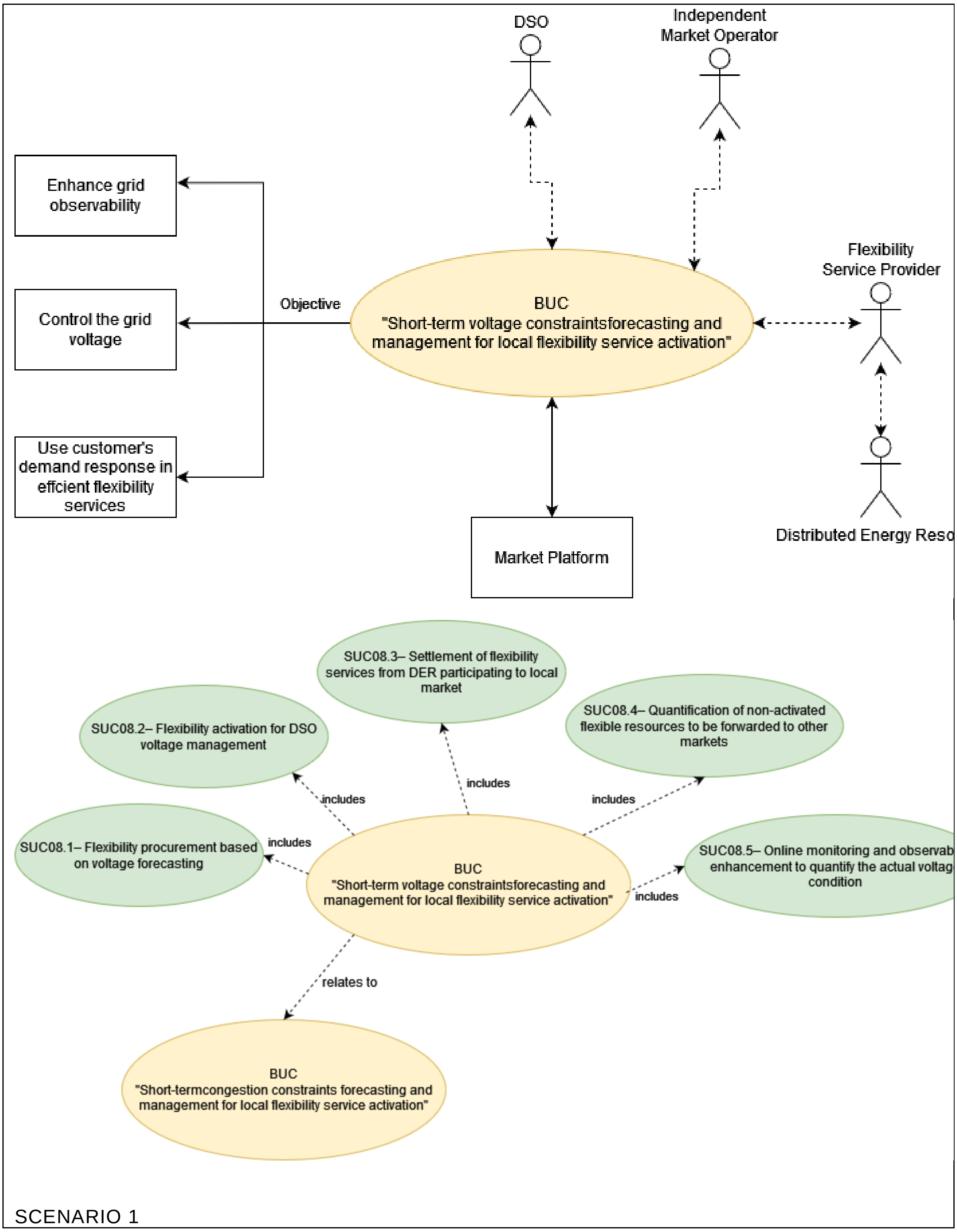
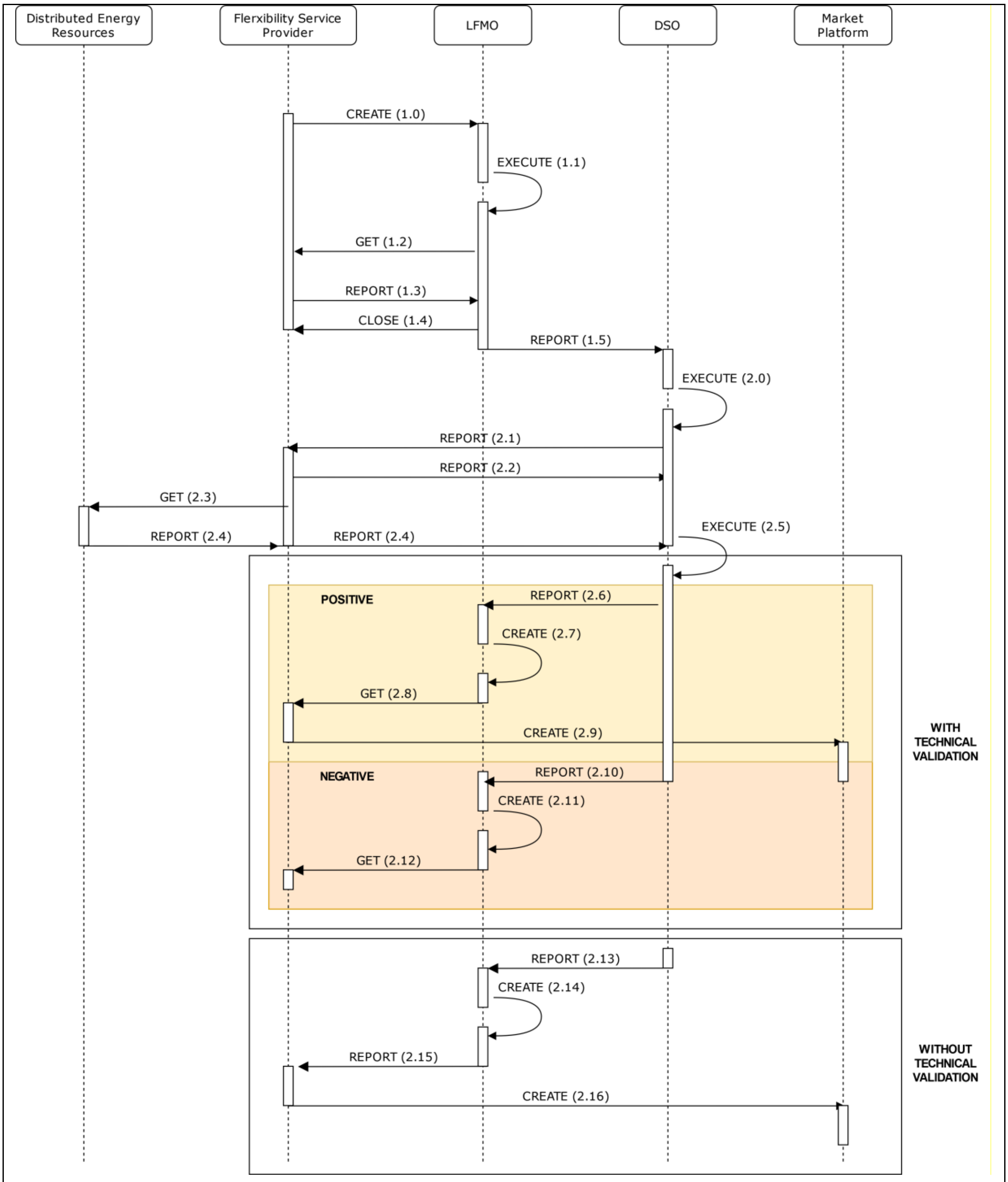
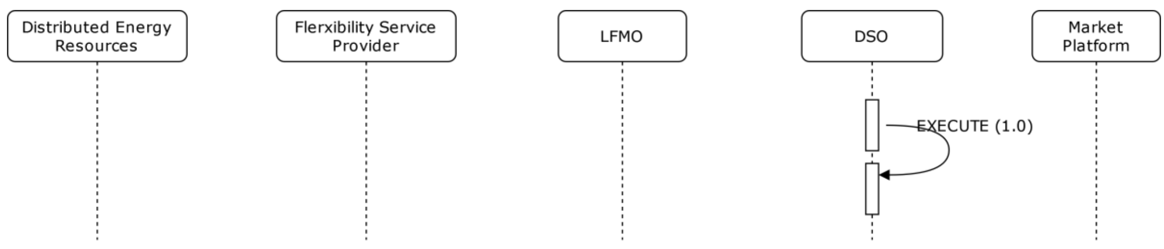

DSO
Independent Market Operator
Enhance grid observability
Control the grid voltage
Use customer's demand response in effcient flexibility services
Objective
BUC
"Short-term voltage constraintsforecasting and management for local flexibility service activation"
Flexibility Service Provider
Distributed Energy Reso
Market Platform
SUC08.3– Settlement of flexibility services from DER participating to local market
SUC08.2– Flexibility activation for DSO voltage management
SUC08.4– Quantification of non-activated flexible resources to be forwarded to other markets
SUC08.1– Flexibility procurement based on voltage forecasting
SUC08.5– Online monitoring and observab enhancement to quantify the actual voltag condition
includes
relates to
BUC
"Short-termcongestion constraints forecasting and management for local flexibility service activation"
SCENARIO 1



SCENARIO 2



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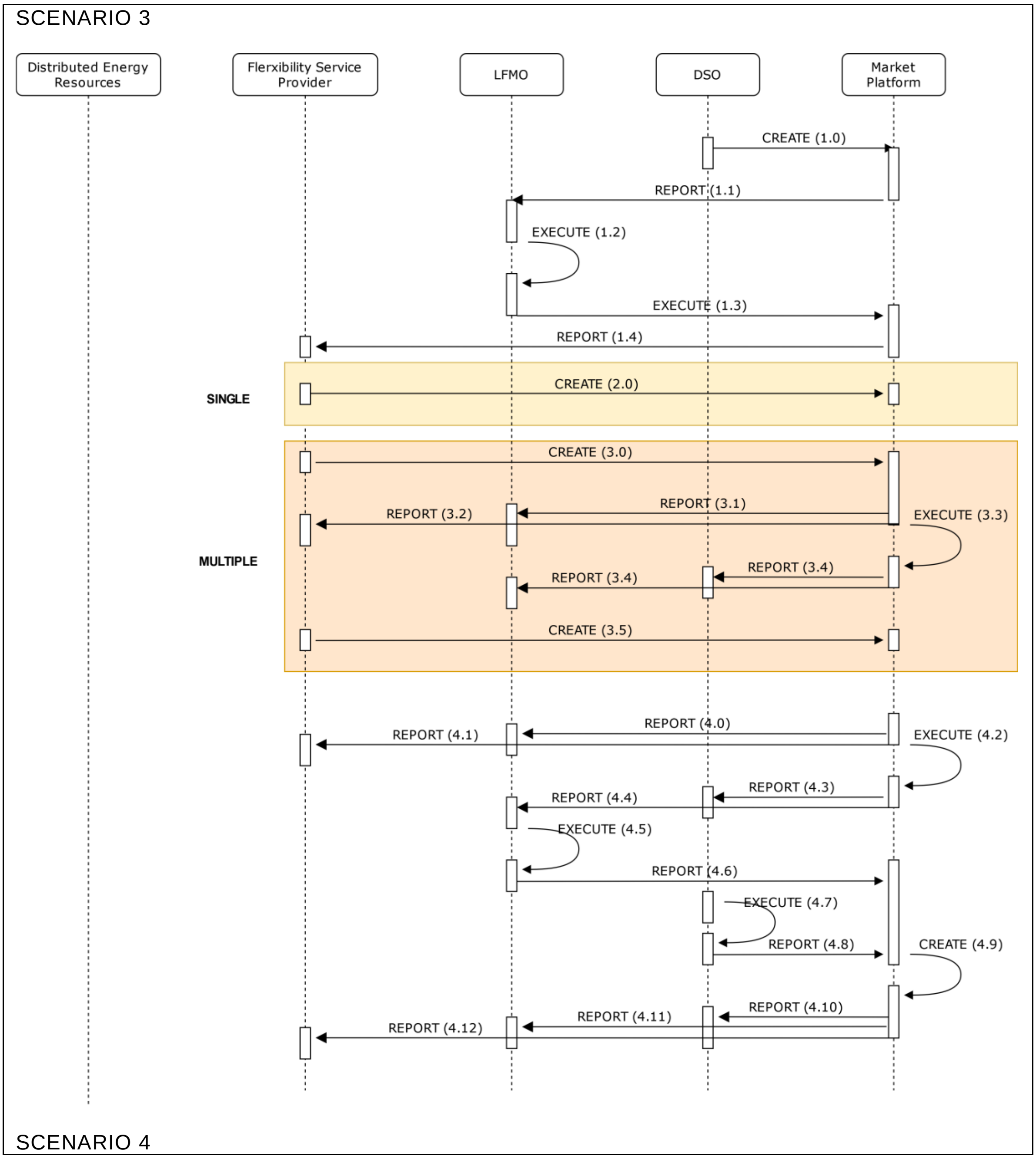

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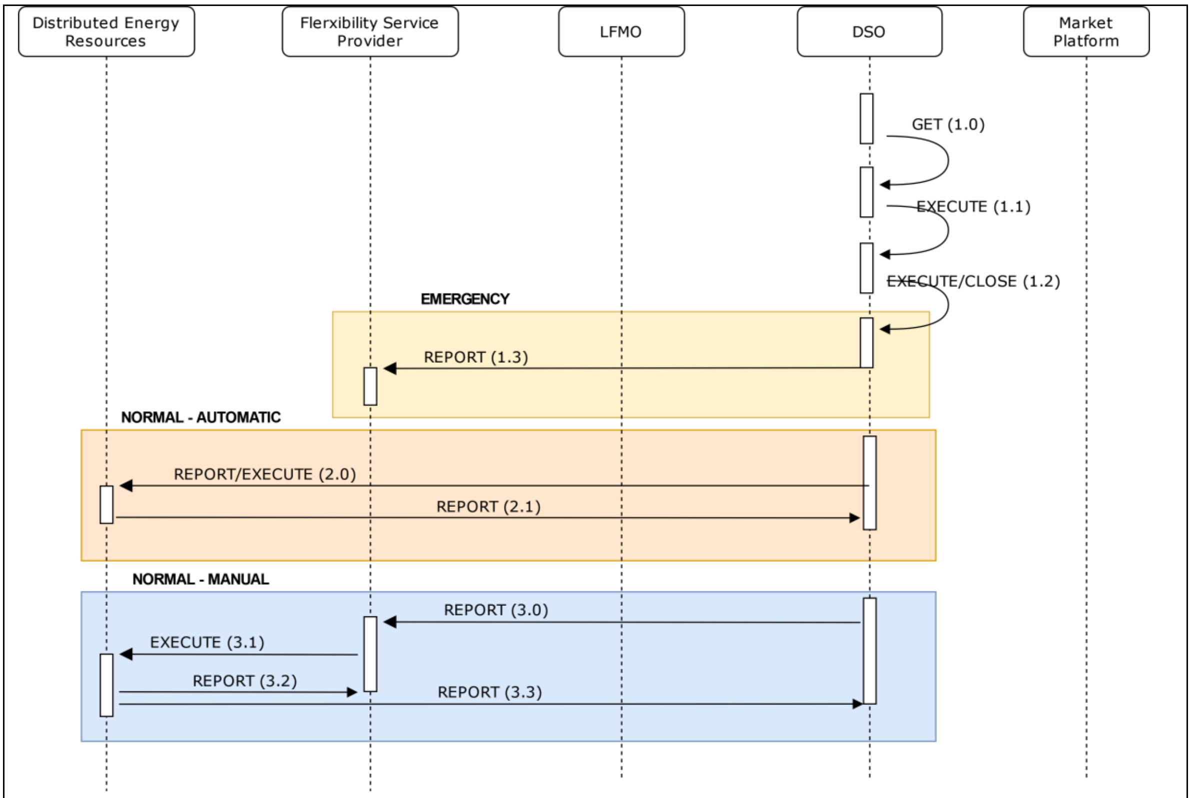
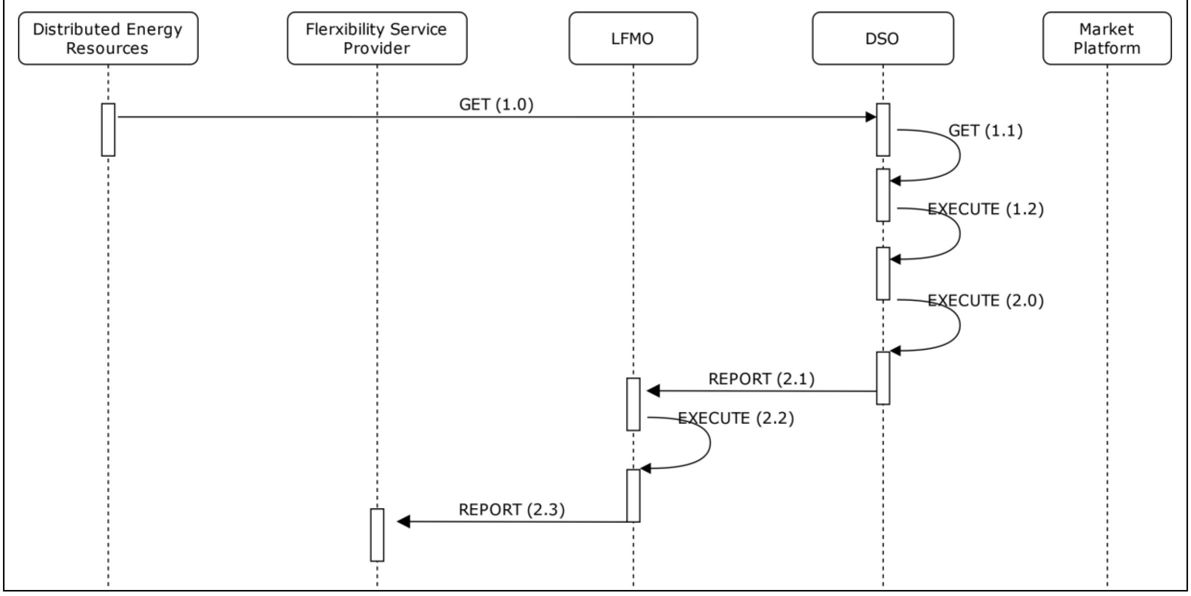


SCENARIO 5



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3 Technical details

3.1 Actors

Actors		
Actor Name	*Actor Type*	*Actor Description*
Distribution System Operator (DSO)	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 or transmission of electricity.
Regional Flexibility Market operator for DSOs - Local Flexibility Market Operator (LFMO)	Role (HEMRM)	A regional flexibility market operator is a party that provides a service whereby the offers to sell electricity flexibility is matched with bids to buy electricity flexibility by DSOs in the region. (Fever)
Flexibility Services Provider	Role (HEMRM)	Resource Aggregator: A party that aggregates resources for usage by a service provider for energy market services. Resource Provider: A role that manages a resource and provides production/consumption schedules for it, if required.
Distributed Energy Resource (DER)	Device	Resources connected at the distribution grid capable of providing active power flexibility, either upward/downward or both. It can comprise several different roles and devices such as demand response (actor/role), distributed generation, electric vehicles, and storage systems.

3.2 References

References						
No.	*References Type*	*Reference*	*Status*	*Impact on use case*	*Originator / organisation*	*Link*
			The status of the referenced document.	e.g. copy right, IPR		
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

4 Step by step analysis of use case

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4.1 Overview of scenarios

Scenario conditions						
No.	**Scenario name**	**Scenario description**	**Primary actor**	**Triggering event**	**Pre-condition**	**Post-condition**
1	Prepare / Pre-qualification	The process in which it is checked whether a unit can deliver the product it intends to sell.	DSO	The DSO and/or the LFMO receives a request from a FSP asking to pre-qualify DER able to offer short-term local congestion management products	The DER/Aggregate complies with the prerequisites publicly made available by the DSO/LFMO	The DER/Aggregate is successfully verified and tested, receiving the permission to offer the products to which the prequalification was aimed at.
2	Plan/Forecast	Forecast of the day-ahead grid condition to identify possible voltage violations	DSO	The forecast and optimization tools identify localized voltage violations in the distribution grid and the amount of flexibility needed.	DSO runs the forecast tool	The resulting flexibility calculation is used by the DSO to identify the different
3	Market phase	Market opening, qualification, bids collection, market clearing and communication of results	LFMO	The DSO calls a market for the procurement of flexibility calculated in scenario 2.	FSPs offer flexibility services by means of pre-qualified DERs/Aggregates.	Markets are cleared and FSPs are nominated to provide the product.
4	Monitoring and Activation	Online state estimation is performed based on the local measurements. Activation is sent based on the auction performed in the market phase	DSO	The scenario happens “periodically” based on the execution time of the state estimation and on the activation time of the flexibility.	Metering data is successfully received by the DSO with the necessary granularity.	The DSO monitors the voltage status in real-time to control the effectiveness of the flexibility activation.
5	Measurement phase	Validation of service delivery	DSO	The service is being provided in real-time or it has been already provided	Metering data is successfully received by the DSO with the necessary granularity and a baseline method was determined	The DSO compares the metered data with the baseline previously computed or sent by the FSP.

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4.2 Steps – Scenarios

Scenario								
Scenario name :		No. 1 - Prepare/Pre-qualification						
Step No.	Event	Name of process/ activity	Description of process/ activity	Service	Information producer (actor)	Information receiver (actor)	Information Exchanged (IDs)	Requirement, R-IDs
1.0	FSP requests to be pre-qualified	Pre-qualification request	The FSP requests to the LFMO to pre-qualify DERS or Aggregates to offer a certain type of product/service	CREATE	FSP	LFMO	I.E.01 I.E.02 I.E.03 I.E.04	GDPR-[1-4]
1.1	LFMO processes market pre-qualification	Product pre-qualification	The LFMO processes the market pre-qualification.	EXECUTE	LFMO	LFMO		
1.2	FSP is notified if information provided is incomplete	Notification (missing data)	The LFMO requests missing data	GET	LFMO	FSP	I.E.03 I.E.04	GDPR-[1-4]
1.3	FSP reports back missing data	Missing data	The FSP reports back missing data	REPORT	FSP	LFMO	I.E.03 I.E.04	GDPR-[1-4]
1.4	LFMO notifies the completion of data collection	Notification (complete)	The notifies the completion on data collection process for the purpose of pre-qualification	CLOSE	LFMO	FSP		
1.5	LFMO forwards prequalification request for technical pre-qualification	Forward req. for grid pre-qualification	The LFMO forwards pre-qualification request for technical pre-qualification	REPORT	LFMO	DSO	I.E.03 I.E.04	GDPR-[1-4]

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2.0	DSO assess the need for a technical validation	Assessment of need for technical validation	The DSO may decide that field tests are necessary to ensure that flexibility can be provided by the applicant FSP. In this step, the DSO assess internally the need for field tests.	EXECUTE	DSO	DSO		
2.1	DSO communicates the need for a technical validation	Notification	If a technical validation is necessary, the FSP is communicated on the new requirement, as well as the details for the technical validation.	REPORT	DSO	FSP		
2.2	FSP acknowledges the technical validation need	Confirmation	The FSP acknowledges the technical validation need	REPORT	FSP	DSP		
2.3	Technical validation test	Technical validation test	The FSP activate the DERs to perform the technical validation test at the moment of activation	GET	FSP	DER		
2.4	DER sends metering data	Metering data	The DER sends metering data regarding the technical prequalification directly to the DSO and to FSP.	REPORT	DER	DSO; FSP	I.E.06	GDPR-[1-4]
2.5	DSO processes the results from technical validation	Process technical validation	The DSO internally processes the results of the technical validation test	EXECUTE	DSO	DSO		
2.6	DSO notifies on successful technical validation	Notification (positive)	The DSO notifies the LFMO on the result of the technical validation	REPORT	DSO	LFMO		

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2.7	The LFMO registers internally the FSP as pre-qualified	Register information (positive)	The LFMO registers internally the FSP as pre-qualified	CREATE	LFMO	LFMO		
2.8	The FSP is communicated on the successful prequalification	Approved pre-qualification	The FSP is communicated on the successful pre-qualification	GET	LFMO	FSP		
2.9	The LFMO registers to the Market Platform the successful pre-qualification	Registration of pre-qualified FSP	The LFMO registers to the Market Platform the successful prequalification	CREATE	LFMO	Market Platform		
2.10	DSO notifies on unsuccessful technical validation	Notification (negative)	The DSO notifies the LFMO on the result of the technical validation	REPORT	DSO	LFMO		
2.11	The LFMO registers internally the FSP as not pre-qualified	Register information (negative)	The LFMO registers internally the FSP as not pre-qualified	CREATE	LFMO	LFMO		
2.12	The FSP is communicated on the unsuccessful pre-qualification	Denied pre-qualification	The FSP is communicated on the unsuccessful pre-qualification	GET	LFMO	FSP		

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2.13	If no technical validation is necessary, DSO informs no technical prequalification result	Notification (positive or negative)	If no technical validation is necessary, DSO informs no technical pre-qualification result	REPORT	DSO	LFMO		
2.14	The LFMO registers internally the result of the prequalification process (positive or negative)	Register information (positive or negative)	The LFMO registers internally the result of the pre-qualification process (positive or negative). All the resources which succeeded the prequalification process are inserted inside the flexibility register.	CREATE	LFMO	LFMO		
2.15	The FSP is communicated on the prequalification result (positive or negative)	Notification (Approved or Denied)	The FSP is communicated on the pre-qualification result (positive or negative)	REPORT	LFMO	FSP		
2.16	The LFMO registers to the Market Platform the successful prequalification	Registration of pre-qualified FSP (if approved)	The LFMO registers to the Market Platform the successful prequalification	CREATE	LFMO	Market Platform		

Scenario

Scenario name :		No. 2 - Plan/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
1.0	DSO evaluates the need for short-term flexibility for voltage violations	DSO evaluates the need for short-term flexibility for voltage violations	The DSO uses forecast data to perform simulations on day-ahead basis to verify if voltage violations happens in the distribution grid. The DSO evaluates it autonomously and no information exchange is required.	EXECUTE	DSO	DSO		

Scenario								
Scenario name :		No. 3 - Market phase						
Step No.	Event	Name of process/ activity	Description of process/ activity	Service	Information producer (actor)	Information receiver (actor)	Information Exchanged (IDs)	Requirement, R-IDs
1.0	DSO requests a short-term market	Call for a short-term market	DSO requests a short-term market based on the results of scenario 2 (plan and forecast). At this request, several parameters will have to be informed by the DSO. These parameters are grouped into (i) generic attributes and (ii) product parameters and they determine the requirements and characteristics of prequalified DER which are able to provide a specific service.	CREATE	DSO	Market Platform	I.E.07 (generic attributes) I.E.08 (product parameters)	GDPR-[1-4]

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1.1	Notification of market request	Notification of market request	The LFMO is notified that a market request was created by the DSO	REPORT	Market platform	LFMO		
1.2	LFMO validates and prepares a market session	Preparation of market session	The LFMO validates the information provided by the DSO (IE07 and IE08). N.B.: Intermediated steps in which the LFMO may identify missing information, request completion from the DSO, and final completion by the DSO are omitted for the sake of simplicity.	EXECUTE	LFMO	LFMO		
1.3	LFMO opens call for a short-term market	Open call for a short-term market	The LFMO, after validating the market session, opens the market session in the Market Platform	EXECUTE	LFMO	Market Platform		
1.4	FSPs are notified of a market opening	Notification (Open Market)	The Market Platform notifies the FSP about a market opening.	REPORT	Market Platform	FSP	I.E.08 (not all parameters)	GDPR-[1-4]
2.0	If the market phase is characteri-zed by a single market, the FSP bids to market session	Bid	Qualified FSPs may bid to the market session as long as market session is open (before the Gate Closer Time [GCT])	CREATE	FSP	Market Platform	I.E.11	GDPR-[1-4]
3.0	If the market phase is characteri-zed by a multiple number of markets, the FSP bids to	Bid	Qualified FSPs may bid to the preliminary market session as long as market session is open (before the Preliminary Market Gate Closer Time [PM-GCT])	CREATE	FSP	Market Platform	IE 11	GDPR-[1-4]

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	Preliminary market session							
3.1; 3.2	Market platform notified the PM-GCT	Preliminary Market closure (PM-GCT)	Market Platform notified the PM-GCT	REPORT	Market Platform	FSP; LFMO		
3.3	Market Platform clears the preliminary market	Preliminary Market clearing	Market Platform reports the preliminary market results and so the pre-selected bid	EXECUTE	Market Platform	Market Platform		
3.4	Market Platform notifies the Preliminary Market results to the DSO	Notification	Market Preliminary market results are notified to the DSO and LFMO	REPORT	Market Platform	DSO; LFMO	IE 12	GDPR-[1-4]
3.5	The FSP bids in the market session	Bid	The FSP bid in the last market session	CREATE	FSP	Market Platform	IE 11	GDPR-[1-4]
4.0; 4.1	Market platform notifies the GCT	Market closure (GCT)	Market platform notifies the GCT	REPORT	Market Platform	FSP; LFMO		
4.2	Market Platform clears the market	Market clearing	Market Platform clears the market taking into account DSO specific needs	EXECUTE	Market Platform	Market Platform		
4.3; 4.4	Market Platform reports market results	Market results	Market Platform reports market results	REPORT	Market Platform	LFMO; DSO		
4.5	LFMO validates the	Validation of results	The LFMO checks the market results for	EXECUTE	LFMO	LFMO		

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	market results		inconsistences. After that, results are validated					
4.6	LFMO registers the validated market results	Validated market results	LFMO registers the validated market results	REPORT	LFMO	Market platform	I.E.12 (market)	GDPR-[1-4]
4.7	DSO validates the market results	Validation of results	The DSO checks the market results for inconsistences (from a technical perspective)	EXECUTE	DSO	DSO	I.E.12 (technical)	GDPR-[1-4]
4.8	DSO registers the validated market results	Validated market results	DSO registers the validated market results	REPORT	DSO	Market platform	I.E.12 (technical)	GDPR-[1-4]
4.9	The Market Platform consolidates the market results	Consolidation (market results)	The Market Platform consolidates the market results based on the validation by the LFMO and the DSO	CREATE	Market Platform	Market Platform	I.E.12 (consolidated)	GDPR-[1-4]
4.10; 4.11; 4.12	Market participants and LFMO are informed of final market results	Notification (market results)	Market participants (DSO, FSPs) and LFMO are informed of final market results	REPORT	Market Platform	DSO; FSP; LFMO	I.E.12 (consolidated)	GDPR-[1-4]

Scenario								
Scenario name :		***No. 4 - Monitoring and 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***
1.0	DSO receives	Measurements data	DSO receives measurements data from	GET	DSO	DSO	I.E.07	GDPR-[1-4]

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	measurements data		installed metering devices and sensors					
1.1	The DSO uses state estimation to monitor the state of the grid near real-time (activation)	Monitoring conditions near activation	The DSO estimate the status of the grid using measurements and state estimation algorithm near activation in order to verify if the grid is in an emergency state	EXECUTE	DSO	DSO		
1.2	If the grid is an emergency state, the DSO starts the emergency protocol, and the BUC is terminated	Beginning emergency state	If the grid is an emergency state, the DSO starts the emergency protocol and the BUC is terminated, as this situation lays outside the scope of this BUC.	EXECUTE; CLOSE	DSO	DSO		
1.3	If the grid is an emergency state, the DSO notifies the FSP to proceed according to the emergency protocol (outside the scope of the BUC)	Notification	If the grid is an emergency state, the DSO notifies the FSP to proceed according to the emergency protocol (outside the scope of the BUC). For example, the FSP may be requested to proceed on a previously agreed way, may be exempted from providing flexibility, or may not be notified at all. This situation is outside the scope of this BUC.	REPORT	DSO	FSP		
2.0	If the state is within normal conditions and the activation	Send activation setpoint	If the state is within normal conditions and the activation type is automatic, the DSO sends the setpoint directly to the DER	REPORT; EXECUTE	DSO	DER		

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	type is automatic, the DSO sends the setpoint directly to the DER							
2.1	DER reports metering data	Metering data	DER reports metering data directly to the DSO	REPORT	DER	DSO	I.E.06	GDPR-[1-4]
3.0	If the state is within normal condition s and the activation type is manual, the DSO sends the setpoint to the FSP	Activation setpoint	If the state is within normal conditions and the activation type is manual, the DSO sends the setpoint to the FSP	REPORT	DSO	FSP		
3.1	The FSP proceeds with the activation in real-time according to the market results.	Activation	If the state is within normal conditions, the FSP proceeds with the activation in real-time according to the market results.	EXECUTE	FSP	DER		
3.2 3.3	DER reports metering data	Metering data	DER reports metering data directly to the DSO and to FSP	REPORT	DER	DSO; FSP	I.E.06	GDPR-[1-4]

Scenario								
Scenario name :	***No. 5 - Measurement phase***							
Step No.	***Event***	***Name of process/ activity***	***Description of process/ activity***	***Service***	***Information producer (actor)***	***Information receiver (actor)***	***Information Exchanged (IDs)***	***Requirement, R-IDs***

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1.0	DSO receives metering data	Metering data	DSO receives metering data (step 2.1 of scenario 4)	GET	DER	DSO	I.E.06	GDPR-[1-4]
1.1	DSO receives measurements data	Measurements data	DSO receives measurements data from installed metering devices and sensors	GET	DSO	DSO	I.E.07	GDPR-[1-4]
1.2	DSO performs grid state estimation	Monitoring	DSO uses the metering data and the voltage measurements from the installed metering devices to perform state estimation after the flexibility activation	EXECUTE	DSO	DSO		
2.0	The DSO validates the service provision	Verification of service provision	The DSO validates the service provision. To do so, the DSO compares the metered data with the service procured and the baseline predefined. DSO evaluates the result of the state estimation to verify that the voltage constraint issue has been solved.	EXECUTE	DSO	DSO		
2.1	The DSO notifies the FSMO on the service provision	Notification of service provision	The DSO informs the LFMO on the level of service provision (e.g., percentage of service provision based on the deviation of the metering data to the agreed flexibility)	REPORT	DSO	LFMO		
2.2	FSMO proceeds with the settlement processing	Settlement processing	The LFMO proceeds with the settlement processing. According to the level of service provision, penalties (reduction of agreed price/payment) may occur.	EXECUTE	LFMO	LFMO		

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2.3	The FSP is notified on the final settlement	Settlement notification	The FSP is notified on the final settlement	REPOR T	LFMO	FSP		

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5 Information exchanged

Information exchanged			
Information exchanged (ID)	***Name of information***	***Description of information exchanged***	***Requirement, R-IDs***
I.E.01	Basic Participant Information	Register and basic information about the market participant such as username and password	
I.E.02	Market participant prequalification information	Contact information; Fiscal data; Access contract; bank details; power of representation; confidentiality agreement; declaration of non-collusion	
I.E.03	Market resource pre-qualification information	Market participants provide information on the resources they want to prequalify: Facility/resource name; Type of technology; Location; Market participant; etc.	
I.E.04	Technical resource pre-qualification information	Verification of the installed capacity to provide the service: Power; Maximum quantity; Response time, etc.	
I.E.05	Technical validation for pre-qualification	In case of the need of a technical validation for prequalification, the FSP receives the information on the when and how the test will be conducted: day; time; power to reduce/increase; duration of the test; etc.	
I.E.06	Metering data	Metering data from DER	
I.E. 07	Measurements data	Measurements data from sensors and metering devices installed in the distribution grid.	
I.E.08	Generic attributes	Composed of generic parameters concerning the market session being requested. E.g.: • Auction identifier • Associated DSO • Product Type: Flexibility Product • Type of negotiation: Auction Area: Basic or aggregated.	
I.E.09	Product parameters	Composed of product parameters concerning the market session being requested. E.g.: • Service window: Selection of the required date and duration of the service • Availability: Selection of the capacity, the direction, and the estimated hours of activation. • Activation window (in case of activation product): Specific	

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		subperiod in an activation window when a particular DER could be activated and thus it must be available. Multiple sets of activation windows can be defined. • Local area: Selection of the trading area. Choice by postal code, connection point, lines… (to be determined). • Activation Announcement: Time in advance that a DSO informs a DER that its activation is programmed confirmed. Form of Remuneration: It establishes form of payment to winner DERs Two different terms are defined availability and activation (depending on the product).	
I.E.10	List of pre-qualified units	List of pre-qualified units for a given market session	
I.E.11	List of qualified units (market, technical or consolidated)	List of qualified units for a given market session. The list can refer to the market qualification, technical qualification or the consolidated list.	
I.E.12	Bid	Composed of bidding information • General attributes (FSP identifier) Availability: Selection of the capacity, the direction and the estimated hours of activation (period of availability and price).	
I.E.13	Validate market results	Validated market results by either the FSMO (market), the DSO (technical) or the consolidated market results.	
I.E.14	Scheduling of FSPs	Scheduling of FSPs	

6 Requirements

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

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GDPR-2	Data retention policy	Data retention policy outlines the time period specific sensitive data can be retained, plus how it will be disposed of when the time to do so comes.
GDPR-3	Right to access, rectify, erasure, restriction	The data subject shall have the right to obtain from the controller without undue delay the access/rectification/erasure/restriction of inaccurate personal data concerning him or her.
GDPR-4	Data transfer consent	Personal data may not be transferred to a third-party if the data subject did not agree and the third party provide appropriate safeguard.
GDPR-X	All GDPR constraints also apply to this BUC.	e.g., proportional measures of protection, communication of data breach, among others

Requirements		
Categories ID	**Category name for requirements**	**Category description**
RCR	Regulatory changes/needs related to DSO remuneration and network development plans	European Electricity Market Directive 944/2019
AM	Regulation for flexibility provision mechanism to be developed	Draft Proposal for Network Code on Demand Response
Requirement R-ID	**Requirement name**	**Requirement description**
RCR-1	Analysis of incentives in DSO remuneration schemes	Regarding operational expenditures, most of the countries studied in deliverable D1.1 establish an ex-ante allowance for operational expenditures with an incentive rate. This type of regulatory framework incentivizes DSO to reduce OPEX. If the regulatory framework does not incentivize the DSO to reduce OPEX, the objectives of this BUC may not be aligned with current regulation introducing distorting incentives that may not lead to overall cost-efficiency in short-term congestion management.
RCR-2	Definition of baseline methodology	The BUCS states that for the resilience measurement, a baseline must be defined beforehand, with which the actual measurement data of the FSP can be compared. Similarly, as with other BUCs the definition of a baseline methodology also for voltage control services has to be defined according to Draft Proposal for Network Code on Demand Response.
AM-1	Regulation for local flexibility markets need to be implemented	The BUC considers the integration of flexibility can effectively exploit its potential in addressing potential

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		voltage constrains, using market-based mechanism like flexibility markets. Availability or activation products can be procured.
AM-2	Coherency with other electricity markets.	Local market timing has to be coordinated with the existing electricity markets to foster the efficient allocation of resources, avoid distortions, and prevent gaming. Possible unbalances should be adequately considered to avoid system level impacts.

7 Common Terms and Definitions

Common Terms and Definitions	
Term	**Definition**
DSO	Distribution System Operator
LFMO	Local Flexibility Market Operator
FSP	Flexibility Service Provider
HC	Hosting Capacity
DER	Distributed Energy Resource

11.8. BUC08 – Crowd Balancing: Interoperable data exchange between stakeholders

1 Description of the use case

1.1 Name of the use case

ID	*Area / Domain(s)*	*Name of Use Case*
BUC08	TSO-DSO flexibility coordination	Crowd Balancing: Interoperable data exchange between stakeholders

1.2 Version management

Version Management			
Version No.	*Date*	*Name of Author(s)*	*Changes*
0.1	19/04/23	Tommaso De Marco	First draft version

1.3 Scope and objectives of use case

Scope and Objectives of Use Case	
Scope	Coordinate local flexibility markets and global ancillary services market in the processes for procuring flexibility services from distributed resources
Objective(s)	• Provide to global and/or local BSPs a common channel allowing data registry, market operation functionalities • Enable a common data exchange approach between TSO, DSOs and BSPs

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Related business case(s)	The BUC 08 has a relationship with business use cases in which there is a data exchange between BSPs, TSO and DSOs. The Crowd Balancing Platform is a tool for distributed data exchanges supporting the integration of roles and responsibilities. Therefore BUC 10 has a direct relation, possibly also BUCs related directly to flexibility services procurement.

1.4 Narrative of use case

Narrative of Use Case
Short description
The Crowd Balancing Platform (CBP) is a blockchain-based system available for sharing information between TSO, DSOs and BSPs in a trusted and secured way. The Business Use Case describes how TSO, DSOs, BSPs can register flexibility resources and exchange data via the Flexibility Register functionality during the resource prequalification process, facilitating TSO-DSO common information exchanges and Balance Service Provider (BSP) participation through a single channel for multiple markets access. Moreover, it supports transactions for market operations and Traffic Light data exchange between stakeholders enabling secure coordination between local markets and global market.
Complete description
The Crowd Balancing Platform (CBP) is a blockchain-based system to share the local and global flexibility services information between TSO, DSOs and BSPs in a trusted and secured way. The Business Use Case describes:

- **Registration and prequalification**

  4. The BSPs uses the Crowd Balancing Platform to register distributed resources data into the Flexibility Register and the DSOs receives the BSP registration data through the Crowd Balancing Platform. The DSO validates resource data enabling BSPs to create aggregates of validated resources. The BSP uses the Crowd Balancing Platform to register aggregates data into the Flexibility Register, the TSO and DSOs register additional flexibility data and tests aggregates performance in the prequalification phase. Finally, the TSO, DSOs and BSPs exchange aggregate prequalification results accessing the Flexibility Register through the Crowd Balancing Platform.

  5. The Flexibility Register is based on TSO-DSO common information exchanges and its functionality facilitates markets participation establishing a common data model across grid operators and across different flexibility products/services.

System Use Case called by the step
SUC 08.1: Flexibility Register

  6.

- **Market Coordination**

  7. In the ex-ante and real-time markets phases, TSO and DSOs exchange global market data and local markets data through the CBP, enabling TSO-DSO coordination and to guarantee visibility over respective aggregates activation.

System Use Case called by the step
SUC 08.2: Market data exchange functionalities

  8.

- **Constraints definition**

  9. In the ex-ante and real-time markets phases, the stakeholders exchange Traffic Light data via the Crowd Balancing Platform enabling coordination between local markets and assuring the global market to operate within distribution grid bottlenecks creation.

System Use Case called by the step
SUC 08.3: Traffic Light data exchange functionalities

  10.

- **TSO and DSO verification and settlement**

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11. TSO and DSOs verify global and local flexibility deliveries; in this phase TSO, DSOs and BSPs exchange data due to the BSP obligation to grant the neutral economical exposure of the BRP, caused by imbalances generated during the supply of flexibility services. Transparency over deliveries of commercial/physical transactions shall be shared to guarantee correct settlement of energy.
12.

System Use Case called by the step
SUC 08.4: Verification functionalities

13.

1.5 Key performance indicators (KPI)

ID	Name	Description	Reference to mentioned use case objectives
1	*KPI8.3*	Impact of local constraints on DER providing global services	Provide to global and/or local BSPs a common channel allowing data registry, market operation functionalities

1.6 Use case conditions

Use case conditions
Assumptions
• TSO and DSOs collect differently flexibility data and do not share it between them • TSO and DSOs use their own communication system with BSPs • TSO-DSO coordination data exchange system do not exist for flexibility procurement
Prerequisites
• The BSP is compliant with market access rules • TSO, DSOs and BSPs have access to the data exchange platform

1.7 Further Information to the use case for classification / mapping

Classification Information
Relation to other use cases
The BUC 08 has a relationship with business use cases in which there is a data exchange between BSPs, TSO and DSOs. The Crowd Balancing Platform is a tool for distributed data exchanges supporting the integration of roles and responsibilities. Therefore BUC 10 has a direct relation, possibly also BUCs related directly to flexibility services procurement.
Level of depth
Business Use case (BUC)
Prioritisation
High priority for Italian demo
Generic, regional or national relation
National
Nature of the use case
Technological Business Use Case focused on data exchange system for the coordination between TSO, DSOs and BSPs
Further keywords for classification
Data exchange platform, Flexibility Register, technological communication system, TSO-DSO coordination.

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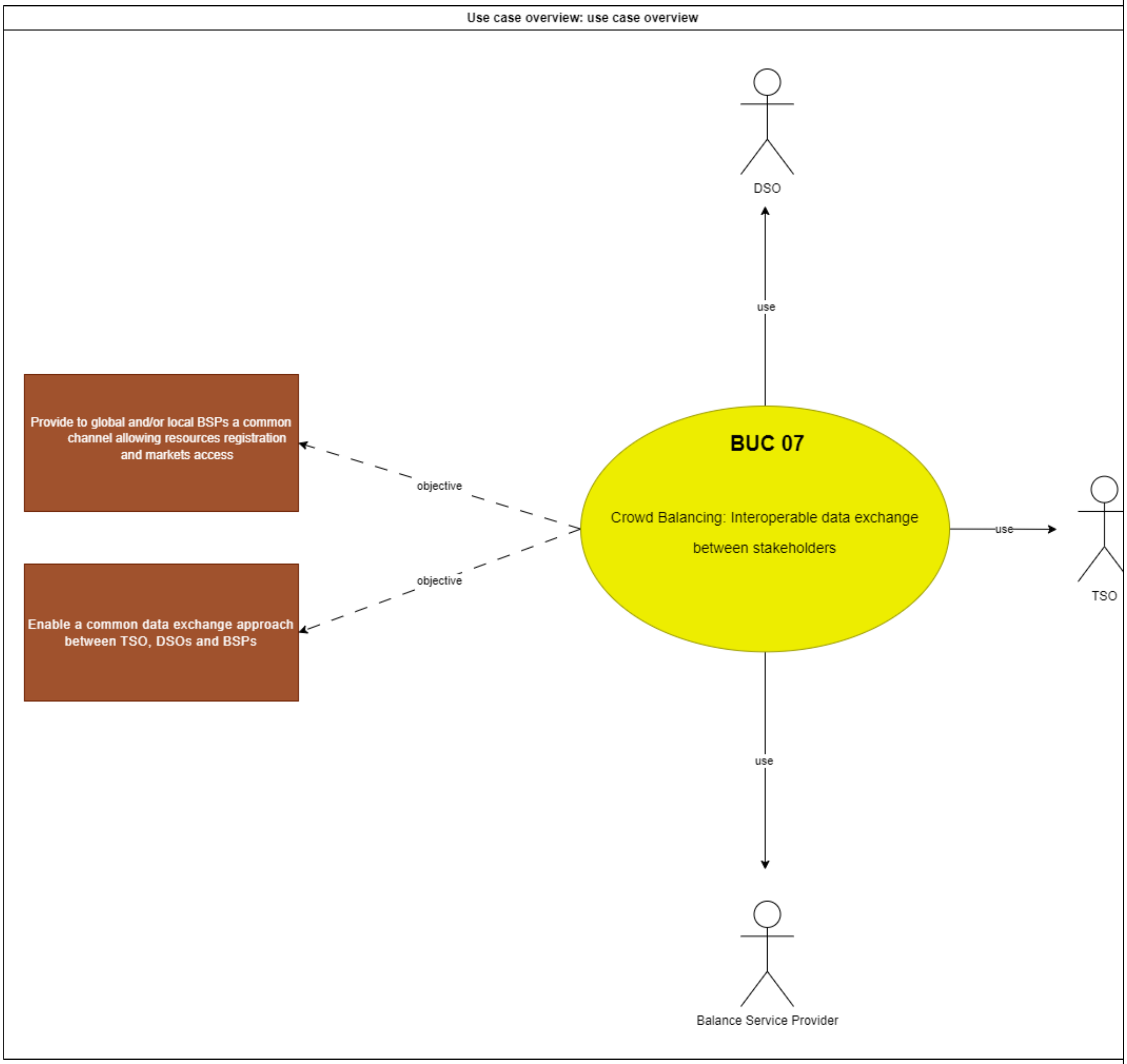
1.8 General Remarks

General Remarks
N/A

2 Diagrams of use case

Diagram(s) of use case



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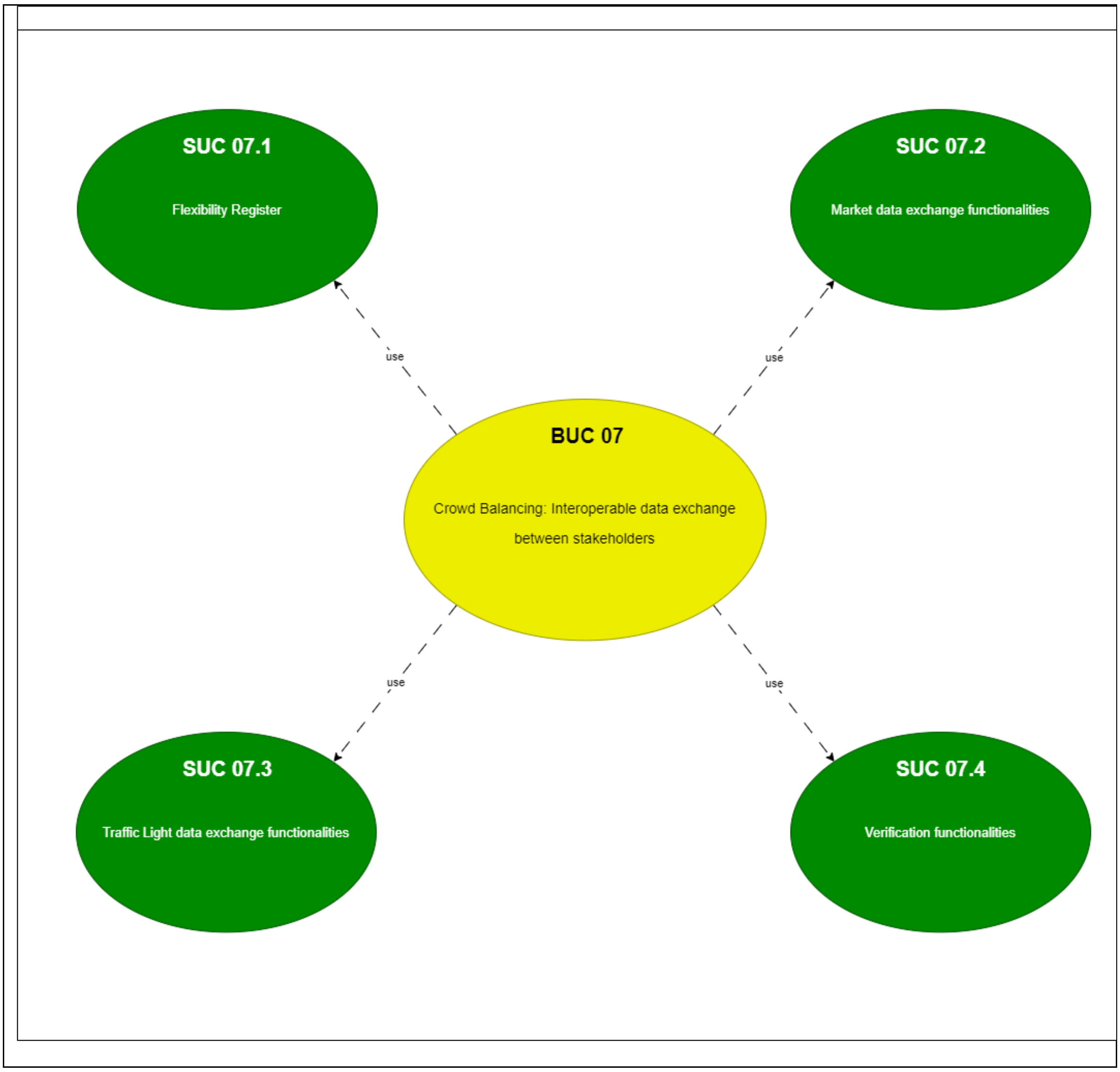
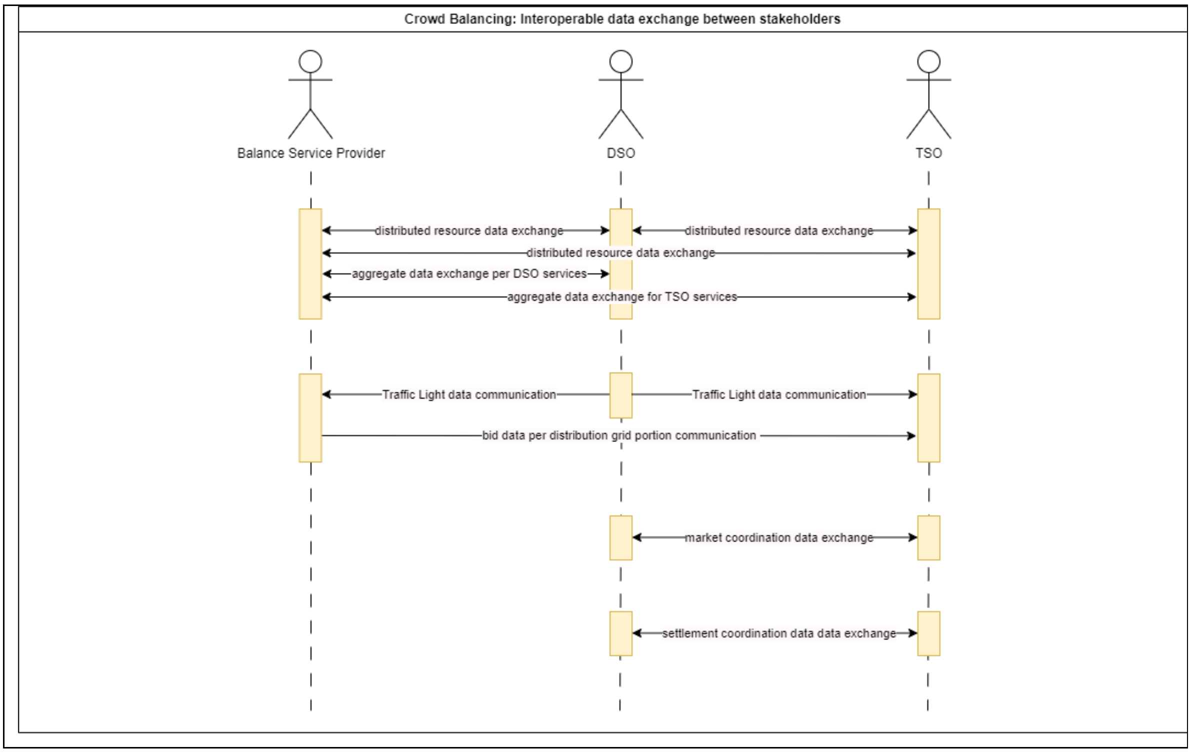

SUC 07.1
Flexibility Register
SUC 07.2
Market data exchange functionalities
use
use
BUC 07
Crowd Balancing: Interoperable data exchange between stakeholders
use
use
SUC 07.3
Traffic Light data exchange functionalities
SUC 07.4
Verification functionalities


Crowd Balancing: Interoperable data exchange between stakeholders
Balance Service Provider
DSO
TSO
distributed resource data exchange
distributed resource data exchange
distributed resource data exchange
aggregate data exchange per DSO services
aggregate data exchange for TSO services
Traffic Light data communication
Traffic Light data communication
bid data per distribution grid portion communication
market coordination data exchange
settlement coordination data data exchange

3 Technical details

3.1 Actors

Actors		
Actor Name	***Actor Type***	***Actor Description***
Balancing Service Provider (BSP)	Business Role (BRIDGE HEMRM)	A party with reserve-providing units or reserve-providing groups able to provide balancing services to one or more LFC Operators
DSO	Business Role (BRIDGE HEMRM)	A DSO is a System Operator. DSO is responsible for security of supply and reliability of the distribution grid. For this reason, it monitors the grid to identify possible arising issues and, if there is a need, it makes use of resources to solve such problems, by network reconfiguration and/or by requests to market operators or directly to properly contracted customers.
TSO	Business Role (BRIDGE HEMRM)	TSO is a System Operator. TSO is responsible for security of supply and reliability of the transmission grid. For this reason, it monitors the grid to identify possible arising issues and, if there is a need, it makes use of resources to solve such problems, by network reconfiguration and/or by requests to market operators or directly to properly contracted customers.

3.2 References

References						
No.	***References Type***	***Reference***	***Status***	***Impact on use case***	***Originator / organisation***	***Link***
	CBP implementation	The Crowd Balancing Platform cannot be implemented by project/demos where Terna is not involved with an implementation role		IPR	Terna/Equigy	

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	Registration, validation, prequalification	The Crowd Balancing Platform (CBP) is used by TSO, DSOs and BSPs to register	TSO, DSO, BSP	N/A	TSO and DSO use different systems to collect BSP distributed	Beside BSPs, the TSO and DSOs can access to the distributed resource and

		distributed resource and aggregate information into the Flexibility Register.			resource and aggregate data.	aggregate data via the CBP and collected into the Flexibility Register.
2	Market	The CBP is used by TSO, DSOs and BSPs to exchange market and Traffic Light data in order to coordinate and optimize the local and global flexibility activation.	TSO, DSO, BSP	N/A	TSO and DSOs are not provided with coordination data exchange system: flexibility activations can lead to market inefficiencies.	TSO and DSO exchange data via the CBP to coordinate flexibility activations increasing market benefits.
3	Settlement	The CBP is used by TSO, DSOs and for data exchange to coordinate the economical settlement.	TSO, DSO	N/A	TSO and DSOs do not coordinate the economical settlement processes via coordination data exchange system.	TSO and DSO exchange data via the CBP to coordinate economical settlement of flexibility activation and imbalances generated.

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4.2 Steps – Scenarios

Scenario								
Scenario name: Registration, validation, prequalification		**No. 1 - Reference 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**
1	N/A	Distributed resource data loading	The CBP loads into the Flexibility Register distributed resource data.	CREATE	BSP	TSO, DSO	Distributed resource data	N/A
2	N/A	Distributed resource data receiving and complete	The CBP is used by the TSO and DSO to receive distributed resource data loading notification and to change the resources status related to the process	GET, CREATE, CHANGE	TSO, DSO	TSO, DSO, BSP	Distributed resource data	N/A
3	N/A	Aggregate data loading	The CBP is used by BSP to load into Flexibility Register aggregate data.	CREATE	BSP	TSO, DSO	Aggregate data	N/A
4	N/A	Aggregate data receiving and complete	The CBP notifies TSO and DSO with the aggregate data loading; they use CBP to change the aggregate status into the Flexibility Register	GET, CREATE, CHANGE	TSO, DSO	TSO, DSO, BSP	Aggregate data	N/A
Scenario name: Market		**No. 2 - Reference scenario**						
Step No.	**Event**	**Name of process/ activity**	**Description of process/ activity**	**Service**	**Information producer (actor)**	**Information receiver (actor)**	**Information**	**Requirement, R-IDs**
1	N/A	DSO's Traffic Light data communicatio n	The CBP enables the communication of Traffic Light data set, created by the DSO based on distribution grid analysis.	CREATE	DSO	TSO, BSP	Traffic Light data	N/A
2	N/A	DSO's Traffic Light data receiving	The CBP transfers DSO Traffic Light data to TSO and BSPs.	GET	DSO	TSO, BSP	Traffic Light data	N/A
3	N/A	BSP's Traffic Light data communicatio	The CBP is used by the BSP to communicate its aggregate offers per each distribution grid	CREATE	BSP	TSO	Traffic Light data	N/A

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		n	portion involved.					
4	N/A	BSP's Traffic Light data receiving	The CBP transfers BSP Traffic Light data to the TSO.	GET	BSP	TSO	Traffic Light data	N/A
5	N/A	Market coordination data elaboration	The CBP allows TSO and DSOs market related data exchange in order to make the flexibility activations coherent.	CREATE	TSO, DSO	TSO, DSO	Market coordination data	N/A
6	N/A	Market coordination data receiving	The CBP transfers market data to TSO and DSOs.	GET	TSO, DSO	TSO, DSO	Market coordination data	N/A
Scenario name: Settlement		***No. 3 - Reference scenario***						
Step No.	***Event***	***Name of process/ activity***	***Description of process/ activity***	***Service***	***Information producer (actor)***	***Information receiver (actor)***	***Information***	***Requirement, R-IDs***
1	N/A	Settlement coordination data communication	The CBP enables TSO-DSO data exchange to verify the flexibility deliveries, to coordinate the imbalances regulation and to define the economical settlement.	CREATE	TSO, DSO	TSO, DSO	Settlement coordination data	N/A
2	N/A	Settlement coordination data receiving	The CBP transfers verification data to TSO and DSOs.	GET	TSO, DSO	TSO, DSO	Settlement coordination data	N/A

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5 Information exchanged

Information exchanged			
Information exchanged (ID)	***Name of information***	***Description of information exchanged***	***Requirement, R-IDs***
Distributed resource data	Registration data	All the technical, economical, topological, legal data of the resource connected to the distribution grid; resource validation status.	N/A
Aggregate data	Qualification data	The aggregate of distributed resources data; flexibility services; aggregate prequalification status.	N/A
Traffic Light data	Constraints data	The Traffic Light data set as described in the "constraints definition" and "bids placements" phases of the BUC10.	N/A
Market coordination data	Coordination data	All the market data needed to coordinate global and local markets and to optimize the TSO-DSO aggregate selection and activation.	N/A
Settlement coordination data	Verification data	The verification data collect all the flexibility deliveries information.	N/A

6 Requirements

Requirements		
Categories ID	**Category name for requirements**	**Category description**
N/A	N/A	N/A
Requirement R-ID	**Requirement name**	**Requirement description**
N/A	N/A	N/A

7 Common Terms and Definitions

Common Terms and Definitions	
Term	**Definition**
CBP	The Crowd Balancing Platform (CBP) is a blockchain-based system available for sharing information between TSO, DSOs and BSPs in a trusted and secured way.

11.9. BUC09 – Local and global market coordination for distributed resources system service provision

1 Description of the use case

1.1 Name of the use case

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

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BUC 09	TSO-DSO flexibility coordination	Local and global market coordination for distributed resources system service provision

1.2 Version management

Version Management			
Version No.	***Date***	***Name of Author(s)***	***Changes***
0.1	01.05.2023	José Pablo Chaves	First draft
0.2	10.05.2023	Serena Cianotti	Review
0.3	15.05.2023	José Pablo Chaves	Add data exchange. Pending diagrams. map requirements per steps and information exchange
0.4	22.05.2023	Serena Cianotti	Review
0.5	10.06.2023	José Pablo Chaves	UML diagrams added
0.6	15.06.2023	José Pablo Chaves	Relation with SUCs added
0.7	28.06.2023	Tommaso de Marco	Review
0.8	06.07.2023	José Pablo Chaves	Review after meeting
0.9	15.07.2023	Tommaso De Marco	Review
0.9.1	18.07.2023	Maja Johansson, David Bjarup, Rebecca Samuelsson	Review
0.9.2	26.10.2023	Tommaso De Marco, Fabio Lucidi	Review

1.3 Scope and objectives of use case

Scope and Objectives of Use Case	
Scope	The Business Use Case describes how TSO and DSO can coordinate the procurement of system services from distributed resources through local and global markets.
Objective(s)	The market-based coordination among the involved actors aims to manage the procurement of services via efficient data exchange, avoiding network constraint violation when the resources are activated, allowing value stacking for the distributed resources, and striving for overall economic efficiency of market-based procurement.
Related business case(s)	BUC 04 - Long-term distribution grid congestion management BUC 06 - Short-term congestion constraints forecasting and management for local flexibility service activation. BUC 07 - Short-term voltage constraints forecasting and management for local flexibility service activation

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	BUC 08 - Crowd Balancing: Interoperable data exchange between stakeholders BUC 10 - Dynamic constraints management for global flexibility activation in transmission system operation

1.4 Narrative of use case

Narrative of Use Case
Short description
The Business Use Case describes how TSO and DSO can coordinate the procurement of system services from distributed resources through local and global markets. Market-based coordination among the involved actors aims to efficiently allocate the resources available eventually avoiding over-procurement, avoiding network constraint violation when the resources are activated, allowing value stacking for the distributed resources, and striving for overall economic efficiency of market-based procurement. This opportunity depends on the market design and on the degree of integration within the DSO and TSO markets. The main actors involved are the TSO and DSO, and the secondary actors are the TSO, DSO, MO (when different from the system operator), Balance Responsible Parties, Flexibility Service providers, producer, and consumer. The local and global market coordination defined in this BUC considers the possible coordination at the market phase level (e.g., pre-qualification, demand forecast, procurement, activation, measurement, settlement) to increase the liquidity in all markets. The coordination between the TSO and DSO depends on different elements, such as where the need is located, who is the primary buyer of the service, how many markets are used and whether the TSO can directly acquire services from the distribution-connected resources via its own market. The coordination between the two markets will also allow for the DSO to monitor and control the participation of DERs in the balancing markets, and also allow for better market liquidity due to the increased possibility of value stacking. **Time-frame**: short-term (near-real-time, intraday, day-ahead), medium-term (week(s)-ahead) and long-term (years to months). **Flexibility market model**: local, multi-level. **Type of Flexibility Service Provider response to activation signal**: manual and automated response to signals, automated control. The BUC includes the following steps: **1. Product/service prequalification in both the DSO and TSO flexibility markets;** **2. Market based procurement:** **a. Explicit bids placement** **b. Local market clearing** **c. Local and Global Markets Coordination via the Dynamic Traffic Light** **d. Global market clearing** **3. Service/product activation and real-time data exchange** **4. Settlement**
Complete description

The Business Use Case is described from the perspective of the TSO and DSOs as Primary Actors. A third actor, taken into account particularly in the market phase, is the LMO (Local Market Operator) which is the subject that manages the local flexibility market. Some national institutional architectures may not contemplate the LMO: in that case, its role is fulfilled by the DSO. For the sake of completeness and simplicity, in the continuation of the BUC, we will refer to the LMO as the operator of the local flexibility market and to the TSO as both the network operator and the Global Service Market operator.

1. **Prequalification of the resources providing flexibility services**
For each considered service, the DSO and TSO will set the requirements to qualify the SPUnit (Resource / DER asset) and/ or SPGroup (Aggregated). In particular, the process works as follows: (i) the FSPs register the SPUnits considering the interface at Grid Connection Point (GDP) as a reference point and the relevant DSO is in charge of validating them by checking the technical attributes of the flexibility product; (ii) eventually, starting with these validated SPUnits, FSPs must aggregate them to form SPGroups; (iii) once the FSP has formed its SPGroups, it chooses to which market it wish these resources are set to participate, i.e. (a) in the local market only, (b) in the global market only, (c) in both the markets; (iii) according to the choice made by the FSP, a different SPGroup pre-qualification path is followed: in the case (a), the pre-qualification will only involve the LMO and the DSO; in case (b), pre-qualification will involve only the TSO; finally, in case (c), a joint pre-qualification path can be set-up depending on equivalences across markets/products/services.

1.1. Registration of SPUnits and SPGroups
FSPs request registration of SPUnits and SPGroups to the registration platform with a system-wide application that connects to TSO, DSO, FSP back-end tools for data registry functionalities.

System Use Case called by the step
SUC 8.1: Flexibility Register

1.2. Ex-ante validation of SPUnits and SPGroups

FSPs request validation from the TSO and DSOs, which perform the technical check for validation at a single asset or aggregation of units level. Validation is performed by the connecting system operator.

System Use Case called by the step
SUC 10.1: Ex-ante validation

2. **Market based procurement**
Overall market-based procurement is based on either multi-level markets. The procurement includes the exchange of grid constraints and market outcomes to allow for overall system balance management.

2.1. Explicit bids placement

FSPs place bids on either/both the local market or global market based on the Unit type and product/service, depending on the specific requirements. Unit type refers as the global/local aggregate - i.e. a set of

GPCs that have successfully undergone qualification and are habilitated for local and/or global market

System Use Case called by the step
SUC 10.3: Bids placements and verification

2.2 Local Market Clearing

The LMO clears the local market hence creating a schedule for activation of FSPs and their resources for a specific day/hour. The DSO prepares the information required for the global market operation including the Traffic Light data (which accounts for the local market clearing if needed).

The data exchange to coordinate markets (and generally procurement if possible based on market design) is leveraged to account for previous markets clearing, grid constraints, unused flexibility bids.

System Use Case called by the step
SUC 8.2: Market Data Exchange Functionalities

2.3 Local and Global Markets Coordination via the Dynamic Traffic Light

The DSO defines the Dynamic Traffic Light by taking into account the results of the local market in order to provide the TSO with the updated state of its local distribution grid.

System Use Case called by the step
SUC 8.3: Traffic Light Data Exchange Functionalities
SUC 10.2: Constraints definition

2.4 Global market clearing

TSO clears the global market considering previous market clearing and grid constraints communicated by the DSO so that indirect contingencies are avoided and so that local market results are not jeopardized.

3. Monitoring and Activation

3.1 Flexibility activation for DSO congestion management

The DSO activates the flexibility resources according to the scheduling emerging from the Local Market.

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System Use Case called by the step
SUC 6.2: Short term flexibility activation for DSO congestion and voltage constraints management

3.2 Activation of distributed flexibility for TSO services

The TSO activates the flexibility resources taking into account the scheduling emerging from the Local Market and the constraints defined by the DSO via the Dynamic Traffic Light

4. Service settlement

Each Market Operator will settle the services delivered based on the validated service delivery.

4.1. Exchange of settlement data

In order to be able to settle the transactions accruing to the Global Flexibility Market, the TSO needs to get information on the activated bids and metering data from the DSO. In order to do so, the DSO needs to know the actual activation of resources. A double information exchange flows is thus required.

System Use Case called by the step
SUC 8.4: Verification functionalities
SUC 10.4: Delivery validation

4.2. Settlement of flexibility services from DER participating to local market

The DSO gets information on the activated bids and metering data to validate the service. The LMO validates the service provided and proceeds with the notification to the SOs and SPs.

System Use Case called by the step
SUC 6.3: Settlement of flexibility services from DER participating to local market

1.5 Key performance indicators (KPI)

ID	Name	Description	Reference to mentioned use case objectives
9.1	*Efficiency of prequalification process in*	Average bureaucracy time and/or average number of technical tests performed by TSO and DSO to qualify the (aggregates of)	1.

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	coordinated markets	DER with respect to the number of services provided by the (aggregates of) DER to both TSO and DSO.	
9.2	*Coordinated market efficiency*	The decoupled nature of local and global markets leads to inefficiencies when they manage shared (aggregates of) DERs. This KPI measures how the TSO-DSO coordination improves the total cost of activated flexibility with respect to the ideal situation (fully coupled market).	1.

1.6 Use case conditions

Use case conditions
Assumptions
• TSO and DSOs systems to identify service needs are assumed to be in place. • TSO markets already functioning • Market Platforms functioning • Coordination processes and tools are in operations
Prerequisites
Metering data for service delivered is expected to be available as well as necessary network data information to assess cross-impacts.

1.7 Further Information to the use case for classification / mapping

Classification Information
Relation to other use cases
BUC 04 - Long-term distribution grid congestion management Aggregators will be present in the Italian demo but BUC 05 is not used BUC 06- Short-term congestion constraints forecasting and management for local flexibility service activation. BUC 07- Short-term voltage constraints forecasting and management for local flexibility service activation BUC 08- Crowd Balancing: Interoperable data exchange between stakeholders BUC 10- Dynamic constraints management for global flexibility activation in transmission system operation
Level of depth
Business use case (BUC) use case which describes a general requirement, idea or concept independently from a specific technical realization like an architectural solution
Prioritisation
High Level of Priority – To be demonstrated in Italy
Generic, regional or national relation
Generic

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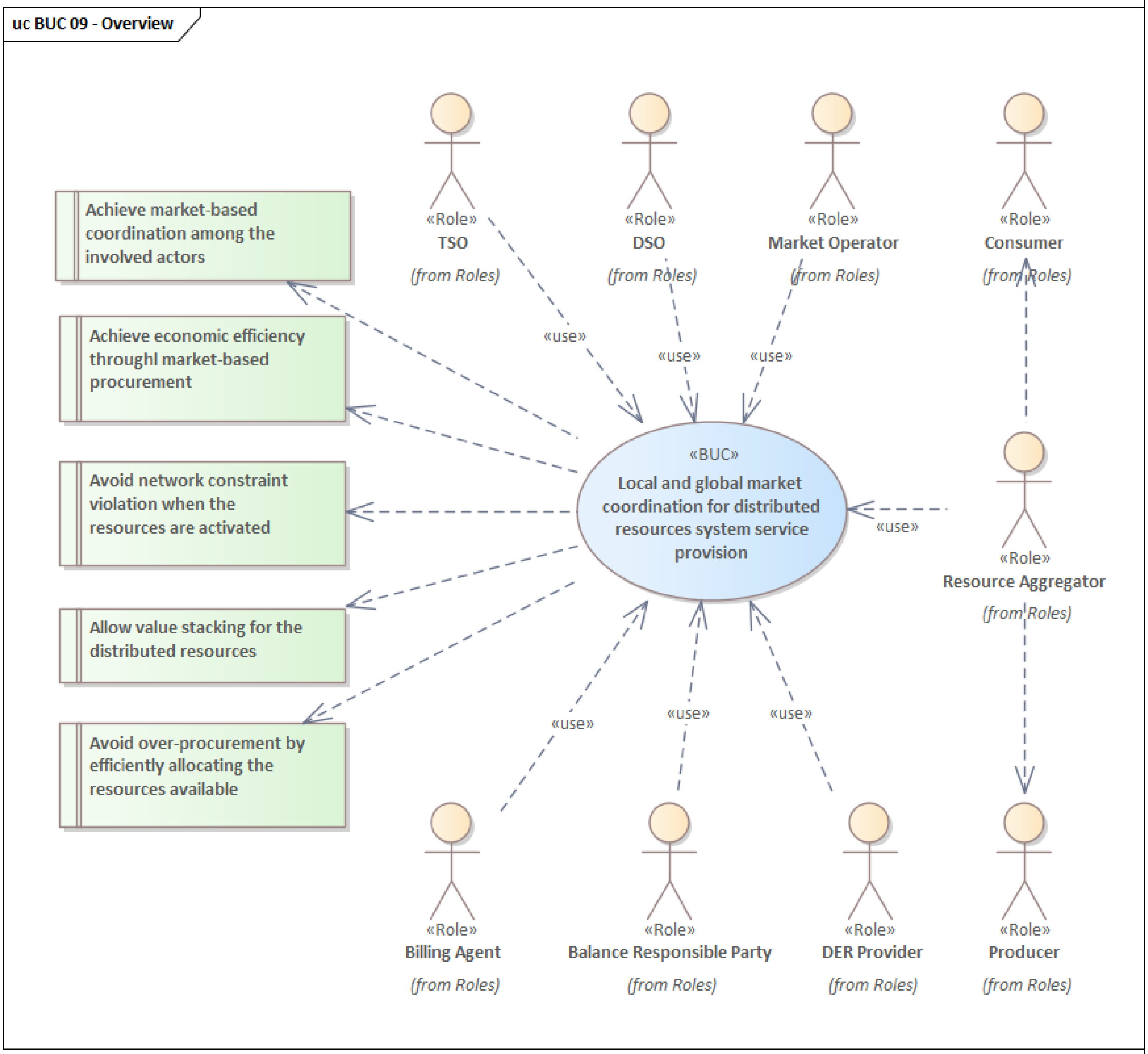
Nature of the use case
business use cases (e.g. market processes)
Further keywords for classification
Flexibility markets, market designs

2 Diagrams of use case

Diagram(s) of use case



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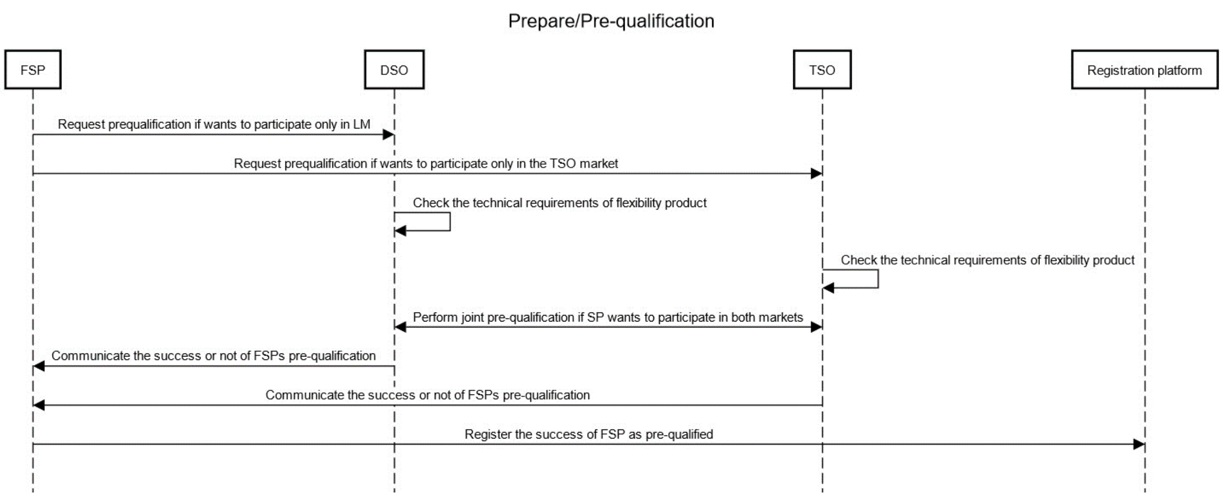
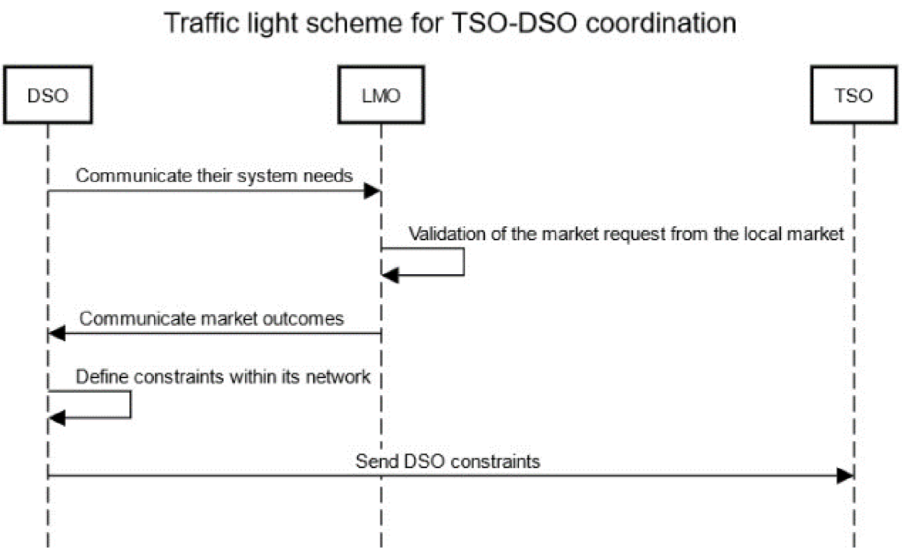
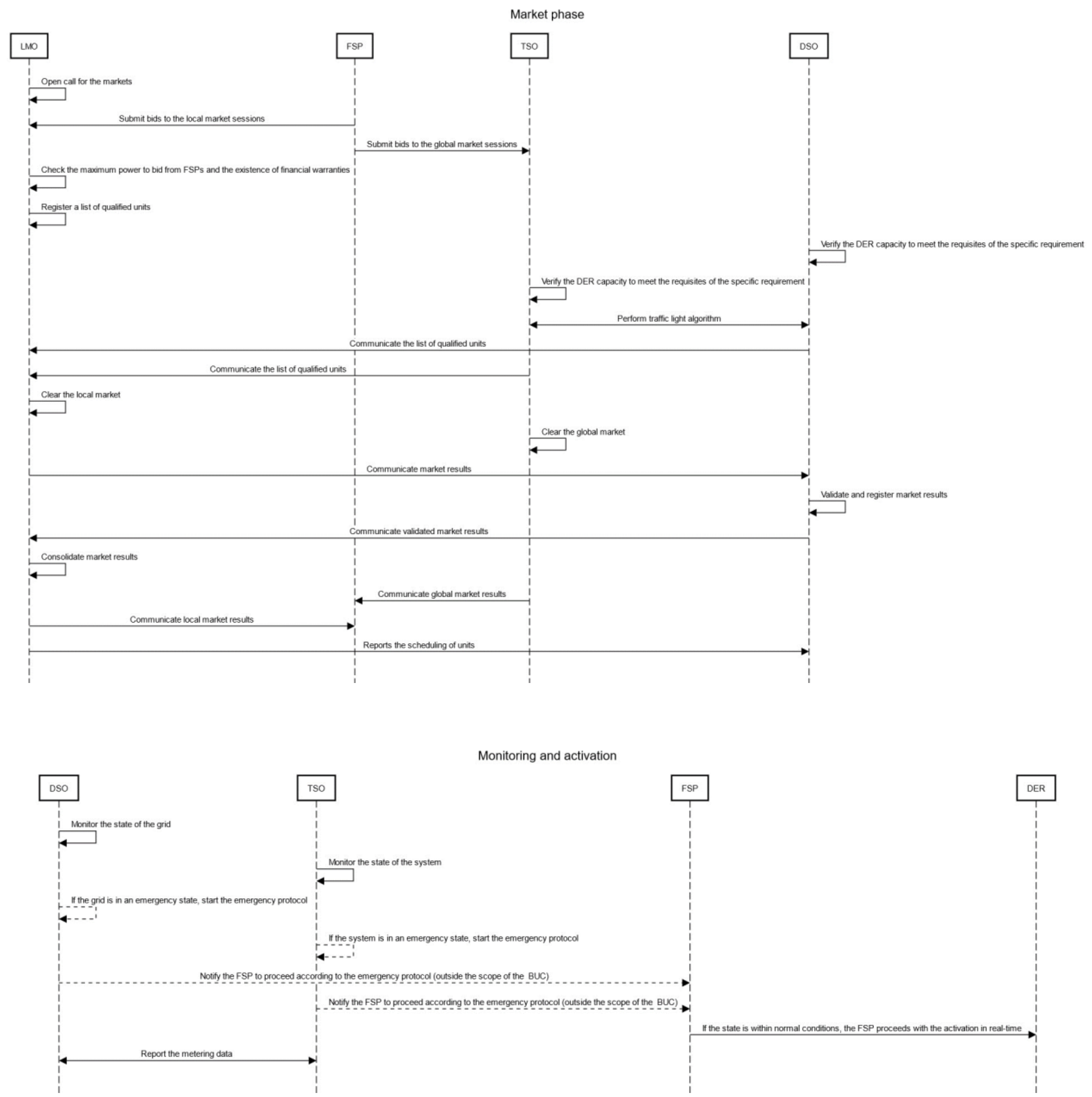

Prepare/Pre-qualification
FSP
DSO
TSO
Registration platform
Request prequalification if wants to participate only in LM
Request prequalification if wants to participate only in the TSO market
Check the technical requirements of flexibility product
Check the technical requirements of flexibility product
Perform joint pre-qualification if SP wants to participate in both markets
Communicate the success or not of FSPs pre-qualification
Communicate the success or not of FSPs pre-qualification
Register the success of FSP as pre-qualified


Traffic light scheme for TSO-DSO coordination
DSO
LMO
TSO
Communicate their system needs
Validation of the market request from the local market
Communicate market outcomes
Define constraints within its network
Send DSO constraints



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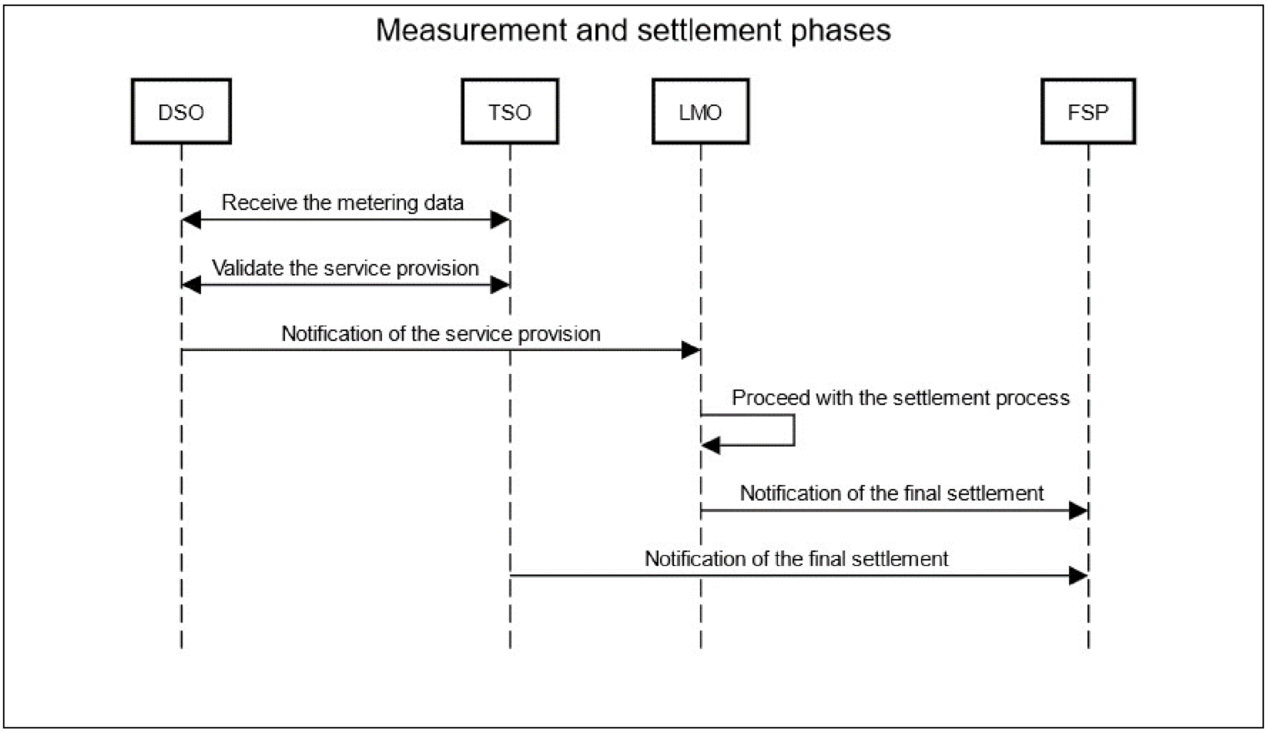

3 Technical details

3.1 Actors

Actors			
Actor Name	***Actor Type***	***Actor Description***	
TSO	Business Role (BeFlexible role model, BRIDGE HEMRM)	Responsible for security of supply and reliability of a transmission network and also real time operation and monitoring, building, expanding, and maintaining the transmission system.	x
DSO	Business Role (BeFlexible role model, BRIDGE HEMRM)	Responsible for the security of supply and reliability of the distribution network. It continuously monitors the grid to detect potential issues and, whenever necessary, it uses multiple resources to solve such problems, including network reconfiguration and/or requesting assistance from Market Operators or directly from contracted customers.	x
Market Operator	Business Role (BRIDGE HEMRM)	Provides a service whereby the offers to sell electricity are matched with the bids to buy it.	x
Resource Aggregator	Business Role (BeFlexible	Aggregates (i.e., collects and combines) multiple resources for usage by a service provider for energy market services.	x

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	role model, BRIDGE HEMRM)		
DER Provider	BeFlexible role model	Responsible for installing and/or maintaining assets related with distributed energy equipment, which are provided/sold to other market agents.	x
Consumer	Business Role (BeFlexible role model, BRIDGE HEMRM)	Party connected to the grid which purchases and consumes electricity.	x
Producer	Business Role (BeFlexible role model, BRIDGE HEMRM)	A party that generates electricity	x
Balance Responsible Party	BeFlexible role model, BRIDGE HEMRM	A Balance Responsible Party is responsible for its imbalances, meaning the difference between the energy volume physically injected to or withdrawn from the system and the final nominated energy volume, including any imbalance adjustment within a given imbalance settlement period	x
Digital Platform Provider	Business Role (BeFlexible role model)	(The ICT/SW/DP Provider) Supports other entities with ICT (Information and Communications Technology), Software (SW) or Digital Platforms (DP).	x
Billing Agent	Business Role (BRIDGE HEMRM)	Responsible for invoicing a concerned party.	x

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

4 Step by step analysis of use case

4.1 Overview of scenarios

Scenario conditions

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No.	Scenario name	Scenario description	Primary actor	Triggering event	Pre-condition	Post-condition
1	Pre-qualification	The process in which it is checked whether a unit can deliver the product it intends to sell.	DSO, TSO	The DSO and TSO receives a request from an FSP to be pre-qualified to offer a flexibility service	The SP complies with the prerequisites publicly made available by the DSO/TSO	The SPUnit (Resource / DER asset) or SPGroup (Aggregate) is pre-qualified.
2	Market phase	Market opening, qualification, bids collection, market clearing and communication of results	Market Operators	The DSO and TSO use a market for the procurement of flexibility.	FSP can offer through pre-qualified SPUnit or SPGroup.	Markets are cleared and FSPs are nominated to deliver the product.
3	Monitoring and activation	Grid monitoring and flexibility bids activation to solve the forecasted congestion management and balancing	DSO, TSO	The real-time for the provision of a service procured in scenario 4 approached	The FSP and the DSO and TSO have the necessary communication infrastructure for the activation order to be sent	The FSP successfully receives the order to provide the flexibility.
4	Measurement phase	Validation of service delivery	DSO, TSO	The service is being provided in real-time or it has been already provided	Metering data is successfully received by the DSO and TSO with the necessary granularity and a baseline method was determined	The DSO, TSO compare the metered data with the baseline previously computed or sent by the FSP.

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4.2 Steps – Scenarios

Pre-qualification

Scenario #1 description

The process in which it is checked whether a unit can deliver the product it intends to sell.

Scenario step by step analysis

Scenario name :							
Step No.	***Event***	***Name of process/ activity***	***Description of process/ activity***	***Service***	***Information producer (actor)***	***Information receiver (actor)***	***Information Exchanged (IDs)***
1.0	FSP requests to be pre-qualified	Pre-qualification request	SO are in charge for their product pre-qualification. Market Operator receives the result for the market access process	CREATE	FSP	TSO, DSO	I.E.01 I.E.02 I.E.03 I.E.04
1.1	DSO, TSO assess the need for a technical validation	Assessment of the need for technical validation	The DSO and TSO may decide that field tests are necessary to ensure that flexibility can be provided by the applicant FSP. In this step, the DSO and TSO	EXECUTE	DSO, TSO	DSO, TSO	

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			assess internally the need for field tests				
1.2	DSO, TSO communicates the need for a technical validation	Notification	If a technical validation is necessary, the FSP is communicated on the new requirement, as well as the details for the technical validation.	REPORT	DSO, TSO	FSP	I.E.05
1.3	DSO, TSO process the results from technical validation	Process technical validation	The DSO internally processes the results of the technical validation test	EXECUTE	DSO, TSO	DSO, TSO	
1.4	The FSP is communicated on the successful pre-qualification	Approved prequalification	The FSP is communicated on the successful pre-qualification	GET	Market Operators	FSP	
1.5	DSO, TSO notify on	Notification (negative)	The DSO, TSO notify the Market Operator on the	REPORT	DSO, TSO	Market Operators	

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	unsuccessful technical validation		result of the technical validation				
1.6	The FSP is communicated on the unsuccessful pre-qualification	Denied pre-qualification	The FSP is communicated on the unsuccessful pre-qualification	GET	Market Operators	FSP	
1.7	The registration platform register to the Market Platform the successful pre-qualification	Registration of pre-qualified FSP(if approved)	The Market Operators register to the Market Platform the successful pre-qualification	CREATE	FSP	Registration Platform	

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Market phase

Scenario #2 description

Explicit bids placement, Local market clearing, Data Exchange across markets, Market coordination via Traffic Light, Global market clearing

Scenario step by step analysis

Scenario								
Scenario name								
Step No	***Event***	***Name of process/activity***	***Description of process/activity***	***Service***	***Information producer (actor)***	***Information receiver (actor)***	***Information exchanged (IDs)***	***Requirement, R-IDs***
2.0	Market platforms notify the GCT	Market closure (GCT)	Market platform notify the GCT	REPORT	Market Platforms	FSP; Market Operators		
2.1	FSP bids to local and global market sessions	Bid	Qualified FSPs may bid to the local market session as long as market session is open (before the Gate Closer Time [GCT])	CREATE	FSP	Market Platforms	I.E.11	
2.2	Market platforms check FSPs	Check warranties	Check the maximum power to bid from FSPs and the existence of financial warranties and register qualified bids	EXECUTE	Market Platforms	FSP; Market Operators		

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2.3	Traffic light execution	DSO executes traffic light algorithms	The DSO defines the Dynamic Traffic Light by taking into account also i) dynamic limitations to the use of the grid, ii) nominal data, iii) overall grid status, iv) historical/forecast data, v) flex data, vi) whatever scenario the DSO deems relevant, vii) Local Flexibility Markets' outcomes viii) every critical threshold to be taken into account.	EXECUTE	DSO	DSO		
2.4	Traffic light reporting	DSO communicates the outcome of DTL	DSO send the results of the traffic light algorithms	REPORT	DSO	TSO		
2.5	TSO, DSO verify requisites	Verification requirements	Verify the DER capacity to meet the requisites of the specific requirements	EXECUTE	TSO, DSO	TSO, DSO		
2.6	TSO, DSO bids qualification	Communicate qualified bids	Communicate the list of qualified bids	CREATE	TSO, DSO	LMO		
2.7	Market Platforms clear the local market	Market clearing	Market Platforms clear the local market	EXECUTE	Market Platforms	Market Platforms		
2.8	FSP bids to global market session	Bid	Qualified FSPs may bid to the global market session as long as market session is open (before the Gate Closer Time [GCT])	CREATE	FSP	Market Platforms	I.E.11	

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2.9	Market Platforms clear the global market	Market clearing	Market Platforms clear the global market	EXECUTE	Market Platforms	Market Platforms		
2.10	Market Platforms report market results	Market results	Market Platform report market results	REPORT	Market Platforms	Market operators; DSO; TSO		
2.11	Market participants are informed of final market results	Notification (market results)	Market participants (DSO, TSO FSPs) are informed of final market results	REPORT	Market Platforms	DSO; TSO: FSP; Market operators	I.E.12 (consolidated)	

Monitoring and Activation

Scenario #3 description

Grid monitoring and flexibility bids activation

Scenario step by step analysis

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Scenario								
Scenario name								
Step No	***Event***	***Name of process/activity***	***Description of process/activity***	***Service***	***Information producer (actor)***	***Information receiver (actor)***	***Information exchanged (IDs)***	***Requirement, R-IDs***
3.0	The DSO and TSO monitor the state of the grid near real-time (activation)	Monitoring conditions near the activation	The DSO and TSO monitor the state of the grid near activation in order to ensure the security of the grid	EXECUTE	DSO, TSO	DSO, TSO		
3.1	If the grid is in an emergency state, the DSO and TSO start the emergency protocol and the BUC is terminated	Beginning emergency state	If the grid is in an emergency state, the DSO and TSO start the emergency protocol and the BUC is terminated, as this situation lies outside the scope of this BUC.	EXECUTE; CLOSE	DSO, TSO	DSO, TSO		
3.2	If the grid is an emergency state, the DSO and TSO notify the FSP to proceed according the emergency protocol (outside the scope of the BUC)	Notification	If the grid is in an emergency state, the DSO and TSO notify the FSP to proceed according the emergency protocol (outside the scope of the BUC). For example, the FSP may be requested to proceed in a previously agreed way, may be exempted from providing flexibility, or may not be	REPORT	DSO, TSO	FSP		

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			notified at all. This situation is outside the scope of this BUC.					
3.3	If the state is within normal conditions, the FSP proceeds with the activation in real-time according to the market results.	Activation	If the state is within normal conditions, the DSO and TSO notify the FSP the needed activation.	EXECUTE	FSP	DER		
3.4	The FSP proceeds with the activation in real-time according to the notified need.	Activation	If the state is within normal conditions, The FSP proceeds with the activation in real-time according to the notified need.	EXECUTE	FSP	DER	I.E.06	
3.5	DSO/TSO reports metering data	Metering data	TSO, DSO reports metering data directly to the corresponding DSO and TSO	REPORT	DSO, TSO	DSO, TSO	I.E.06	

Measurement and settlement phases

Scenario #4 description

Validation of service delivery.

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Scenario step by step analysis

Scenario								
Scenario name								
Step No	***Event***	***Name of process/activity***	***Description of process/activity***	***Service***	***Information producer (actor)***	***Information receiver (actor)***	***Information exchanged (IDs)***	***Requirement, R-IDs***
4.0	DSO and TSO receive metering data	Metering data	DSO and TSO receive metering data (step 3.1 of scenario 4)	GET	DSO, TSO	DSO, TSO	I.E.06	
4.1	The DSO and TSO validate the service provision	Verification of service provision	The DSO and TSO validate the service provision. To do so, the DSO and TSO compare the metered data with the service procured and the baseline predefined.	EXECUTE	DSO, TSO	DSO, TSO		
4.2	Market Operators proceed with the settlement processing	Settlement processing	Market Operators proceed with the settlement processing. According to the level of service provision, penalties (reduction of agreed price/payment) may occur.	EXECUTE	Market Operators	Market Operators		

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4.3	The FSP is notified on the final settlement	Settlement notification	The FSP is notified on the final settlement	REPORT	Market Operators	FSP		

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5 Information exchanged

Information exchanged			
Information exchanged (ID)	*Name of information*	*Description of information exchanged*	*Requirement, R-IDs*
I.E.01	Basic Participant Information	Register and basic information about the market participant such as username and password	
I.E.02	Market participant pre-qualification information	Contact information; Fiscal data; Access contract; bank details; power of representation; confidentiality agreement; declaration of non-collusion	
I.E.03	Market resource pre-qualification information	Market participants provide information on the resources they want to prequalify: Facility/resource name; Type of technology; Location; Market participant; etc.	
I.E.04	Technical resource pre-qualification information	Verification of the installed capacity to provide the service: Power; unit ID information; Maximum quantity; Response time, Etc	
I.E.05	Technical validation for pre-qualification	In case of the need of a technical validation for prequalification, the FSP receives the information on the when and how the test will be conducted: day; time; power to reduce/increase; duration of the test; etc.	
I.E.06	Metering data	Metering data from DER	
I.E.07	Generic attributes	Composed of generic parameters concerning the market session being requested. E.g.: • Auction identifier • Associated DSO and TSO • Product Type: Flexibility Product	

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		• Type of negotiation: Auction Area: Basic or aggregated.	
I.E.08	Product parameters	Composed product parameters concerning the market session is requested. E.g.: 1. Service window: Selection of the required date and duration of the service o Start date: o Duration: o Selection of days: M, T, W, T, F, S and S. o Opening time: o Closing time: 2. Availability: Selection of the capacity, the direction and the estimated hours of activation. o Capacity: o Direction: Upwards (up for generation, down for consumption) o Estimated hours of activation: 3. Activation window (in case of activation product): Specific subperiod in an activation window when a particular DER could be activated and thus it must be available. Multiple sets of activation windows can be defined. E.g.: o Day: o Hour: o Duration: o Capacity to modify: o Direction: 4. Local area: Selection of the trading area. Choice by postal code, connection point, lines… (to be determined). o Area: postal code? 5. Activation Announcement: Time in advance that a DSO and TSO informs a DER that its activation is programmed confirmed. 6. Form of Remuneration: It establishes the form of payment for the winner DERs. Two different terms are defined availability and	

		activation (depending on the product). ○ Type of product: availability/activation Availability/Activation cap price: X €/MW or X €/MWh	
I.E.09	List of pre-qualified units	List of pre-qualified units for a given market session	
I.E.10	List of qualified units (market, technical or consolidated)	List of qualified units for a given market session. The list can refer to the market qualification, technical qualification or the consolidated list.	
I.E.11	Bid	Composed of bidding information 1. General attributes • FSP identifier 2. Availability: Selection of the capacity, the direction and the estimated hours of activation. • Period of availability (multiple periods may be possible within the service window) • Price: for availability and/or activation Additional parameters (complex bids) may be considered (under discussion).	
I.E.12	Validate market results	Validated market results by either the Market Operator, the DSO (technical), TSO or the consolidated market results.	

5 Requirements

Requirements		
Categories ID	**Category name for requirements**	**Category description**
RCR	Regulation on market phases	Draft Proposal for Network Code on Demand Response

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		Framework guidelines on demand response
AM	Regulation for flexibility provision mechanism to be developed	Draft Proposal for Network Code on Demand Response
Requirement R-ID	**Requirement name**	**Requirement description**
RCR-1	Regulation on market phases may establish conditions to be respected	Market phases such as prequalification, market clearing, activation and metering are subject to regulation that define conditions for procedures and transparency to be adopted.
AM-1	Coherency with other electricity markets.	Local market timing has to be coordinated with the existing electricity markets to foster the efficient allocation of resources, avoid distortions, and prevent gaming. Possible imbalances should be adequately considered to avoid system level impacts.

11.10. BUC10 – Dynamic constraints management for global flexibility activation in transmission system operation

1.2 Version management

Version Management			
Version No.	*Date*	*Name of Author(s)*	*Changes*
0.1	19/04/23	Tommaso De Marco	First draft version

1 Description of the use case

1.1 Name of the use case

ID	*Area / Domain(s)*	*Name of Use Case*
BUC10	Grid-centric flexibility	Dynamic constraints management for global flexibility activation in transmission system operation

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1.3 Scope and objectives of use case

Scope and Objectives of Use Case	
Scope	To guarantee the distribution grid security and quality during the provision of global services from distributed resources.
Objective(s)	• To integrate in the global flexibility procurement the possibility to make use of recourses connected to the distribution grid • To avoid indirect contingencies on DSOs
Related business case(s)	N/A

1.4 Narrative of use case

Narrative of Use Case
Short description
Dynamic constraints management aims to integrate in the global flexibility procurement the possibility to make use of resources connected to the distribution grid while avoiding indirect contingencies on DSOs. For this purpose, the Traffic Light Model is implemented as the following coordination scheme describes: the DSO expresses a constraint in terms of capacity available per grid portion to allow the flexibility activation of MV/LV connected resources without creating bottleneck; TSO, when selecting resources needed for the correct and safe operations of the Electricity System, is called to respect the constraints identified by the DSO. To properly enable the Traffic Light Model, a set of coordinated prequalification processes between TSO and DSO should be established and an accessible, customer friendly and secure data exchange platform should be provided to all the stakeholders.
Complete description
Dynamic constraints management aims to integrate into the global flexibility procurement the possibility to make use of resources connected to the distribution grid while avoiding indirect contingencies on DSOs. For this purpose, the Traffic Light Model is implemented as the following coordination scheme describes: • **Registration and prequalification** The BSP registers the flexibility resource of its portfolio and its information (technical) considering the interface of Grid Connection Point (GCP) as reference point. The DSO is informed of every single GCP that the BSP registers onto the platform and starts the validation process. The aim of the validation process is to confirm the possibility for the BSP to use that resource in a pool and if so for which amount of flexible power. Furthermore, the DSO is requested to complement the information available for the resource by adding the field that indicated the reference grid element and the Static Traffic Light as the color code among a predefined list of green, yellow, red associated with a Go, Go-If, No-Go. The DSO is requested to provide the DSO flexible power only in those cases where the Traffic

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Light is yellow as a green light implies the full availability of the BSP flexible power and a red light implies no flexible power at all. When the DSO has concluded the analysis of the GCP it is then enabled to change the status of the asset that the asset itself can continue along the prequalification journey. The information is shared with TSO. The information registered by the BSP on every GCP is complemented by the information available in the TSO systems so that a consistent data package for every GCP is considered. At the end of the GCP validation process, the full spatial information is available and therefore the Topology Matrix can be setup. The Topology Matrix includes the reference DSO Perimeter, the reference TSO perimeter and the GCP linked to both the elements and as registered by the BSP. The Matrix is made available to all parties: BSP, DSO, TSO for the relevant actions and acknowledgment feedback. After the GCPs are registered by the BSP and validated by the DSO, the BSP itself can proceed to combine them together in pools of resources (where number of resources is >=1) and register them. The resource group information is shared with the TSO and the pool qualification process starts so that the asset can be qualified into the global market.

System Use Case called by the step
SUC 10.1: Ex-ante validation

- **Dynamic Traffic Lights creation**
  If there are MV/LV distributed flexibility resources connected to the distribution grid and qualified to provide global services, the DSO must necessarily and continuously assess its own grid capacity to express limits to the flexibility activation. This ability is the Dynamic Traffic Light that is to be referred at a specific grid interface between the involved grid operators. The constraint is ideally expressed by the DSO based on technical data such as: net exchanges, overall grid status, forecasts, historical data, nominal ratings. Generally, the DSO is able to define the optimal methodology to define the grid constraint so as to minimize the flexibility limitations. Considering the detected criticalities, DSO informs the TSO about the Dynamic Traffic Light values (DSO DTL) referring to the grid interface defined in the Topology Matrix: no restriction on the use of flexibility resources (Green), presence of restrictions on the use of flexibility resources (Yellow), or the use of flexibility resources is not possible for the existence of criticalities (Red). In tandem with the Traffic Light color the DSO is also responsible for expressing the actual value of the constraint for each DSO Grid Element that is characterized by a Yellow Traffic Light. The constraint value can also be defaulted by the DSO if there is no intention on providing a dynamic value. The DSO is allowed to provide a single set of the mentioned elements for every time window of operation of the global market (24 hourly values) with a time horizon of 24h forward; the DSO on the D-1 expresses the constraints valid for D with possibility to update them during D consistently with global market operation.

System Use Case called by the step
SUC 10.2: Constraints definition

- **Grid constraints integration**

  Based on their own business operations the BSP creates global market bids based on available flexibility and forwards them to the market operator, identified as 3rd Party. The bid that is forwarded to the market operator is defined by an aggregate price and an aggregate quantity together with a validity time and timestamp. At the same time the BSP is requested to give the TSO visibility in the components of the bid at DSO perimeter level. This level of information is needed so as to compare the constraint provided by the DSO and the quantity the BSP is meaning to activate in case of selection. The BSP is allowed to provide a single set of the mentioned elements for every time window of operation of the global market (24 hourly values) with a time horizon of 24h forward; the BSP on the D-1 expresses the flexibility bids valid for D with possibility to update them during D consistently with global market operation. The TSO shall be able to read the content shared by the BSP according to the global market operational timing. The TSO read the information and forwards it to the relevant market system so that the constraints can be properly allocated onto involved bids. After the reception of DSO information regarding constraints per secondary substation and BSP cumulative flexibility bids available at secondary substation, TSO compares on each substation the flexible availability offered by BSP and the Dynamic Traffic Light constraints imposed by the DSOs. The TSO, at this point, evaluates the resources activation taking into consideration the DSO constraints to avoid distribution grid bottlenecks. Therefore, the TSO proceeds to assign the TSO Dynamic Traffic Light to each bidding component communicated by the BSP. The TSO's global market clearing algorithm receives from the 3rd Party all bids placed for assets participating in the global market and the previously adjusted bids (those that were subject to a DSO constraint) are processed as per the usual market clearing processes. The TSO registers the market clearing outputs at the end of every single Selection process; it collects validated upward/downward quantities and accepted/reserved quantities for every period of the market session. If there are modified flexibility bid components (related to bids that have undergone limitations due to DSO constraints), the TSO informs the BSP about limitations. Finally, the BSP, that had submitted at least one aggregate with MV/LV resources, receives the global market results; specifically, it is informed by the TSO about the bidding components that are selected to the global services provision. The BSP must receive that information package because it is responsible to the proper flexibility activation in order to supply ancillary services to the TSO.

System Use Case called by the step
SUC 10.3: Bids placements and verification

- **TSO and DSO Verification**

  As a matter of fact the DSO will be able to verify whether the BSP has correctly activated the resources in its portfolio compliant to the selection made by the TSO (which in turn is compliant with the DSO constraint) by using the measurements of the certified meter installed at the resource premises as per any flexibility service in place at the moment.

System Use Case called by the step
SUC 10.4: Delivery validation

All market model processes adopt a single data exchange platform to standardize TSO, DSOs and BSPs participation.

1.5 Key performance indicators (KPI)

ID	*Name*	*Description*	*Reference to mentioned use case objectives*

1	*KPI10.1*	Impact of local constraints on DER providing global services	Integrate in the global flexibility procurement the possibility to make use of resources connected to the distribution grid

1.6 Use case conditions

Use case conditions
Assumptions
• There are a few distributed resources available for global services market • The DSO cannot impose activation limits to the distributed resources
Prerequisites
• The BSP is compliant with market access rules • The BSP's distributed resources fulfil technical requirements • The DSO participates into the Traffic Light project in compliance with the project regulation • TSO, DSOs and BSPs have access to the data exchange platform

1.7 Further Information to the use case for classification / mapping

Classification Information
Relation to other use cases
N/A
Level of depth
Business use case (BUC)
Prioritisation
High priority for Italian demo
Generic, regional or national relation
National
Nature of the use case
Technical Business Use Case focused on market processes
Further keywords for classification
Distributed resources, electric vehicles, renewable energy, storage, DSO constraints, Traffic Light, TSO-DSO coordination, global services market, data exchange platform

1.8 General Remarks

General Remarks
DSO participation will be not mandatory.

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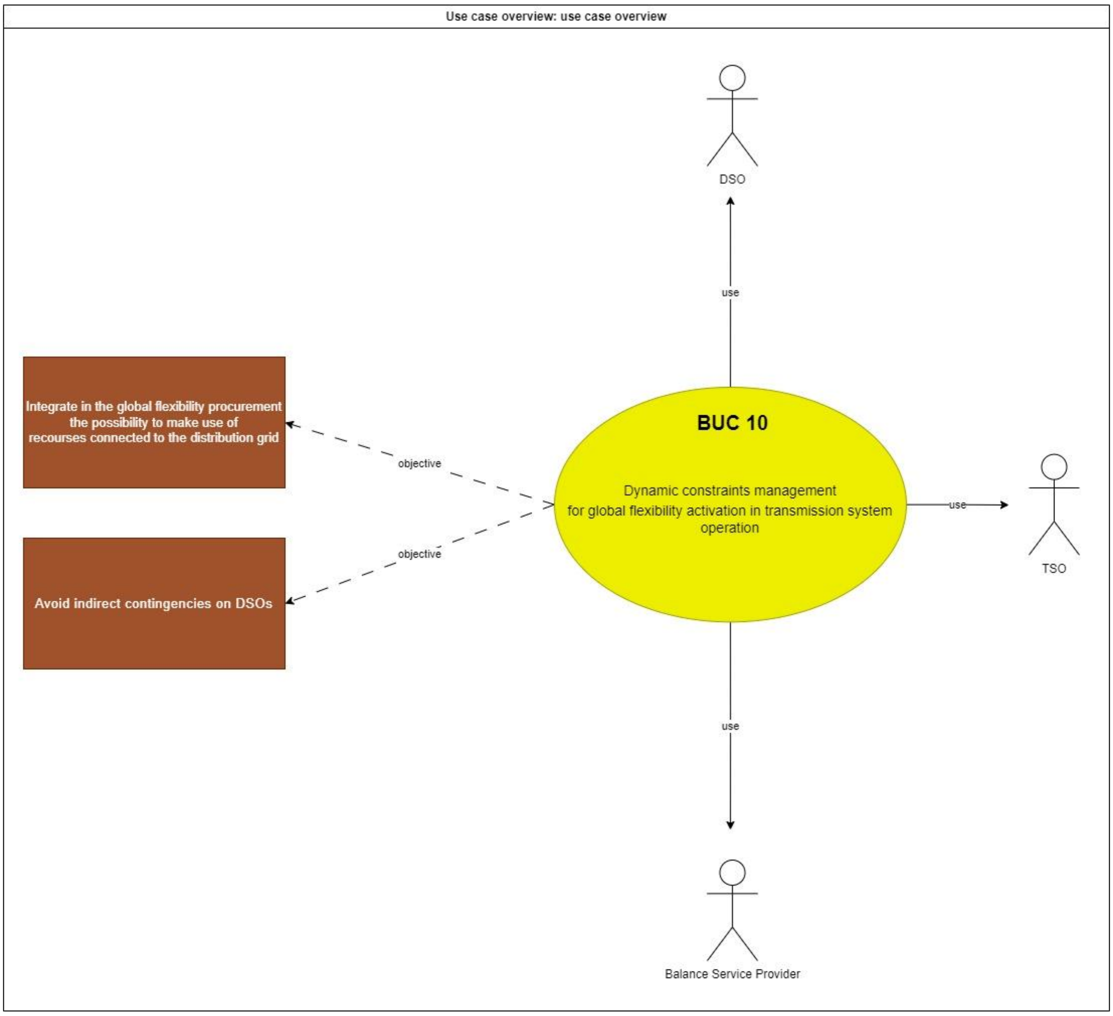
2 Diagrams of use case

Diagram(s) of use case


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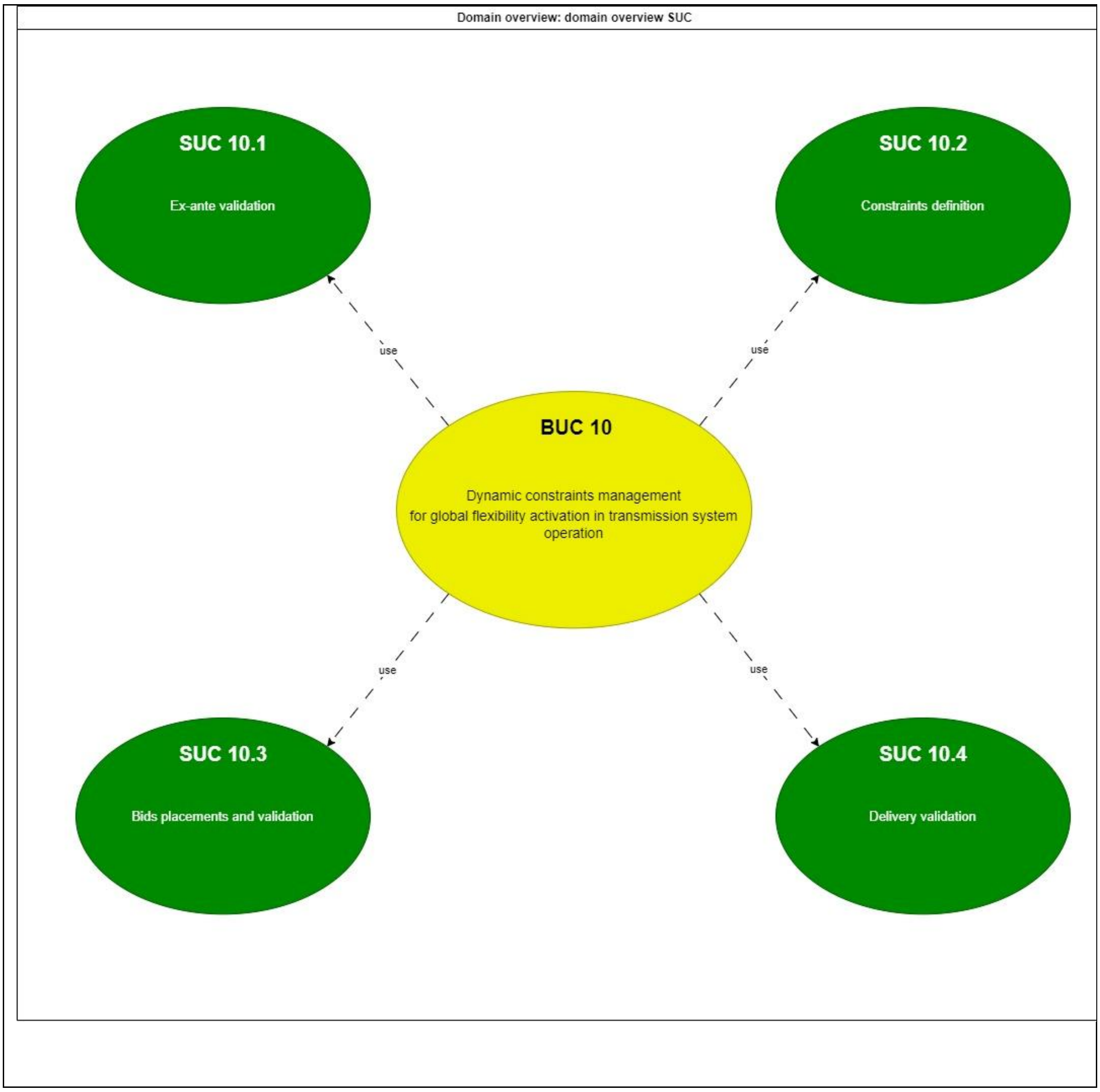

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3 Technical details

3.1 Actors

Actors		
Actor Name	***Actor Type***	***Actor Description***
Balancing Service Provider (BSP)	Business Role (BRIDGE HEMRM)	A party with reserve-providing units or reserve-providing groups able to provide balancing services to one or more LFC Operators
DSO	Business Role (BRIDGE HEMRM)	A DSO is a System Operator. DSO is responsible for security of supply and reliability of the distribution grid. For this reason, it monitors the grid to identify possible arising issues and, if there is a need, it makes use of resources to solve such problems, by network reconfiguration and/or by requests to market operators or directly to properly contracted customers.
TSO	Business Role (BRIDGE HEMRM)	TSO is a System Operator. TSO is responsible for security of supply and reliability of the transmission grid. For this reason, it monitors the grid to identify possible arising issues and, if there is a need, it makes use of resources to solve such problems, by network reconfiguration and/or by requests to market operators or directly to properly contracted customers.

3.2 References

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

4 Requirements

Requirements		
Categories ID	**Category name for requirements**	**Category description**
N/A	N/A	N/A

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Requirement R-ID	Requirement name	Requirement description
N/A	N/A	N/A

5 Common Terms and Definitions

Common Terms and Definitions	
Term	**Definition**
N/A	N/A

11.11. BUC11 – Capitalizing on flexibility available by leveraging on water distribution network assets

1 Description of the use case

1.1 Name of the use case

ID	*Area / Domain(s)*	*Name of Use Case*
BUC11	Cross-sector flexibility boosters	Capitalizing on flexibility available by leveraging on water distribution network assets

1.2 Version management

Version Management			
Version No.	*Date*	*Name of Author(s)*	*Changes*
0.1	26.04.2023	Olivia Cicala	First draft version
0.2	29.05.2023	Ferdinando Bosco	Added UC diagrams and Scenario 1
0.3	12.06.2023	Olivia Cicala	Final version

1.3 Scope and objectives of use case

Scope and Objectives of Use Case	
Scope	Investigate new methods to boost cross-sector flexibility
Objective(s)	The main goal is the exploitation of Water Distribution Network (WDN) capability to provide flexibility services to avoid/solve grid issues
Related business case(s)	-BUC 04: Long-term distribution grid congestion management -BUC05: Aggregation for TSO and DSO grid services -BUC 06- Short-term congestion constraints forecasting and management for local flexibility service activation.

1.4 Narrative of use case

Narrative of Use Case

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Short description
The main actors of this use case are • The Water Distribution System Operator (WDS-O) who is a party that is responsible for distributing and managing water resources from the withdrawal by supply sources to the final consumers. • Its role in this BUC is studying the behaviour of water distribution assets in order to quantify the flexibility potential of its assets to make it available to the electrical grids • The Distribution System Operator (DSO) who is a party that is responsible for distributing and managing energy to the final consumers. • Its role in this BUC is provide tools and devices in order to monitor flexibility offered by WDS-O. This Use Case consists in: • Studying of the behaviour of water distribution assets • Defining the process to monitor flexibility asset (tools and devices to provide flexibility) • Quantify flexibility potential to make it available to the electrical grids This will enable the integration of the energy flexibility of water distribution systems in power systems operation. The benefits are • From WDS-O side, optimizing the operation of Water Distribution System flexible components for minimizing its energy costs, while respecting the hydraulic operation constraints of the Water Distribution System • From DSO side, evaluate available flexibility purchased by W-DSO in specific periods of the years
Complete description
Traditionally, water and power systems have been designed and operated as two uncoupled systems. However, in reality these systems are mutually interdependent. Water is used, often in large amounts, in energy sector for mining, fuel production, hydropower, and power plant cooling. On the other hand, energy is an indispensable component of the waterfacilities as electricity is used for pumping, treatment and distribution of water. This interrelationship is often referred to as water-energy nexus and couples these critical infrastructures upon which human civilization depends. The large energy consumption of water facilities along with their flexible assets such as water pumps and tanks make them suitable candidates for energy efficiency and optimization applications. The water distribution system operators (W-DSOs) have a natural incentive to act energy-conscious, where the operation coordination with power systems could reduce their electricity costs. However, W-DSOs may be also concerned about the negative impacts of modifying the operation of their systems on the reliable delivery of water to the consumers. For the reasons outlined above, the BUC is focused on determining the flexibility potential from water distribution network to make it available to the electrical grids, thanks to a device provided by DSO to monitor the flexibility resource. **1. Study of the behavior of water distribution assets** The main steps of the study are • defining the water distribution network portion being studied • monitoring and analizing main hydraulic (flow rate and hydraulic head) and energy parameters (Electricity Consumption) of the portion of the water distribution network studied • matching water demand with energy consumption of the portion of water distribution network studied • forecasting water demand **2. Defining the process to monitor flexibility asset (tools and devices to provide flexibility)** The main steps are • The DSO provides to the WDS-O a device which is able to monitor and certify measurements by blockchain technology.

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- The DSO collects measurement in the Flexibility Register
-

3. Quantify flexibility potential to make it available to the electrical grids

The main steps of the analysis are

- The DSO runs the algorithm to evaluate the baseline of the flexibility assets
- The DSO monitors available flexibility

1.5 Key performance indicators (KPI)

ID	Name	Description	Reference to mentioned use case objectives
1	Available Flexibility	Available Power Flexibility in a defined asset configuration that can be allocated by the DSO at a specific grid perimeter. Measured in kW.	All

1.6 Use case conditions

Use case conditions
Assumptions
Prerequisites
• Availability of devices to monitoring flexibility resource • Availability of DSO smart meter for Medium and Low Voltage connection • Availability of Flexibility Register, which is a database that collects measurements and anagraphic data of flexibility assets

1.7 Further Information to the use case for classification / mapping

Classification Information
Relation to other use cases
BUC 04: Long-term distribution grid congestion management
BUC06 – Short-term congestion constraints forecasting and management for local flexibility service activation
BUC05: Aggregation for TSO and DSO grid services
Level of depth
Business use case (BUC)
Prioritisation
Generic, regional or national relation
Generic
Nature of the use case
Business case
Further keywords for classification

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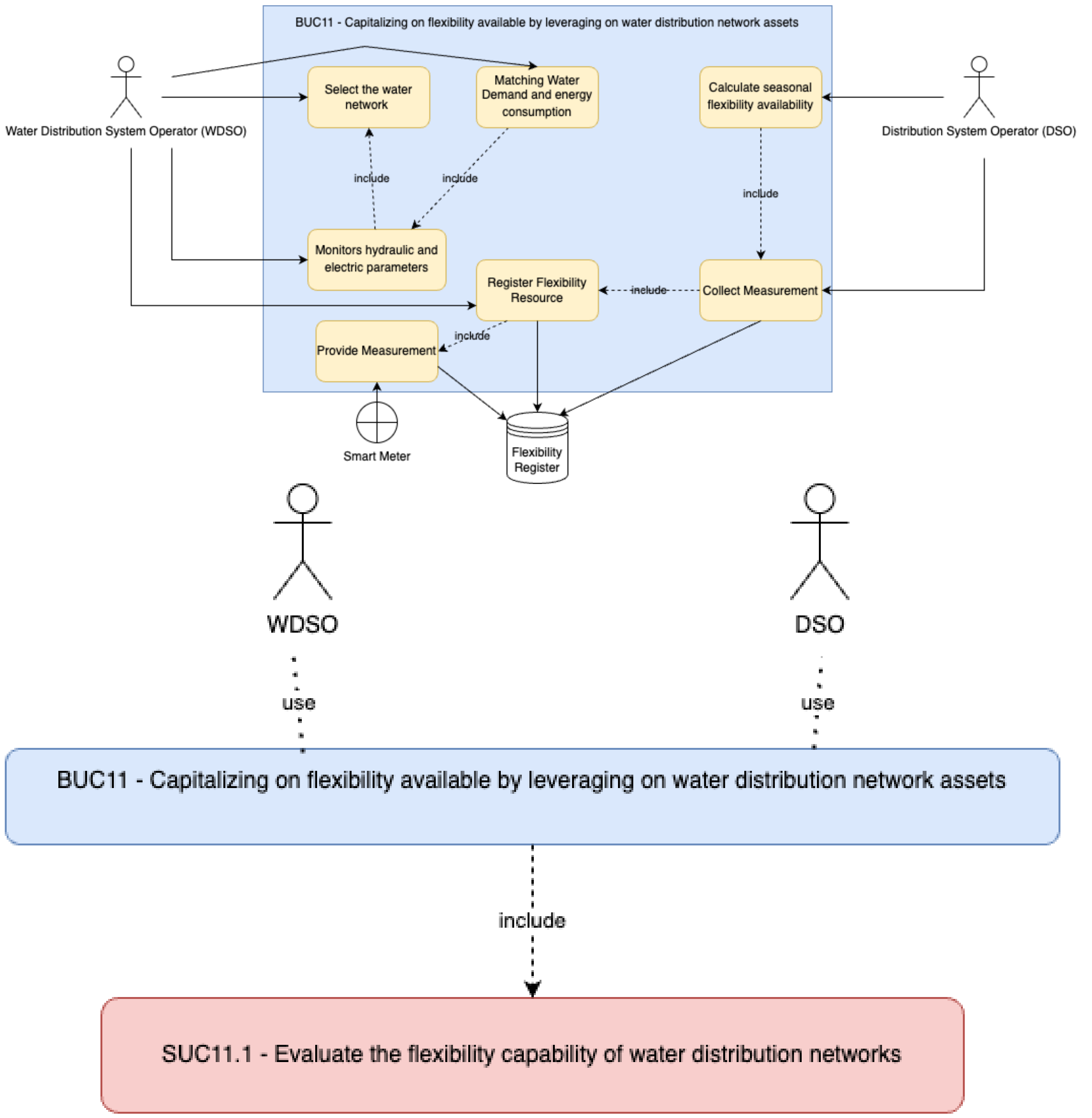
Renewable energy, local flexibility, planning, storage, asset sharing, Blockchain Access Layer, Access Layer,

1.8 General Remarks

General Remarks

2 Diagrams of use case

Diagram(s) of use case


3 Technical details

3.1 Actors

Actors		
Actor Name	***Actor Type***	***Actor Description***
Water Distribution System Operator (WDSO)	Business Role (BRIDGE HEMRM)	A WDSO is a party responsible for security of supply and reliability of the water distribution grid.
Distribution System Operator (DSO)	Business Role (BRIDGE HEMRM)	A DSO is a System Operator. DSO is responsible for security of supply and reliability of the distribution grid. For this reason, it monitors the grid in order to identify possible arising issues and, if there is a need, it makes use of resources to solve such problems, by network reconfiguration and/or by requests to market operators or directly to properly contracted customers. In addition to the above and more in detail: -is responsible for the access of the customers to the grid; -operates, maintains, develops and is fully responsible of the part of the electricity system, named "Distribution Network", typically starting from the HV/MV transformers (or vHV/HV transformers depending upon Member State Regulation) down to the customer's POD; -acts on Local Flexibility Market requiring Local Flexibility Services to solve distribution grids issues; -ensures a transparent and non-discriminatory access to the distribution network for each users; -assess network status of the distribution grid and broadcasts selected information of the network status to eligible actors (e.g. aggregators, other system operators); -in critical situations, implements dedicated actions and deliver alerts during stress events If necessary, implement emergency measures including load shedding and DER curtailment; -cooperates with the Transmission System Operator in carrying out their responsibilities (e.g. load shedding).

3.2 References

References						
No.	***References Type***	***Reference***	***Status***	***Impact on use case***	***Originator / organisation***	***Link***
1	Scientific paper	Optimal Coordination of Water Distribution Energy Flexibility With Power Systems Operation	Published.		IEEE	

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	**Study of the behavior of water distribution assets**	defining the water distribution network portion being studied monitoring and analizing main hydraulic	WDS-O	At the beginning of the project	Availability of flexibility assets connected to the selected portion of grid	
2	**Defining the process to monitor flexibility asset (tools and devices to provide flexibility)**	Collecting measurements and analyzing data	DSO	Occurs periodically (daily)	Availability of measurements coming from the field	Outcome of the analysis
3	**Quantify their flexibility potential to make it available to the electrical grids**	Runs the algorithm to evaluate the baseline of the flexibility assets	DSO	Occurs periodically (seasonal)		Flexibility potential quantified

4.2 Steps – Scenarios

Scenario								
Scenario name : Study of the behavior of water distribution assets		***No. 1 -*** **Study of the behavior of water distribution assets**						
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	At the beginning of the project	Defining the water distribution network portion being studied	Detecting the network topology	CREATE	WDS-O	WDS-O		FLEX-VOL1
2	Occurs periodically (daily)	Monitoring main hydraulic and energy parameters	monitoring and analizing main hydraulic (flow rate and hydraulic head) and energy parameters (Electricity Consumption) of the portion of the water distribution network studied	GET	WDS-O	WDS-O	ID2, ID3	
3	Occurs periodically (daily)	Matching Water Demand and energy consumption	Matching water demand with energy consumption of the portion of water distribution network studied	CREATE	WDS-O	WDS-O	ID2, ID3	
4	On Event	Registration in the Flexibility Register	Provide DER information, in to the flexibility register	GET	WDS-O	DSO	ID1, ID3	

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Scenario								
Scenario name : **Defining the process to monitor flexibility asset**		No. 2 - **Defining the process to monitor flexibility 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*
1	Occurs periodically (daily)	Monitoring flexibility Resources	Providing a device which is able to monitor and certify measurements by blockchain technology	create	DSO		ID3	
2	Occurs periodically (yearly)	Determining Seasonal availability	collecting measurement in the Flexibility Register	GET	DSO	DSO		

Scenario								
Scenario name : Quantify flexibility potential to make it available to the electrical grids		*No. 3 Quantify flexibility potential to make it available to the electrical grids*						
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	Occurs periodically (daily)	Determining Baseline of flexibility assets	The DSO runs the algorithm to evaluate the baseline of the flexibility assets	create	DSO	W-DSO		

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2	Occurs periodically (yearly)	Determining Seasonal availability Flexibility	The DSO monitors available flexibility	GET	DSO	W-DSO	ID4, ID5	

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5 Information exchanged

Information exchanged			
Information exchanged (ID)	*Name of information*	*Description of information exchanged*	*Requirement, R-IDs*
ID1	Registration data	All the technical, legal data of the resource connected to the distribution grid;	
ID2	Hydraulic parameters	flow rate and hydraulic head of the portion of the water distribution network studied	
ID3	Energy parameters	Electricity Consumption of the portion of the water distribution network studied	
ID4	Potential Power Flexibility	Potential Power Flexibility in a defined asset configuration that can be allocated by the DSO at a specific grid perimeter	
ID5	Seasonal Power Flexibility	Amount of Power Flexibility available in a specific season of the year	

6 Requirements

Requirements		
Categories ID	**Category name for requirements**	**Category description**
FLEX-VOL	Consent to participate in flexibility services	The W-DSO gives consent to participate in flexibility services.
Requirement R-ID	**Requirement name**	**Requirement description**
FLEX-VOL1	Opt in	The W-DSO should opt in to participate in flexibility services.

7 Common Terms and Definitions

Common Terms and Definitions	
Term	**Definition**
WDS-O	Water Distribution System Operator
DSO	Distribution System Operator
FLEXIBILITY REGISTER	Unique Database to collect the flexibility data

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11.12. BUC12 – Operating a value chain enabler for flexibility-centric energy and non-energy services

1 Description of the use case

1.1 Name of the use case

ID	Area / Domain(s)	Name of Use Case
BUC 12	Cross-sector flexibility booster	Operating a value chain enabler for flexibility-centric energy and non-energy services.

1.2 Version management

Version Management			
Version No.	Date	Name of Author(s)	Changes
0.1	03.02.2023	Fábio Coelho (INESCTEC)	First draft.
0.2	24.04.2023	Fábio Coelho (INESCTEC)	Scenarios and step by step definition.
0.3	29.05.2023	Fábio Coelho (INESCTEC)	Reshape of the objectives and descriptions.
0.4	20.06.2023	Stephane Dotto, Mateo Munar, PAZZAGLIA, Jean-Christophe (SAP)	Review of contents, clarifications and new KPIs
0.5	28.06.2023	Fábio Coelho (INESCTEC)	Clarification of cash-flow and contractual monitoring needs in section 4. Review of KPIs.
1.0	30.10.2023	Fábio Coelho (INESCTEC)	Final review

1.3 Scope and objectives of use case

Scope and Objectives of Use Case	
Scope	This UC describes the operation of a value chain enabler for flexibility-centric and non-energy services. The vision is taken from the main perspective of a Digital Platform Provider to: • Promote sustainable business models to unlock the distributed flexibility capacity of final consumers for an improved system operation, with special emphasis on DSO flexibility system services. • Facilitate DSOs of all sizes to participate in the flexibility value-chain
Objective(s)	3. Identify and unlock consumers flexibility capacity by facilitating flexible resources acquisition or retrofit and their integration into the flexibility provision value chain. 4. Simplify the process of customer identification and acquisition in the scope of DSF services. 5. Streamline a low-cost establishment of renewable energy communities with flexibility provision. 6. Create business opportunities by linking prosumers, aggregators, DSOs and local flexibility and aggregator platforms for the different steps of the value chain. 7. Facilitate the dispatch and activation process of flexibility.

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Related business case(s)	BUC 6 – Short term congestion constraints forecasting and management for local flexibility service activation.

1.4 Narrative of use case

Narrative of Use Case
Short description
Operation of a flexibility-centric value chain that leverages from a cloud-based digital platform (Grid Data Business Network - GDBN) to connect and engage key stakeholders in promoting new business services for energy flexibility. The main goals are: • Connect consumers with suppliers/installers/O&M service providers of flexible DER to participate in the value chain and exploit flexibility business models. • Offer and search for targeted energy and non-energy services to consumers. • Validate contractual agreements between parties. • Integrate cash-flow mechanisms in the value-chain. • Enable the DSO to dispatch and activate flexibility in a fully interoperable way.
Complete description
The Business use case is described from the perspective of the Digital Platform Provider as Primary Actor. It allows to: **1. Engage flexibility stakeholders to participate in the value chain. [Flexibility Capacitation]** • Prosumers (with or without flexible assets) and providers of services with business cases exploiting flexibility are engaged in the value-chain to exploit all available flexibility potential. Service providers exploit business models to install flexible assets in candidate consumers in exchange for their participation while providing them incentives. Contractual relationships between stakeholders are handled and recorded. Service subscriptions benefit from the integrated cash-flow. **2. Integrate flexible assets and services in the value chain. [Integration/Enablement]** • Service providers integrate their operational platforms with the value chain enabler to collect the flexibility potential from prosumers. Prosumers integrate their smart flexible assets with the value-chain enabler directly or as part of the flexibility capacitation described in 1. The latter happens when service providers install flexible assets that are integrated with the service provider's operational platform. • ***System Use Case called by the step*** SUC12.1 – Connect flexibility providers across the value chain **3. Aggregate flexibility potential. [Aggregation]** This step considers an upstream and downstream stage, respectively covering preparations to market operation and the results from market operation. • A renewable energy community manager embodying the role of aggregator, or an aggregator creates and pre-qualifies a flexibility bid that will be submitted to market negotiation during the upstream stage. In the downstream stage, the renewable energy community manager disaggregates the flexibility bids that were selected for activation and settles the process. Service providers with subscribed prosumers or capacitated prosumers are expected to activate the flexible loads. • ***System Use Case called by the step*** SUC12.2 – Support investment in flexibility by value chain actors • **4. Prepare flexibility bids and take them to Market. [Negotiation]** • Flexibility needs are established considering the flexibility zones. Flexibility bids are prepared by the Aggregator. The DSO pre-qualifies the bids with the expectation that they are activated during the activation and settlement stage after market clearing.

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5. **Operate Market and select flexibility bids. [Market Operation]**
   - The Flexibility Market Operator via its market digital platform allows flexibility bids to be selected. Contractual agreements are validated or established to fulfil the procurement of flexibility between stakeholders.

6. **Enable the DSO to dispatch flexibility in a fully interoperable way. [Activation & Settlement]**
   - During the downstream stage, the DSO dispatches the activation of flexibility to aggregators or to the Renewable Energy Community Manager, with the expectation that aggregators disaggregate the activation to prosumers. The interoperable interface allows linking with several aggregator interfaces, with the expectation of no barriers or interface lockdowns. Most importantly it pushes for prosumers to directly collect the activation signals from DSOs. Compensations as part of the flexibility cash-flow and the settlement process is handled and billing is triggered directly in the value-chain enabler.

System Use Case called by the step
SUC06.2 –Short term Flexibility activation for DSO congestion management

Handling and validation of contractual agreements between stakeholders of the distinct stages is considered as a transversal capability. Adoption of common cash-flow mechanisms in the several stages is considered as a transversal capability.

1.5 Key performance indicators (KPI)

ID	*Name*	*Description*	*Reference to mentioned use case objectives*
12.1	Number of consumers that acquired demand side flexibility potential through the value chain.	Number of consumers that acquired demand side flexibility potential through the value chain.	1,2
12.2	Consumer awareness and engagement	Measure the satisfaction on consumers using the services available in the GDBN (including those from external parties - ESCos and FSPs)	1,2
12.3	Number of services operating the value-chain	The total number of services in the GDBN.	3,4
12.4	Number of consumers that have used the GDBN	Number of customers onboarded on services of the GDBN	1,4
12.5	Number of GDBN user connections	Averaged number of users connecting to the GDBN every month.	3,4
12.6	Flexibility capacity unlocked through the GDBN	Flexible assets (classified by type) made available via services provided in the GDBN.	1,2,3,4,5
12.7	Flexibility activated by the DSO via the GDBN	The flexibility activation requests that were dispatched by the DSO to be activated in FSPs onboarded in the GDBN, provided that regulation allows it.	5

1.6 Use case conditions

Use case conditions
Assumptions
The energy and non-energy services are not detailed in this BUC (just their relationship in the value-chain enabler). The business models and services from energy stakeholders are not described in this BUC. Some processes of the value chain pertain a periodic operation namely: the aggregation,

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negotiation, market operation and activation & settlement. An upstream direction is set promoting the sequence in stages as: aggregation, negotiation, market operation, activation & settlement. A downstream direction is set, inverting the sequence as to push down the activation of flexibility bids, namely: activation & settlement, aggregation.
Prerequisites
Service providers have services with an associated business use case that places incentives for consumers/prosumers to contribute with their flexibility capacity.

1.7 Further Information to the use case for classification / mapping

Classification Information
Relation to other use cases
BUC 6 – Short term congestion constraints forecasting and management for local flexibility service activation.
Level of depth
Business use case (BUC) use case which describes a general requirement, idea, or concept independently from a specific technical realization like an architectural solution
Prioritisation
High Level of Priority – To be demonstrated in Spain (Pilot 3.2) and France (Pilot 3.5,3.6).
Generic, regional or national relation
Generic
Nature of the use case
Cross-sector: flexibility boosters.
Further keywords for classification
Flexibility, value-chain,cross-sector,GDBN

1.8 General Remarks

General Remarks
The value-chain enabler is to be deployed with as a Software as a Service approach.

2 Diagrams of use case

Diagram(s) of use case

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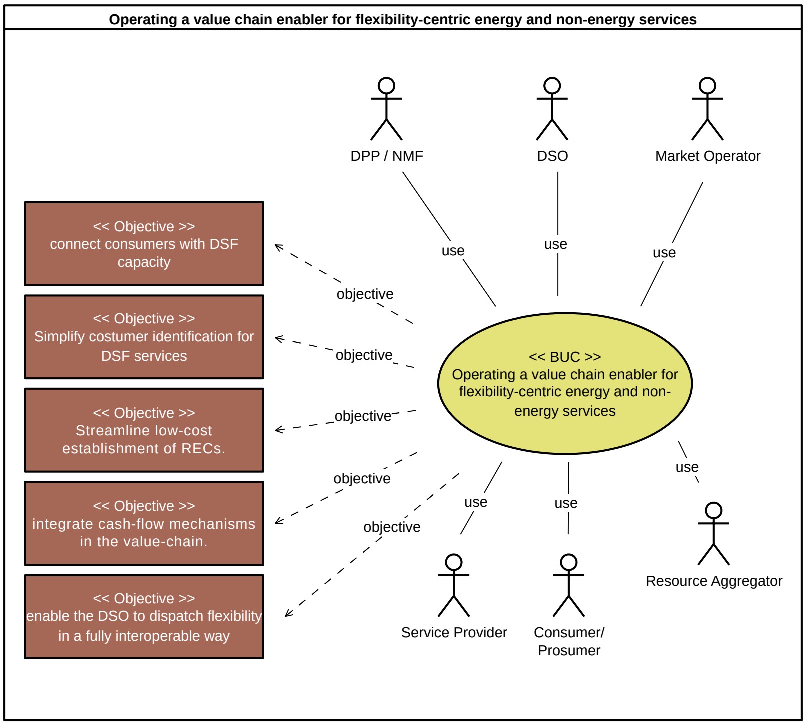

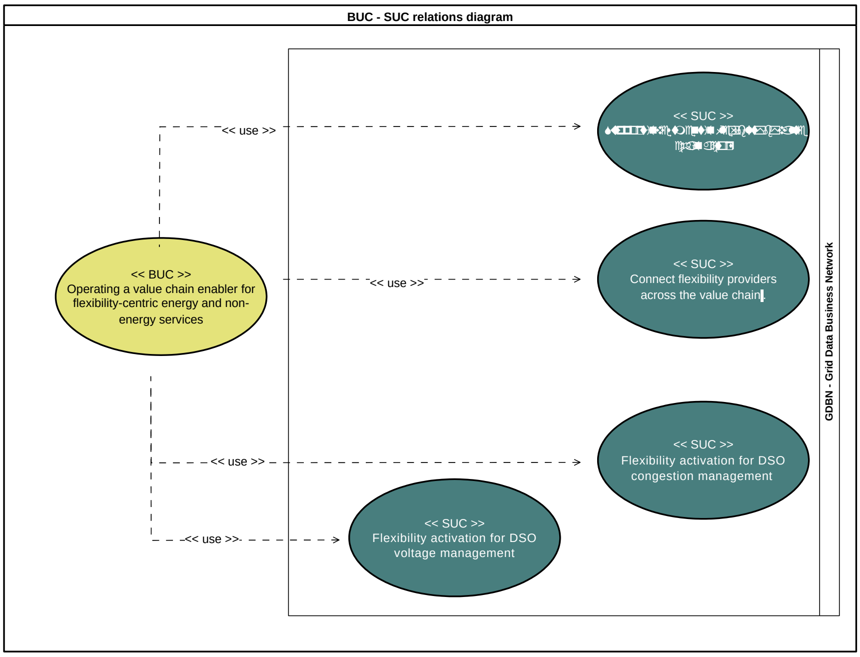

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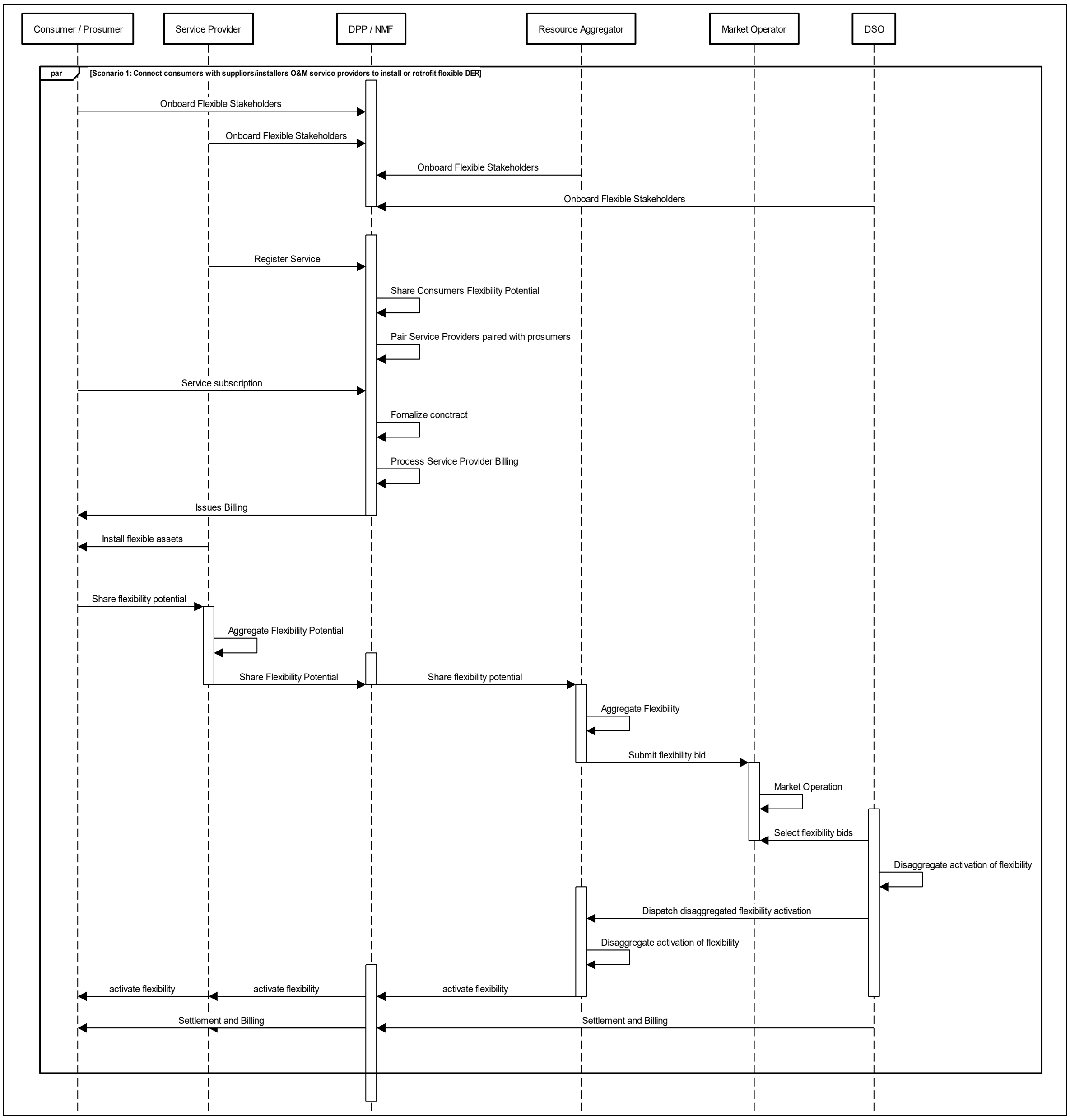

3 Technical details

3.1 Actors

Actors		
Actor Name	***Actor Type***	***Actor Description***
DSO	Business Role (BeFlexible role model, BRIDGE HEMRM [1])	Responsible for the security of supply and reliability of the distribution network. It continuously monitors the grid to detect potential issues and, whenever necessary, it uses multiple resources to solve such problems, including network reconfiguration and/or requesting assistance from market operators or directly from contracted customers.

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Resource Aggregator	Business Role (BeFlexible role model, BRIDGE HEMRM [1])	Aggregates (i.e., collects and combines) multiple resources for usage by a service provider for energy market services.
DER Provider	BeFlexible role model	Responsible for installing and/or maintaining assets related with distributed energy equipment, which are provided/sold to other market agents.
Consumer	Business Role (BeFlexible role model, BRIDGE HEMRM [1])	Party connected to the grid which purchases and consumes electricity.
Market Operator	Business Role (BRIDGE HEMRM [1])	Provides a service whereby the offers to sell electricity are matched with the bids to buy it.
Digital Platform Provider	Business Role (BeFlexible role model)	(The ICT/SW/DP Provider) Supports other entities with ICT (Information and Communications Technology), Software (SW) or Digital Platforms (DP).
NMF	(BeFlexible role model)	Operates a transparent and non-discriminatory platform to automate the exchange of flexibility among different parties.

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

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	Explore consumers flexibility potential and take it to market via a flexibility value-chain enabler	Explore DER flexibility through a value-chain enabler, linking consumers with flexibility service providers that explore their flexibility potential in the market.	Digital Platform Provider	Consumers and Flexibility Service Providers explore the available flexibility potential and take it to market for later activation.	Services with a business model to subscribes services with a monthly fee to in return of installed DER assets; consumers onboarded in the GDBN	Consumers contribute with flexibility towards the value-chain and collect incentives when activating procured flexibility.

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4.2 Steps – Scenarios

Scenario								
Scenario name :	No. 1 – Explore consumers flexibility potential and take it to market via a flexibility value-chain enabler.							
Step No.	Event	Name of process/ activity	Description of process/ activity	Service	Information producer (actor)	Information receiver (actor)	Information Exchanged (IDs)	Requirement, R-IDs
1.1	Stakeholders onboard the value-chain enabler	Onboard Flexible Stakeholders	Registered stakeholders are onboarded on the value-chain enabler but going through the Flex capacitation stage of the flexibility centric value chain. Consumers and their underlying flexible assets become discoverable. - SUC 12.1	CREATE	Consumer, Service Provider, DSO, Resource Aggregator	DPP	I-1, I-2, I-3, I-4, I-8	GDPR-[1-4]
1.2	Service provider registers service	Register Service	Service Provider registers service offering in the value-chain enabler. - SUC 12.1	CREATE	Service Provider	DPP	I-5, I-7, I-8, I-9	GDPR-[1-4]
1.3	Occurs periodically (daily/hourly)	Share consumers flexibility potential	The flexibility potential available on behalf of consumers is made available to be explored by service providers - SUC 12.1	CREATE	DPP	Service Provider	I-1, I-2, I-3, I-5, I-6, I-7	GDPR-[1-4]
1.4	Occurs periodically (daily/hourly)	Pair Service Providers paired with consumers.	Service recommendations are delivered to consumers suggesting the subscription of services from the available service catalogue. Paring is done via the availability of given classes of flexible assets, suggesting their upgrade or retrofit, or in the case of absence of flexible	EXECUTE	DPP	Consumer	I-1, I-2, I-3, I-4, I-8	GDPR-[1-4]

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			resources, suggesting installation - SUC 12.1					
1.5	Consumer subscribes a service	Service subscription	Consumer subscribes a service from a given service provider, accepts consent management. - SUC 12.1	EXECUTE	Consumer	DPP	I-1,I-2, I-5, I-8,I-9	GDPR-[1-4]
1.6	Contract agreement	Formalize contract	Service subscription establishes a contract between consumer and service provider which the value-chain enabler records and tracks.	EXECUTE	Consumer, Service Provider	DPP	I-1, I-2,I-14	GDPR-[1-4]
1.7	Occurs periodically (every time consumer requires capacitation)	Install flexible assets	Service providers install controllable flexible assets according to service constraints. This maps to the Integration/Enablement stage of the flexibility centric value chain. - SUC 12.1	REPEAT	Service Providers (installers and O&Ms)	Consumer	I-1,I-2, I-5, I-8	
1.8	Occurs periodically (daily/hourly)	Share flexibility potential	Shares flexibility potential of consumer with energy and non-energy services, particularly those from the service provider / installer - SUC 12.2	GET	Consumer, Service Providers (installers and O&Ms)	DPP	I-1, I-2,I-3, I-6	GDPR-[1-4]
1.9	Occurs periodically (daily/hourly)	Aggregate flexibility	Service provider aggregates the flexibility potential of consumers that subscribed its services - SUC 12.2	CREATE	Service Providers (installers and O&Ms)	Resource Aggregator	I-1, I-2,I-3, I-6	GDPR-[1-4]
1.10	Occurs periodically (daily/hourly)	Submit flexibility bid	Computed flexibility is communicated to the Resource aggregator as a bid. - SUC 12.2	CREATE	Service Providers (installers and O&Ms)	Resource Aggregator	I-1, I-2,I-3, I-6, I-10	GDPR-[1-4]

1.11	Occurs periodically (daily)	Market Operation	Flexibility Market operation - SUC 12.2	EXECUTE	Market Operator	DSO	I-10, I-11	GDPR-[1-4]
1.12	Occurs periodically (daily)	Select flexibility bids	Select flexibility bids that will be activated. DSO operational platform validates chosen bids	CREATE	DSO	DSO	I-4, I-10,I-11,I-12	GDPR-[1-4]
1.13	Occurs periodically (daily)	Disaggregate activation of flexibility	Disaggregate flexibility activation requests per resource aggregator	EXECUTE	DSO	DSO	I-3, I-4, I-10,I-11,I-12	GDPR-[1-4]
1.14	Occurs periodically (daily)	Dispatch disaggregated flexibility	Sets selected flexibility bids for dispatch. Makes use of the interoperable data formats via the GDBN.	CREATE	DSO	DPP	I-3, I-4, I-10,I-11,I-12	GDPR-[1-4]
1.15	Occurs periodically (daily)	Activate flexibility	Dispatches the activation of disaggregated flexibility bids.	EXECUTE	DPP	Resource Aggregator, Service Provider, Consumer	I-3, I-4, I-10,I-11,I-12	GDPR-[1-4]
1.16	Occurs periodically (daily/monthly)	Settlement and Billing	Cash flow management is performed from the computed incentives and service subscription fees	EXECUTE	DPP	Consumer	I-11, I-12, I-13	GDPR-[1-4]

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5 Information exchanged

Information exchanged			
Information exchanged (ID)	**Name of information**	**Description of information exchanged**	**Requirement, R-IDs**
I-1	Consumer profile	Data and metadata about a consumer.	
I-2	Service provider profile	Data and metadata about a service provider	
I-3	Resource Aggregator profile	Data and metadata about a resource aggregator profile	
I-4	DSO profile	Data and metadata about a DS profile	
I-5	Service offering	Data that describes a service	
I-6	Flexibility potential	Flexibility potential of a stakeholder. Also represented as an aggregated shape.	
I-7	Consent	Consent for data usage	GDPR-[1-4]
I-8	Asset	Description of a flexible asset	
I-9	Business model	Business model description	
I-10	Flexibility bid	A flexibility bid	
I-11	Flexibility activation	Flexibility activation request. Also considers the disaggregated version	
I-12	Energy Settlement	Settlement detail on Energy exchange	
I-13	Cash-flow Settlement	Settlement detail on Billing needs.	
I-14	Contract	Contract between stakeholders	GDPR-[1-4]

4 Requirements

Requirements		
Categories ID	**Category name for requirements**	**Category description**
GDPR	Regulatory obligation related to privacy	2016/679 (General Data Protection Regulation)
Requirement R-ID	**Requirement name**	**Requirement description**
GDPR-1	Data processing consent	Personal data may not be processed unless there is at least one legal basis to do so.
GDPR-2	Data retention policy	Data retention policy outlines the time period specific sensitive data can be retained, plus how it will be disposed of when the time to do so comes.
GDPR-3	Right to access, rectify, erasure, restriction	The data subject shall have the right to obtain from the controller without undue delay the access/rectification/erasure/restriction of inaccurate personal data concerning him or her.
GDPR-4	Data transfer consent	Personal data may not be transferred to a third-party if the data subject did not agree and the third party provide appropriate safeguard.

GDPR-X	All GDPR constraints also apply to this BUC.	e.g., proportional measures of protection, communication of data breach, among others
Requirements		
Categories ID	**Category name for requirements**	**Category description**
SOC	Social requirements for value addition and engagement	Inputs from 2.1 and 2.2
Requirement R-ID	**Requirement name**	**Requirement description**
SOC-1	Flexible assets installation	Economic constraints exist from user's side as the economic benefit from their efficiency is not high.
SOC-2	Incentives provision for participation	The actual economic incentive is not enough for users to participate in flexibility mechanisms. Incentives must be interesting and not only economics.
SOC-3	Non-energy services	Information (traffic, weather), health (air quality) and comfort are some of the non-energy services most expressed by users.

Requirements		
Categories ID	**Category name for requirements**	**Category description**
RCR	Regulations on aggregators to be fully developed	Draft Proposal for Network Code on Demand Response
Requirement R-ID	**Requirement name**	**Requirement description**
RCR-1	Regulations on aggregators may outline boundaries for the aggregation and market participation practices.	National regulations prescribe for aggregation activities rules concerning data exchange and confidentiality, market access and compensation for aggregated entities. Moreover, the relation with the retailer considering unbalance responsibility and transfer of energy requires bilateral agreements whether not regulated.

5 Common Terms and Definitions

Common Terms and Definitions	
Term	**Definition**
DER	Distributed Energy Resource
DPP	Digital Platform Provider
DSF	Demand Side Flexibility
DSO	Distribution System Operator
GDPR	General Data Protection Regulation
NMF	Neutral Market Facilitator

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11.13. BUC13 – Combine energy services (production, storage) with mobility

1 Description of the use case

1.1 Name of the use case

ID	Area / Domain(s)	Name of Use Case
BUC13	Cross-sector flexibility boosters	Combine energy services (production, storage) with mobility

1.2 Version management

Version Management			
Version No.	**Date**	**Name of Author(s)**	**Changes**
0.1	03.04.2023	Ricardo Bessa	First draft version
0.2	06.04.2023	Jean-Christophe Pazzaglia	Refine the scenario
0.3	18.04.2023	Jean-Christophe Pazzaglia	Add data exchange + set of requirements reread the whole. Pending diagrams. map req per steps and information exchange (a bit cumbersome should we keep this column
0.4	20.04.2023	Ricardo Bessa	Completed information exchange table. Revised the document.
0.5	05.05.2023	Ricardo Bessa	UML diagrams added

1.3 Scope and objectives of use case

Scope and Objectives of Use Case	
Scope	Electric Vehicle Supply Equipment (EVSE) powered by renewable energy sources considering charging flexibility, digital platforms, and data sharing.
Objective(s)	Decarbonize the corporate's fleet, offer EV users uniform charging tariffs (independently if they charge at home or office), maximize the use of local and grid RES, and ensure maximum availability of the EVSE.
Related business case(s)	Use the EVSE independently if the elective vehicle (EV) is at home or at the office, in both case EVSE operational data will be extracted from OCPP transactions. Exploit and share data from EVSE for non-energy services from third-party providers.

1.4 Narrative of use case

Narrative of Use Case
Short description
The advent of e-mobility blurs the current organization framework of companies as it impacts fleet, facilities, human resources, and corporate social responsibility (CSR). As the main actor of this Business Use Case (BUC) we introduce the figure of Energy Facility Manager aiming to decarbonize the corporate's fleet, offer EV users uniform charging tariffs (independently if they charge at home or office), maximize the use of local and grid RES, and ensure maximum availability of the EVSE. It will leverage charging point operator (CPO) data to induce via direct and indirect control optimal charging policies in communities (e.g., sharing EV charging points), homes, and offices with PV and battery energy storage, combined seamlessly (by data sharing) with a portfolio of value-added non-energy

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services (associated to mobility) targeting both end-users and energy facility managers (e.g., resolve timely EV supply equipment faults, multi-site charging).

It consists in:

- Incentivize EV drivers to privilege low cost or carbon friendly charging from private EVSE (e.g., home or office) leveraging grid renewable energy sources (RES), including EVSE control with prioritization and community sharing of EVSE.
- Offer convenient EV charging tariffs, independently if the EV user charges the car at home or at the office relying on Charging Detail Records (CDR) provided by EVSE aiming to incentive best practices.
- Optimize the energy consumption at domestic homes by combining EVSE and smart appliances flexibility to maximize self-consumption.
- Provide data access for enabling cross-sector service development, that may include maintenance, predictive EVSE usage forecast, recommendation services or carbon footprint reports.

The BUC includes the following steps.

1. Provide data and information to EV users and service providers
   1.1 Inform EV users about the best charging periods at office and at home
   1.2 Share charging point data with service providers

2. Manage and optimize office EV charging
   2.1 Send state-of-charge warnings to EV drivers when a threshold is reached
   2.2 Manage charging queue of the corporate fleet and community users
   2.3 Notify stakeholders about EVSE failures

3. Optimize energy consumption and flexibility at domestic homes
   3.1 Define optimal schedules for controllable assets
   3.2 Obtain and share data for behind-the-meter and EV flexibility quantification
   3.3 Get EVSE charging session data

4. Revenue management for invoicing or cost claim systems
   4.1 Provide CDR data for EVSE usage
   4.2 Provide RES generation / Energy storage usage

Complete description

1. Provide data and information to EV users and service providers

The advent of e-mobility blurs the current organization framework of companies as it impacts fleet, facilities, human resources, and CSR. The Energy Facility Manager, primary actor of this BUC, assumes the role of Data Hub Operator to share data and pre-processed information with EV users, energy and non-energy service providers. This data and information are mainly related to local and grid RES availability, electricity prices and the operating conditions of the charging points (e.g., to resolve timely faults). The Energy Facility Manager also takes the business role of CPO at office and home level to enable end-to-end management of charging scenarios.

1.1 Inform EV users about the best charging periods at office and home

CPO inform the EV users (corporate employees, neighbor community) for the next hours and day (enabling day-ahead planning of the EV charging) about the best charging periods both at office and home, considering the following the following parameters: a) near real-time and/or forecasted availability of RES in the facility (and local grid), b) wholesale / retail electricity price of the corporate; c) information provided by the DSO about grid technical constraints (grid-compliant charging); d) forecasted occupancy of the corporate charging points.

System Use Case called by the step
SUC 13.1: Incentives for charging from RES and EV chargers sharing

1.2 Share charging point data with service providers

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Data Hub Operator, after obtaining and verifying explicit consent from the Data Owner, shares charging point data, real-time and/or historical, with energy (Energy Service Company – ESCO) and non-energy (Mobility Service Provider, Maintenance Service Provider) service providers, which assume the business role of Data User. This data results from monitoring the charging infrastructure status and charging sessions and can be used for different purposes, in particular: a) design and apply predictive maintenance strategies for the charging infrastructure, e.g., fault prediction and root cause analysis; b) optimize/enhance the charging signals communicated in (1.1); c) conduct analytics for optimizing mobility patterns and extract KPIs for carbon footprint reports; d) generate insights for OEM in terms of product improvement.

2. Manage and optimize office EV charging

Energy Facility Manager manages and optimizes the EV charging in the office building, considering the operation of different DER, namely RES and battery energy systems, electricity prices, and charging points occupancy. The objective is to reduce electrical energy costs and conduct power grid-compliant charging with smart charging.

2.1 Send warnings to EV users

CPO issues the following warnings: a) If state-of-charge is above a certain threshold (e.g., 80%), then send warning to remove the EV from the charging point; b) RES surplus or low grid CO2 emissions together with charger occupancy below 100% (“happy hour”).

2.2 Manage charging queue of the corporate fleet and community users

CPO provides charging prioritization of the corporate fleet considering EV user data and analytics (total electrical energy requested for charging, departure hour), facility contracted power, grid constraints, and RES availability. Keeping EV user satisfaction (EVUS) is a fundamental requirement, KPIs and feedback loop will monitor the EVUS.

System Use Case called by the step
SUC 13.2: Optimize and manage corporate EV charging

2.3 Notify charging points faults

In case of unplanned unavailability of EVSE, the CPO notifies the maintenance service provider of the faulty equipment. Optionally the maintenance service provider can leverage the data service to collect the relevant data to understand and fix the issue (e.g., OCPP communications, energy availability, car model and brand and eventually other sensors temperature, humidity).

3. Optimize energy consumption and flexibility at domestic homes

To increase employee satisfaction with the convenience of charging at home or work and reduce electricity costs, the Energy Facility Manager will propose an energy optimization/management service (EOS) for domestic homes eventually relying on services contracted with an ESCO on behalf of the workforce. The employees would enroll voluntarily to the scheme, delegating to the CPO, the business roles of Meter Operator and Metered Data Administrator, to operate a dedicated (sub-)metering system for EV charging monitoring and flexibility provision.

3.1 Inform optimal schedules for controllable assets

The EOS communicates to the Energy Facility Manager and Consumer the optimal scheduling for EV flexibility combined with other behind-the-meter assets (thermal loads and white goods), which minimizes a predefined objective: a) electricity cost reduction, b) grid CO2 emissions reduction, c) self-consumption maximization. This schedule is implemented automatically, and the Consumer assumes a supervisor role (i.e., can override autonomous functions).

System Use Case called by the step
SUC 13.3: Optimize residential demand-side flexibility

3.2 Obtain and share data for behind-the-meter and EV flexibility quantification

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Departing from the scheduled created in (3.1), the Energy Facility Manager shares with Resource Aggregator data about remaining flexibility from the office and home buildings, which can be processed, aggregated, and offered by the Resource Aggregator in the ancillary and flexibility services market.

System Use Case called by the step
SUC 13.3: Optimize residential demand-side flexibility

3.3 Get EV charging session data

Energy Facility Manager gets charging session data for corporate expense management.

4. Revenue management for invoicing or cost claim systems

The Energy Facility Manager is responsible for defining the revenue management strategy surrounding the platform including EV charges, RES production, Energy storage, Flexibility capacity or Data services. This strategy should be done in accordance with local laws about energy but also labor laws. The platform will be responsible for providing the evidence to support the pricing, billing, and invoicing of all charging scenarios supporting different pricing plans and tariffs and real-time invoicing for contractual and pay-as-you-go neighbor customers. This e-mobility information will be consumed by existing business systems, corporate finance processes, external invoicing may rely on a third-party payment provider (e.g., roaming platform, payment as a service platform).

System Use Case called by the step
SUC 13.4: Share EV charging data for non-energy services

4.1 Provide CDR data for EVSE usage

CDR Data enables the Energy Facility Manager to handle reimbursement of employee electricity costs from charging company EV at home, and eventually to invoice company external EV users (community charging).

4.2 Provide RES generation / Energy storage usage

The Energy Facility Manager collects the information related to RES generation and Energy storage usage. This electrical energy can be purchased via power purchase agreement or shared within a renewable energy community / citizens energy community.

1.5 Key performance indicators (KPI)

ID	*Name*	*Description*	*Reference to mentioned use case objectives*
13.1	Reduction of EV charging CO2 emissions	Baseline: starts charging when EV plug-in in EVSE; typical charging profile; no corporate electrification. Means: Charging is controlled to maximize use of RES or low-CO2 generation (carbon signal); signals for behavioral shift of charging hours; increase electrification of corporate car fleet.	Decarbonize the corporate's fleet. Maximize the use of local and grid RES.
13.2	Reduction of EV charging cost	Baseline: not full use of local RES for EV charging. Means: Charging is controlled to maximize use of RES; signals for behavioral shift of charging hours.	Maximize the use of local and grid RES. Offer EV users uniform charging tariffs (independently if they charge at home or office).

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13.3	Reduce cost of operating EV charging infrastructure	Baseline: Modification / implementation of a corporate EV charging infrastructure. Means: Reduction in time to onboard new chargers; increase in efficiency for CPO department and fleet management	Share data and pre-processed information with EV users, energy, and non-energy service providers.
13.4	Increase energy flexibility from e-mobility	Baseline: “dumb” EV charging. Means: direct control of EV charging flexibility (can be quantified for each session).	Grid compliant charging and provision of services to third-parties (data sharing and energy flexibility).

1.6 Use case conditions

Use case conditions
Assumptions
Billing EVSE charging at the office and home with corporate tariff is possible from the regulatory viewpoint.
Prerequisites
Corporate has CPO license. Contract with an Energy Supplier (for e-mobility) and Resources Aggregator (for EV flexibility valorization). Grid constraints signal available from the DSO.

1.7 Further Information to the use case for classification / mapping

Classification Information
Relation to other use cases
BeFlexible project: BUC01 – Planning and sizing of energy communities considering customer flexibility; BUC02 – Operation, energy sharing and flexibility boosting of local energy communities; BUC04 – Long-term distribution grid congestion management; BUC05 – Short-term congestion constraints forecasting and management for local flexibility service activation; BUC08 – Aggregation for TSO and DSO grid services; BUC 12 – Operating a value chain enabler for flexibility-centric and non-energy services. GAIA-X use cases: Infrastructure data for new business models. Utilizations of data from critical infrastructures for new business models.
Level of depth
Business use case (BUC).
Prioritisation
To be demonstrated in France (Pilots 3.5 and 3.6).
Generic, regional or national relation
Generic
Nature of the use case
Corporate business process. Cross-sector: electricity and mobility.
Further keywords for classification
Electric vehicles, mobility, renewable energy, storage, charging control, data sharing, corporate social responsibility, decarbonization.

1.8 General Remarks

General Remarks

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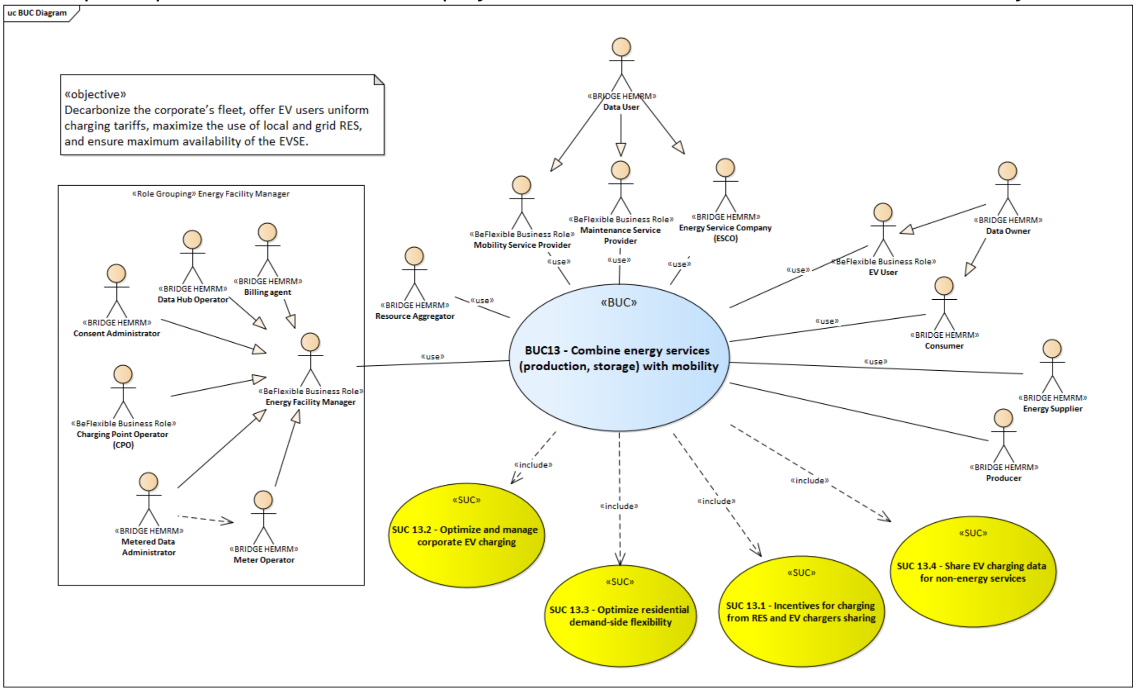
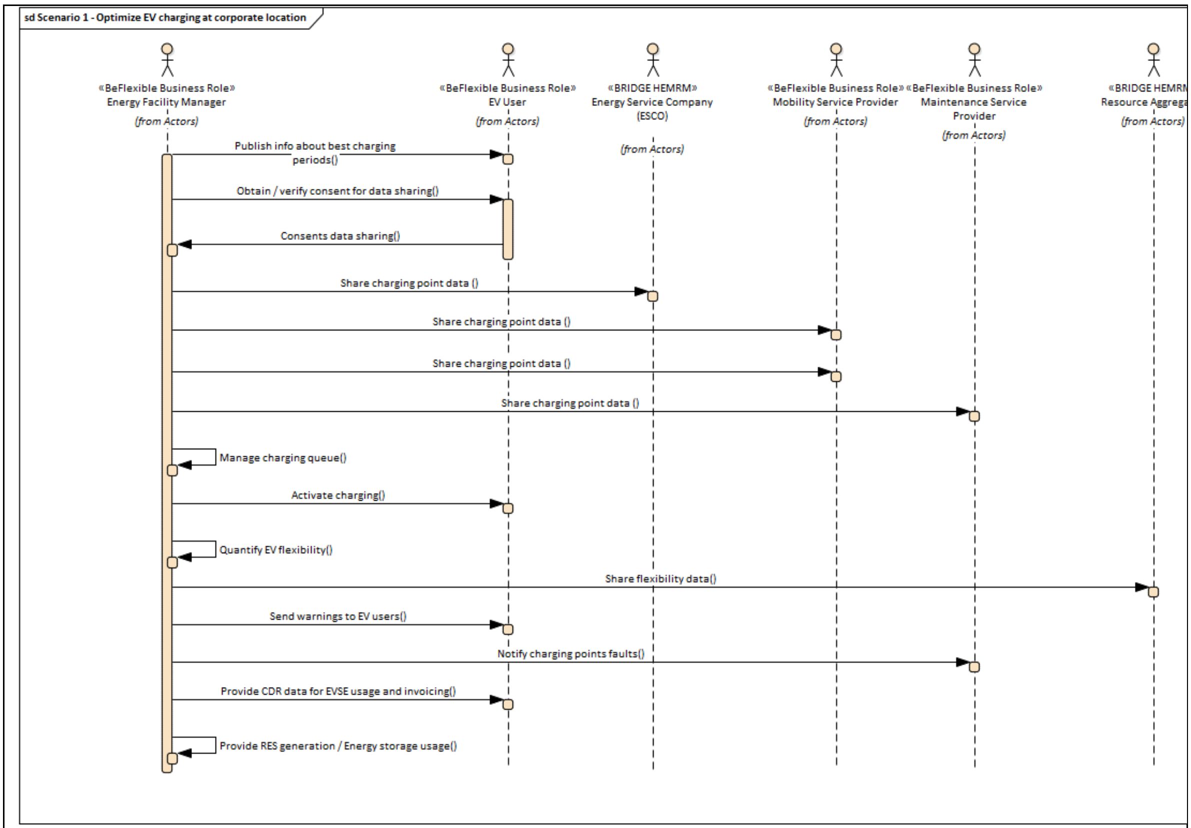
The participation of SLF employees will be done on a voluntary basis.

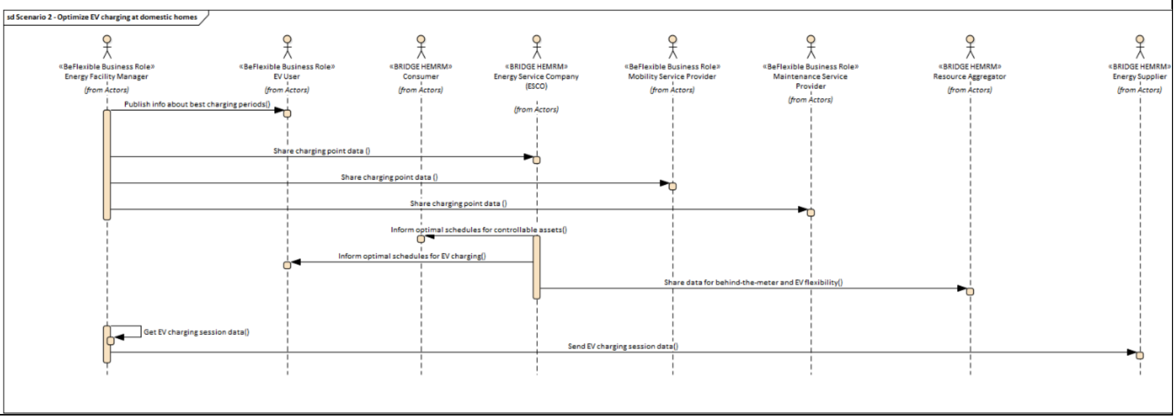


2 Diagrams of use case

Diagram(s) of use case



Sequence Diagram. Scenario 2 - Optimize EV charging at domestic homes



3 Technical details

3.1 Actors

Actors		
Actor Name	***Actor Type***	***Actor Description***
Billing agent	Business Role (BRIDGE HEMRM)	The party responsible for invoicing a concerned party
Consumer	Business Role (BRIDGE HEMRM)	A party that consumes electricity.
Consent Administrator	Business Role (BRIDGE HEMRM)	A party responsible for administrating a register of consents for a domain. The Consent Administrator makes this information available on request for entitled parties in the sector.
Energy Service Company (ESCO)	Business Role (BRIDGE HEMRM)	A party offering energy-related services to the Party Connected to Grid, but not directly active in the energy value chain or the physical infrastructure itself. Entity with the objective of building and selling added value services on data.
Energy Supplier	Business Role (BRIDGE HEMRM)	An Energy Supplier supplies electricity to or takes electricity from a Party Connected to the Grid at an Accounting Point.
Meter Operator	Business Role (BRIDGE HEMRM)	A party responsible for installing, maintaining, testing, certifying, and decommissioning physical meters. EVSE are required to embed a Meter Operator.
Metered Data Administrator	Business Role (BRIDGE HEMRM)	A party responsible for storing and distributing validated measured data.
Data Hub Operator	Business Role (BRIDGE HEMRM)	Data Hub Operator owns and operates an information system whose main function is to store and make available electricity (also gas, heat) metering data and associated master data. In this BUC, it will be also submeter Data Hub Operator.
Producer	Business Role (BRIDGE HEMRM)	A party that generates electricity.
Data Owner	Business Role (BRIDGE HEMRM)	Any physical person or legal entity that owns data and can give authorization to other parties to access them.
Data User	Business Role (BRIDGE HEMRM)	Any person who uses data. Can be a Data Owner or a Data Delegated Third party. He has the right to use the data of a Data Owner as specified by a contract policy.
Resource Aggregator	Business Role (BRIDGE HEMRM)	A party that aggregates resources for usage by a service provider for energy market services.
Charging Point Operator (CPO)	Business Role	Manage a network of interconnected charging stations grouping EVSE (which the operator may or not own) operating through an application platform.
Mobility Service Provider	Business Role	Providing end-customer (e.g., EV users, vehicle manufacturers and grid operators) with a range of mobility product or value-added services.
EV User	Business Role	A party that owns and charges an EV.
Energy Facility Manager	Business Actor	A party that oversees the energy infrastructure, including the EVSE and EV.
Maintenance Service Provider	Business Role	A party providing maintenance services under a Contract.

3.2 References

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References						
No.	***References Type***	***Reference***	***Status***	***Impact on use case***	***Originator / organisation***	***Link***
1	Protocol	Open Charge Point Protocol (OCPP)	Public	Data exchange and format	Open Charge Alliance	https://www.openchargealliance.org/protocols/ocpp-201/
2	Protocol	Open Charge Point Interface protocol (OCPI)	Public	Data exchange and format	EVRoaming Foundation	https://evroaming.org/ocpi-background/

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	Optimize EV charging at corporate location	Concerns the EVSE and charging management at the corporate location, as well as data sharing for internal invoicing and with third-party service providers	Energy Facility Manager	Occurs periodically (daily)	Electrification of corporate fleet; possibility to charge at home and office with corporate car	Invoice or cost claim for different e-mobility centric services
2	Optimize EV charging at domestic homes	Concerns the EVSE and other loads management at householders (corporate' employees) and invoice management	Energy Facility Manager (relying on an ESCO)	Occurs periodically (daily)	Availability of home automation and interoperability with smart appliances	Availability of optimal schedules for controllable assets and flexibility potential

4.2 Steps – Scenarios

Scenario								
Scenario name:		***No. 1 - Optimize EV charging at corporate location***						
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	Occurs periodically (daily)	Inform EV users about the best charging periods at the office	Inform the EV users for the next hours and day about the best charging periods considering: near real-time and/or forecasted availability of RES; wholesale / retail electricity price; grid technical constraints; forecasted EVSE occupancy.	CREATE	Energy Facility Manager	EV user	EnedisID	LAB-REG1, LAB-REG2, FLEX-VOL1
2	Occurs periodically (daily)	Obtain / verify consent for data sharing	Obtain / verify explicit consent from the Data Owner to share charging point data (real-time and/or historical)	GET	Energy Facility Manager (Consent Administrator role)	EV user (Data Owner role)	UserConsent ProfileID	GDPR-[1-4]
3	Occurs periodically (daily)	Share charging point data with service providers	Shares charging point data with energy and non-energy service providers.	CREATE	Energy Facility Manager (Data Hub Operator role)	ESCO, Mobility Service Provider, Maintenance Service Provider (Data User Role)	SitesID	GDPR-[1-4]
4	EV plugs-in to EVSE for charging	Manage charging queue of the corporate fleet and community	Charging prioritization of the corporate fleet considering EV user data and analytics, facility contracted power, grid constraints, and RES	REPEAT	Energy Facility Manager (CPO role)	EV User	PluginSchedule ID	LAB-REG2

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		users	availability.					
5	Occurs periodically (daily/hourly)	Quantify EV flexibility and share this data	Estimate the EV flexibility for the next hours and day for valorization in the ancillary and flexibility services market.	CREATE	Energy Facility Manager (CPO role)	Resource Aggregator	FlexID	FLEX-VOL1, FLEX-VOL2
6	EV state-of-charge > threshold value OR RES surplus OR low grid CO2 emissions	Send warnings to EV users	Warnings: a) If state-of-charge above a certain threshold (e.g., 80%), then send warning to remove the EV from the charging point; b) RES surplus or low grid CO2 emissions together with charger occupancy below 100% (“happy hour”).	CREATE	Energy Facility Manager (CPO role)	EV User	NotificationID	LAB-REG2
7	EV unable to charge in a specific EVSE	Notify charging points faults	Notifies the maintenance service provider of the faulty equipment.	CREATE	Energy Facility Manager (CPO role)	Maintenance Service Provider	NotificationID	
8	Charging session ended	Provide CDR data for EVSE usage and invoicing	Store CDR data about EV usage in the corporate facility for carbon footprint analytics. Invoice corporate external EV users (community charging).	CREATE	Energy Facility Manager (Meter Operator and Metered Data Administrator role)	Energy Facility Manager / EV user	CDRTransactionID	GDPR-[1-4], LAB-REG1
9	Occurs periodically (daily)	Provide RES generation / Energy storage usage	The Energy Facility Manager collects the information related to RES generation and Energy storage usage. It can be purchased within a community.	CREATE	M Metered Data Administrator	Energy Facility Manager / Producer	AssetCompsumptionID	

Scenario	
Scenario name:	***No. 2 - Optimize EV charging at domestic homes***

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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	Occurs periodically (daily)	Inform EV users about the best charging periods at home	Inform the EV users for the next hours and day about the best charging periods at home, considering near real-time and/or forecasted availability of RES; wholesale / retail electricity price; grid technical constraints.	CREATE	Energy Facility Manager	EV user	ChargingProfileID	LAB-REG1
2	Occurs periodically (daily)	Share charging point data with service providers	Shares charging point data (real-time and/or historical) with energy and non-energy service providers.	CREATE	Energy Facility Manager (Data Hub Operator role)	ESCO, Mobility Service Provider, Maintenance Service Provider (Data User Role)	SitesID	GDPR-[1-4]
3	Occurs periodically (daily/hourly)	Inform optimal schedules for controllable assets	Communicates the optimal scheduling for EV flexibility combined with other behind-the-meter assets to minimize a predefined objective: a) electricity cost reduction, b) grid CO2 emissions reduction, c) self-consumption maximization. This schedule is implemented automatically, and the Consumer assumes a supervisor mode.	CREATE	ESCO	Consumer / EV user	EnedisID, TarfID, ChargingProfileID	
4	Occurs periodically (daily/hourly)	Obtain and share data for behind-	Departing from the scheduled created in (3), the remaining flexibility is	CREATE	ESCO	Resource Aggregator	FlexID	GDPR-[1-4], FLEX-VOL1, FLEX-VOL2

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		the-meter and EV flexibility quantification	shared for valorization in the ancillary and flexibility services market.					
5	Charging session ended	Get EV charging session data	Energy Facility Manager gets charging session data for corporate expense management for charging at home.	CREATE	Meter Operator	Energy Facility Manager (Billing Agent role) / Energy Supplier	CDRTransactionID	LAB-REG1

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5 Information exchanged

Information exchanged			
Information exchanged (ID)	***Name of information***	***Description of information exchanged***	***Requirement, R-IDs***
ChargingProfileID	Charging Profile (OCPP 1.6)	Define for a period of time the charging rate per time period. Cf. GET charging profiles	
UserConsentProfileID	Consent profile (extension)	Define for each data dimension (e.g., location, energy, price, time), the consent to exchange the data with different stakeholders, for each stakeholders the granularity, the first time of acceptance, the duration.	
CDRTransactionID	Transaction CDR (OICP)	Define the energy exchanged, duration per time interval, parking time and all related aspect to the charging session Cf. GET CDR export	
SitesID	Charging point data with energy and non-energy service providers (extension)	Extension of the current sites API to include non-energy service providers Cf. GET Sites-	
PluginScheduleID	Plugin Schedule (new)	A list of EVSE-EV assignation per time period (15-min) eventually linked with the associated charging profile	
FLexID	Flexibility capacity (new)	A list of energy requirement per period of time per charging location (data structure similar to ChargingProfile)	
NotificationID	Notification (extension)	Notification binding different objects (eg. assets, EVSE, userID), a distribution channel and an informative message GET Notifications	
AssetCompsumptionID	Asset consumption / production (extension)	Retrieve consumption / production / baterry SoC for an asset during a time period including some meta data (geoloc, siteID, etc). GET Assets	
EnedisID	Energy availability forecast	3 days forecast, 3 states , 30 minutes step, refreshed every 4 hours GET Enedis	
TarifD	Energy Price	kWh price per time period reflecting the end-user tariff	

6 Requirements

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Requirements		
Categories ID	**Category name for requirements**	**Category description**
GDPR	Regulatory obligation related to privacy	2016/679 (General Data Protection Regulation)
Requirement R-ID	**Requirement name**	**Requirement description**
GDPR-1	Data processing consent	Personal data may not be processed unless there is at least one legal basis to do so.
GDPR-2	Data retention policy	Data retention policy outlines the time period specific sensitive data can be retained, plus how it will be disposed of when the time to do so comes.
GDPR-3	Right to access, rectify, erasure, restriction	The data subject shall have the right to obtain from the controller without undue delay the access/rectification/erasure/restriction of inaccurate personal data concerning him or her.
GDPR-4	Data transfer consent	Personal data may not be transferred to a third-party if the data subject did not agree and the third party provide appropriate safeguard.
GDPR-X	All GDPR constraints also apply to this BUC.	e.g., proportional measures of protection, communication of data breach, among others
Categories ID	**Category name for requirements**	**Category description**
LAB-REG	Regulatory obligation related to labor law	National labour law regulates the scheme related to benefit in kind such as cars or energy, but also protect the fairness in employee management.
Requirement R-ID	**Requirement name**	**Requirement description**
LAB-REG1	Energy price and benefit in kind	As of today, there is no clear regulation with respect to the reimbursement of energy at home especially in the case of local production (usually the price is based on the energy contract) soon we may expect more regulation and the duty to reintegrate it as benefit in kind (after end 2024).
LAB-REG2	Employee fairness	All employees should be equally treated, in this respect we may be careful that the charge prioritization does not discriminate certain population especially if their usage pattern is bound to extra-work constraints (e.g., parents with young children, people with disabilities)
Categories ID	**Category name for requirements**	**Category description**
FLEX-VOL	Free will to participate to flexibility	The participation to flexibility program, especially at home, should be done in a voluntary basis.
Requirement R-ID	**Requirement name**	**Requirement description**
FLEX-VOL1	Opt in	The employee should opt in to participate to the flexibility program.
FLEX-VOL2	Reasonable penalties	The penalties for opting out should not exceed the extra cost generated to the

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		company (e.g., energy price, carbon footprint, usage of EVSE).
Requirement R-ID	**Requirement name**	**Requirement description**
SOC	Social requirements for value addition and engagement	Inputs from 2.1 and 2.2
SOC-1	Charging tariffs	Users prefer a fixed tariff as the variety of prices lowers their trust. If changing they need to be notified in advance.
SOC-2	Charging points and charging periods	It requires users to charge in specific places/times modifying their behavior. Charging points must be available, easy to use and reliable as user's main fear is to damage their battery
SOC-3	Maximize self-consumption	It is a highly demanded from users but it must be easy and integrated in their daily routines.
SOC-4	Data from devices and behavior	The way providers will use and treat data must be transparent and explained for users as they are reticent to giving data to specific actors.

Requirements		
Categories ID	**Category name for requirements**	**Category description**
RCR	Submetering regulations to be developed	Draft Proposal for Network Code on Demand Response
Requirement R-ID	**Requirement name**	**Requirement description**
RCR-1	Regulations regarding submetering usage, data privacy, accuracy and cybersecurity need to be defined	In this BUC the Data Hub Operator owns and operates an information system whose main function is to store and make available electricity (also gas, heat) metering data and associated master data. In this BUC, it will be also submeter Data Hub Operator. The roles and responsibilities for the real-life implementation need to be defined regarding the submetering data usage and related regulations.

7 Common Terms and Definitions

Common Terms and Definitions	
Term	**Definition**
EVSE	Electric vehicle supply equipment
OCPP	Open Charge Point Protocol. Application protocol for communication between EV Charging Stations and a central management system, also known as a Charging Station network.
CDR	Charging Detail Records. Are the charging transaction detail that is produced after every charging process.
CSR	Corporate Social Responsibility
CPO	Charging Point Operator. Mobility partner who operates the charging infrastructure

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HEMRM	Harmonized Electricity Market Role Model
EVUS	EV User Satisfaction
GDPR	General Data Protection Regulation

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12. Annex IV – Key Performance Indicators

KPI name	Type (technical, social, grid)	Definition	DoA KPI	Target	Calculation methodology	Data collection procedure	Instrument preparation	Instrument / data delivery	Data analyst	Reporting period	Business-as-usual (BAU) scenario
Available flexibility from water distribution grids	Technical	Available Power Flexibility in a defined asset configuration that can be allocated by the DSO at a specific grid perimeter. Measured in kW.	No	range 10% - 20 % (from the operator experience)	ΣPavailable(t) / Σppotential(t) Pavailable(t) is the flexibility power available (in kW) of the water distribution, in a DSO perimeter for a defined temporary window. Ppotential(t) is the maximum flexibility power (in kW) of the water distribution, in a DSO perimeter for a defined temporary window. t is quartorary timeslot	Hybrid between data collected from the field and simulated data	ARETI	Report + Excel	ARETI/ENG	Yearly	It depends on the demo
Number of prequalified FSP for flexibility provision	Technical	Number of FSPs able to provide system services.	No	NA	N_FSP N_FSP: Number of FSPs	From demo tests - platform information	Demo leaders	Report + Excel	DSO/Demo leader	After demos	Sweden: 3 customers pre-qualified, Italy: no customers pre-qualified
Number of flexibility activations	Technical	Number of services activated by the DSOs and TSOs.	No	NA	Counting of activated services by TSO and DSO	From demo tests - platform information	Demo leaders	Report + Excel	DSO/Demo leader	After demos	It depends on the demo
Volume of data exchange	Technical	Volume of data exchange between local and TSO markets.	No	TBD for each demo site	Number of files exchanged	From demo tests - platform information	Demo leaders	Report + Excel	DSO/Demo leader	After demos	It depends on the demo
Satisfaction of involved FSPs	Social	It assesses the level of satisfaction of FSPs participating in the programmeme	Yes	Consumer satisfaction increase >50%	Apply the questionnaire to consumers/FSPs with X questions using methodology 3-itemed, 7-point Likert scale, adapted from Mulcahy et al. (2017) or Morgan & Hunt (1994)	Questionnaire	Comillas	Demo leaders	Comillas	After demos	Questionnaire are applied in the beginning of the pilot and determines initial satisfaction level; same questions applied at the end of project to calculate the difference
Satisfaction of involved end consumers	Social	It assesses the level of satisfaction of end consumers participating in the programmeme	Yes	Consumer satisfaction increase >50%	Apply the questionnaire to consumers/FSPs with X questions using methodology 3-itemed, 7-point Likert scale, adapted from Mulcahy et al. (2017) or Morgan & Hunt (1994)	Questionnaire	Comillas	Demo leaders	Comillas	After demos	Questionnaire are applied in the beginning of the pilot and determines initial satisfaction level; same questions applied at the end of project to calculate the difference
Registered end customers	Social	End customers signing the Terms and Conditions	No	NA	NA	TC signed	Demo leaders (	Demo leaders	Comillas	Monthly/en	No. of registered users sent the first week of each month.
Citizens benefitting from the solution	Social	Inhabitants of the building/household benefitting from service/solution (e.g., no. of employees in the organization or no. of household members). Estimation facilitated by usign DSO point of delivery.	No	NA	Number of inhabitants of househ	Questionnaire	Comillas	Demo Leaders	Comillas	T1, upon ent	Total inhabitants per demo and total
Typology of users (FSPs and end customers)	Social	Users classified by type, asset and/or sociodemographic information (only for end customers)	No	NA	Users are classifed by type (res	Questionnaire	Comillas	Demo Leaders	Comillas	T1, upon ent	Description of users per demo and total
Energy engagement (with flexibility services)	Social	It measures the level of engagement of end customers/FSPs with flexibility services	Yes	Increase consumer engagement by 20% in terms of cognitive, affective and behavioural assessment	12-itemed, 7-point Likert scale, adapted from Mulcahy et al. (2017)	Questionnaire	Comillas	Demo Leaders	Comillas	T1, upon entering the project; T2 to be decided (end of project)	Questionnaire are applied in the beginning of the pilot and determines initial satisfaction level; same questions applied at the end of project to calculate the difference
Literacy about flexibility	Social	Ability to understand and apply information about flexibility services	No	NA	Items adapted from DeWaters (	Questionnaire	Comillas	Demo Leaders	Comillas	T1, upon ent	Questionnaire are applied in the beginning of the pilot and determines initial satisfaction level; same questions applied at the end of project to calculate the difference
Trust/commitment with energy market actors	Social	Confidence in other	No	NA	Items adapted from Morgan and	Questionnaire	Comillas	Demo Leaders	Comillas	T1, upon ent	Questionnaire are applied in the beginning of the pilot and determines initial satisfaction level; same questions applied at the end of project to calculate the difference
Perceived value creation: economic, functional, experiential, episteme, environmental and community	Social	Perceived benefits in the solution	No	NA	Items adapted from Gallarza et al. (2017)	Questionnaire	Comillas	Demo Leaders/installer/aggregator	Comillas	T2 to be decided (end of project)	
Continuace adoption	Social	Willingness to provide flex provision services once the project ends	Yes	Continuance adoption of at least 30% of consumers with intention to continue providing flexibility services	Items adapted from Goyal et al	Questionnaire	Comillas	Demo leaders	Comillas	T2 to be decided (end of project)	

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Readiness for flexibility provision	Social	Individual/organizational propensity to provide/use flexibility services, comprising perceptions of optimism, proficiency, vulnerability and dependency	No	NA	Items taken from Ratchford & Bo	Questionnaire	Comillas	Demo leaders	Comillas	T1, upon entering the project	
Available ~~long-term~~ flexibility	Technical	Available power flexibility in a defined period (e.g., per day) that can be allocated by the DSO at a specific grid segment. Measured in MW. This in relation with the total amount of power in the specific grid perimeter in the same period. One KPI for each test. the term power refer to measure demand in the area in reporting tiem at the specific grid location	No	>0	Flexibility (%)=(∑P(Available_Flexibility) /(∑P(Total_in_Area))·100 Variables: Flexibility (%): Percentage of available flexible power with respect to the total demand at a specific grid segment in reporting period (%) ∑P(Available_Flexibility): Power in MW of available flexibility at a specific grid segment in reporting period (MW). ∑P(Total_(in_Area)):Total power demand in MW at DEMO grid segment (MW)	From demo tests - grid information	Demo Leaders	Report + Excel	Demo Leaders	After demos	Define the affected specific area to obtain the power (demand) to compare with the flexibility capacity
Congestion forecast accuracy	Technical	Degree of accuracy in predicting the occurrence and severity of grid congestions.	No	NA	~~Load~~_(FA_24h)=100-1/N (∑_(t=1,n)(FC_load,t-RL_load,t)/(RL_load,t))·100 Variables: Load_(FA_(T,h)): Error of load forecast calculated T hour in advance (%) FC_load : Load estimated T hours in advance (MW) RL_load : Real load (MW) N: Number of available data points	From demo tests - grid information	Demo Leaders	Report + Excel	Demo Leaders	After demos	Planning forecasting methodology
Activated flexibility	Technical	This indicator measures the amount of activated flexibility by the DSO.	No	TBD for each demo site	Activated flexibility.	From demo tests - platform information	Demo Leaders	Report + Excel	Demo Leaders	After demos	N/A
Delivered flexibility	Technical	This indicator measures the amount of delivered flexibility in comparison with requested activated flexibility (%).	No	To be defined for each demo site when penalties will be applied	Delivered flexibility/requested f	From demo tests - metered data	Demos Leaders	Report + Excel	Demo Leaders	After demos	Flexibility provider agreement done in Market platform
Quality of flexibility delivery per FSP	Technical	This indicator measures how well each FSP delivers the flexibility that was activated by the DSO.	No	TBD for each demo site	For each FSP: Delivered flexibility/requested flexibility*100	From demo tests - metered data	Demo Leaders	Report + Excel	Demo Leaders	After demos	N/A
Active flexibility service providers	Technical	This indicator measures the number of flexibility service providers that participate actively in the market.	No	TBD for each demo site	N_FSP N_FSP: Number of FSPs	From demo tests - Manually	DSO/Demo leader	Platform.	DSO/Demo leader	After demos	N/A
Economic value	Economic	Compare cost for flexibility and its management with cost if flexibility was not available, e.g., cost deferral or avoidance of network reinforcement.	No	<100%	[Cost]_effectiveness=(1-[Cost]_flex/[Cost]_Sub)·100 [Cost]_effectiveness: Cost effectiveness (%) [Cost]_Sub: Avoided traditional solution cost (€/MWh) [Cost]_flex: Cost of flexibility (€/MWh)	From demo tests	DSO/Demo leader	Report	DSO/Demo leader	After demos	traditional solution cost
Reduction of asset electrical energy consumption	Technical	Baseline: forecasted baseline vs flexibility activation.	No	NA	CR=([AL]_initial-[AL]_final)/[AL]_initial ·100 CR: Congestion reduction (%) [AL]_initial : asset load before delivering flexibility (initial asset load (kW)) [AL]_final: asset load a during delivery of flexibility (final asset load (kW))	From demo tests - grid information	DSO/Demo leader	Report	DSO/Demo leader	After demos	It depends on the demo/NA
Reduction of asset energy wholesale value consumption	Economic	Baseline: forecasted baseline cost in day ahead market vs flexibility activation price.	No	<100	Hour daily price - DSO price of activation	From demo tests - grid information	DSO/Demo leader	Report	DSO/Demo leader	After demos	It depends on the demo/NA
Number of DER's participants in aggregation	Technical	Number of aggregated flexibility providers.	No		Counted number of providers + its MW	From demo tests - grid information	Demo participants/Demo leader	Report	Demo participants/ Demo leader	After demos	It depends on the demo/NA
Electricity cost reduction	Economic	Energy cost reduction for the individual members of the EC due to belonging to the EC and due to the provision of flexibility	No	TBD for each demo site	Individual: (E_cost_no_EC - E_cost_EC) / E_cost_no_EC *100 EC: ∑ (E_cost_no_EC - E_cost_EC) / ∑ E_cost_no_EC *100 1 - Multiply the energy consumed by the internal tariffs from the EC participation (E_cost_EC) 2 - Multiply the energy consumed by the retailer tariffs, simulating a energy bill without the EC (E_cost_no_EC) 3 - If its the EC case, sum the results from step 1 and 2 for all the EC members	Simulated results from real and synthetic data	Demo leader + INESC TEC	Report + Excel	INESC TEC	After demos	Individual self-consumption/Not an EC member

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KPI name	Type (technical, social, grid)	Definition	DoA KPI	Target	Calculation methodology	Data collection procedure	Instrument preparation	Instrument / data delivery	Data analyst	Reporting period	Business-as-usual (BAU) scenario
Payback period	Economic	Time to recover the investment cost	No	TBD for each demo site	Payback = Investment / Cash_inflow_per_year Cash_inflow_per_year = Cash_flow_no_investment - Cash_flow_investment Time period it takes the cost reduction to compensate the investments costs	Simulated results from real and synthetic data	Demo leader + INESC TEC	Report + Excel	INESC TEC	After demos	Individual self-consumption/Not an EC member
Energy sharing ratio	Technical	Energy shared between EC members as a percentage of total locally produced energy.	No	TBD for each demo site	∑E_shared / ∑E_produced_locally 1 - Obtain, from DSO measurements, the energy produced by each one of the EC members (E_produced_locally) 2 - Obtain, from DSO measurements, the energy shared by each on of the EC members (E_shared) 3 - Sum the results from step 1 and 2 for all the EC members	Simulated results from real and synthetic data	Demo leader + INESC TEC	Report + Excel	INESC TEC	After demos	Individual self-consumption for all
Emissions reduction	Environmental	Aggregated members' emissions reduction from participating in the EC compared to trading only with their BRPs.	No	TBD for each demo site	[(∑ Individual_emissions) - EC_emissions] / (∑Individual_emissions) *100 Estimation of the total GHG emissions of the EC for a specific time period, compared to the sum of the individual GHG emissions. Methodology needs to be decided/developed	Simulated results from real and synthetic data	Demo leader + INESC TEC	Report + Excel	INESC TEC	After demos	Individual self-consumption for all
Self-sufficiency	Technical	Energy consumed locally compared to the total energy consumed	No	TBD for each demo site	∑E_supplied_local / ∑E_supplied_total 1 - Obtain, from DSO measurements, the amount of energy consumed by the EC member (E_supplied_total) 2 - From this consumption, obtain how much energy was provided by the EC (E_supplied_local) 3 - Sum the results from step 1 and 2 for all the members	Simulated results from real and synthetic data	Demo leader + INESC TEC	Report + Excel	INESC TEC	After demos	Individual self-consumption for all
Average buying price reduction	Economic	Average price of buying the energy within the EC.	No	TBD for each demo site	1 - Calculation of buying price within the EC for each EC member 2 - Verificate the total number of EC members 3 - Calculation of average buying rate	Simulated results from real and synthetic data	Demo leader + INESC TEC	Report + Excel	INESC TEC	After demos	Individual self-consumption for all
Flexibility provision	Technical	Flexibility provided by the EC to the DSO compared to the flexibility required.	No	TBD for each demo site	Calculation of the flexibility that can be offered by the EC to the DSO according to the expected price and DSO needs 1 - Obtain the amount of flexibility registered on the flexibility bid that was accepted, according to the DSO needs 2 - Obtain the amount of flexibility that was efectively provided to the DSO	Simulated results from real and synthetic data	Demo leader + INESC TEC	Report + Excel	INESC TEC	After demos	EC doesn't provide flexibility/Individual self-consumption for all
Number of consumers that acquired demand side flexibility potential through the GDBN	Technical	Number of consumers that acquired demand side flexibility potential through the GDBN	No	>20	The number of consumers (cumulative sum from deployment to current period) that onboarded or are linked with a service provider to acquire demand slide flexibility products via the GDBN.	Data collected from the platform during field demo	Platform developed by INESC TEC + SAP	Platform + data export + report	INESCTEC	Quarterly	GDBN doesnt exist.
Consumer satisfaction about the GDBN services	Social	Measure the satisfaction on consumers using the services available in the GDBN (inluding those from external parties - ESCos and FSPs)	No	NA	A final questionaire will request consumers to rate the usability and likelyhood to continue using the services available in the GDBN.	Questionaire filled in the Platform developed by INESCTEC SAP	Platform developed by INESC TEC + SAP	Platform + data export + report	INESCTEC	After first month of demo and after demos	The survey after the first month acts as baseline for the comparison in the end of the demo.
Number of services operating in the GDBN	Technical	The total number of services in the GDBN.	No	NA	The total number (cumulative sum from deployment to current period) of services available in the GDBN.	Data collected from the platform during field demo	Platform developed by INESC TEC + SAP	Platform + data export + report	INESCTEC	Quarterly	The baseline will be the number of existing services in the GDBN in the first month of the demo.
Number of consumers that have used the GDBN	Technical	Number of customers onboarded on services of the GDBN	No	NA	Number of customers onboarded on some of the services of the GDBN classified by pilots and locations	Data collected from the platform during field demo	Platform developed by INESC TEC + SAP	Platform + data export + report	Demos	After demos	The baseline will be the number of consumers in the GDBN in the first month of the demo.
Number of GDBN user connections	Technical	Averaged number of users connecting to the GDBN every month.	No	NA	The average number of login operations in the GDBN done by users with all roles by pilots and locations.	Data collected from the platform during field demo	Platform developed by INESC TEC + SAP	Platform + data export + report	INESCTEC	Monthly	The baseline will be the average number of users connecting in the GDBN in the first month of the demo.
Flexibility capacity unlocked through the GDBN	Technical	Flexible assets (classified by type) made available via services provided in the GDBN.	No	NA	Number of flexible assets (by type) made available via services provided in the GDBN.	Data collected from the platform during field demo	Platform developed by INESC TEC + SAP	Platform + data export + report	INESCTEC	After demos	Flexibility of assets is activated through their FSP systems.

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KPI name	Type (technical, social, grid)	Definition	DoA KPI	Target	Calculation methodology	Data collection procedure	Instrument preparation	Instrument / data delivery	Data analyst	Reporting period	Business-as-usual (BAU) scenario
Flexibility activated by the DSO via the GDBN	Technical	The flexibility activation requests that were dispatched by the DSO to be activated in FSPs onboarded in the GDBN, provided that regulation allows it.	No	NA	The cumulative number of flexibility activation requests issued by a DSO using the GDBN. For real flexibility activation tests, the regulatory frameworks must allow it.	Data collected from the platform during field demo	Platform developed by INESC TEC + SAP	Platform + data export + report	INESCTEC	Monthly	Flexibility is activated directly by the DSO.
Number of validated business models	Technical	Short term: 3-4 business models are expected per each project demo with 2 pilots in DEMO1, 2 pilots in DEMO2, and 6 pilots in DEMO3	Yes	4 x 3 demos pilots i.e. up to 12 validated business models	The flexibility-centric business models (BM) will be analyzed in D7.1 and will depart from the KPIs and results of WPs 4-6 and the business use cases of D1.2. The calculation will be direct from the number of BM in D7.1.	KPIs and key results from D4.4, D5.4 and D6.4; stakeholders consultation	on-line questionnaire, phone interviews with key respondents, and a European workshop, results obtained in the tests of value propositions with consumers (T2.1, 7.3.)	Deliverable report, excel (processed) data	INESC TEC	After demos (until M40)	0
Dimension of the services ecosystem	Technical	Short term: ecosystem of 32 services validated through the demos.	Yes	32 services	Number of services demonstrated during the project. Starts with the identification of the system use cases, and ends with the results per SUC reported in D4.4, D5.4 and D6.4	Demo activities and results in D4.4, D5.4 and D6.4	Demo leaders	Deliverable report (nº of services demonstrated)	All	End of the project	0
Increase of the number of services/platforms endowed with digital technologies	Technical	Enabled efficient functioning, standardized and interoperable energy services/platforms through digital technologies	Yes	Increasing from 21 to 32 the number of services/platforms endowed with digital technologies compared to those that did not use these technologies before the project, increasing thin number by 50%	Count the number of services demonstrated, and which use or benefit from digital technologies (cloud, blockchain, AI/ML, etc.)	Survey about project outcomes/technologies	Survey	Survey of project results and used digital tech	Zabala	End of the project	21
Increase resilience of energy system	Technical	Improving Resistence and Recovering Index (RRI)	Yes	According to GA: Improvement of RRI of 10-15% by the end of the project. **According to consultation with demo leaders: Non-significant improvement of resiliency is expected from the implementation of considered experimentation. Some DSOs have non-projet-related experience on these use cases which are related to resiliency. In case information will be available, the indicator will be calculated.**	**Survey with network operators/demo leaders on the pilot experience or other experimentation results. They will be requested to report on the expected resiliency improvement on the basis of the tested use cases.** In case detailed results and dedicated experimentation/simulation: calculation of the RRI with the formula listed in - F. Oprea, M. Onofrei, D. Lupu, G. Vintila, and G. Paraschiv, "The Determinants of Economic Resilience. The Case of Eastern European Regions," Sustainability, vol. 12, no. 10, p. 4228, May 2020, doi: 10.3390/su12104228. [Online]. Available: http://dx.doi.org/10.3390/su12104228	Survey or resiliency analysis performed by the pilot responsibles.	Demo leaders	Report + Excel	RSE	End of the demo experimentation	It depends on the demo
Available short-term flexibility	Technical	Available power flexibility in a defined period (e.g., per day) that can be allocated by the DSO at a specific grid perimeter. This in relation with the total amount of flexible power registered in the specific grid perimeter in the same period (but not always entirely available and/or responsive).	No	>0 (there are not many numerical references to fix a value, it should just be demonstrated that accrding to the designed framework flexibility is offered on markets)	Average flexibility offered in short-term market for each pilot perimeter (calculated over all the experimented market sessions) with respect to the total flexibility registered within the same area.	Experimental - Data collected from the field	Pilot Owner	Report + Excel	Demo leaders	End of the demo experimentation	It depends on the demo
Voltage violations forecasting accuracy	Technical	Degree of accuracy (Mean Absolute error) in predicting the voltage violations.	No	NA	The viable voltage forecasting approach is based on load forecasting of power consumption (at the substation level) and simulation of the	Measurements /Simulation	Demo participants	Grid Information	Demo participants/ Demo leader	After demos	It depends on the demo
State estimation accuracy	Technical	accuracy (Mean Absolute error) in estimating voltage values in the grid based on a limited	No	NA	measurement/historical data/simulation outputs can be fed to pyvolt (state estimation service of SOGNO platform) and the estimated values can be	Measurements /Historical data	Demo participants	Grid Information	Demo participants/ Demo leader	After demos	It depends on the demo
Reduction of EV charging CO2 emissions	Environmental	Baseline: starts charging when EV plug-in in EVSE, typical charging profile, no corporate electrification. Means: Charging is controlled to maximize use of RES or low-CO2 generation (carbon signal), signals for behavioral shift of charging hours, increase electrification of corporate car fleet.	No	10%	CO2 eq (mix national) / CO2 eq (infrastucture during charging periods) -1 [we may havee to norm that with prod cap vs cons cap]	Data collected from the platform during field demo	SAP	Platform + data export + report	SAP	Yearly	CO2 eq (mix national)

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Reduction of EV charging cost	Economic	Baseline: starts charging when EV plug-in in EVSE; typical charging profile; no corporate electrification. Means: Charging is controlled to maximize use of RES or low-CO2 generation (carbon signal); signals for behavioral shift of charging hours; increase electrification of corporate car fleet.	No	10%	Price (grid) / Price (infrastucture	Data collected from the platform during field demo	SAP	Platform + data export + report	SAP	Yearly	Price (grid)
Increase energy flexibility from e-mobility	Technical	Baseline: "dumb" EV charging. Means: direct control of EV charging flexibility (can be quantified for each session).	No	NA	The cumulative number of flexibility activation requests issued by a DSO using the GDBN. For real flexibility activation tests, the regulatory frameworks must allow it.	Data collected from the platform during field demo	SAP	Platform + data export + report	SAP	Yearly	GDBN doesnt exist.
Efficiency of prequalification process in coordinated markets	Technical	Average bureaucracy time and/or average number of technical tests performed by TSO and DSO to qualify the (aggregates of) DER with respect to the number of services provided by the (aggregates of) DER to both TSO and DSO. Reduce the technical tests to be performed over candidate flexibilities.	No	NA	Average bureaucracy time and/or average number of technical tests performed by TSO and DSO to qualify the (aggregates of) DER with respect to the number of services provided by the (aggregates of) DER to both TSO and DSO	Hybrid between data collected from the field and simulated data	Demo leader + Demo partecipants	Report + Excel	Demo leader + Demo partecipants	End of the demo experimentation	It depends on the demo
Impact of local constraints on DER providing global services	Technical	Amount of flexible power that can be reliably delivered from DERs to provide global services, with respect to their total potential. Evaluate the hosting capacity of the distribution network for DERs providing global services. KPI improvements can be expected in case of: - Effective and functional TSO-DSO coordination scheme - Local markets aimed at maximising global market participation	No	NA	Amount of flexible power that can be reliably delivered from DERs to provide global services, with respect to their total potential	Hybrid between data collected from the field and simulated data	Demo leader + Demo partecipants	Report + Excel	Demo leader + Demo partecipants	End of the demo experimentation	It depends on the demo

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Coordinated market efficiency	Technical	The decoupled nature of local and global markets leads to inefficiencies when they manage shared (aggregates of) DERs. This KPI measures how the TSO-DSO coordination improves the total cost of activated flexibility with respect to the ideal situation (fully coupled market).	No	NA	Total cost of activated flexibility with respect to the ideal situation (fully coupled market)	Simulated results from real and synthetic data	Demo leader + Demo partecipants	Report + Excel	Demo leader + Demo partecipants	End of the demo experimentation	It depends on the demo
Reduction of energy consumption of thermal loads	Technical	Reduce the energy consumption of thermal loads by applying an efficient control.	No	15% reduction	Compare real measured consumption with the BAU consumption: Reduction = 100* (Cbau-Creal) / Cbau	Hybrid between data collected from the field and simulated data	TV	Report	TV	Quarterly	Calcualte the thermal consumption without the external control based on user usage and learned thermal parameters
Reduction of energy costs of thermal loads	Economic	Reduce the energy associated cost of thermal loads by applying an efficient control.	No	15% reduction	Compare real measured consumption with the BAU consumption, and then multiply it for the energy price. Reduction = 100* (Price*Cbau - Price*Creal) / (Price*Cbau)	Hybrid between data collected from the field and simulated data	TV	Report	TV	Quarterly	Calcualte the thermal consumption without the external control based on user usage and learned thermal parameters
Reduction in computational infrastructure for digital services and ADMS/DERMS	Technical	Rather than running, monitoring, and maintaining a system, utilities can keep focus on their business, i.e., operate the grid rather than maintaining IT and playing role in SLA,	Yes	Up to 40% faster time to production comparing to on-premises deployments The results show that Azure Compute is 52–79 percent more energy efficient than compute equivalents deployed in traditional enterprise data-centres	Reduction of integration challenges Time to production for a DERMS implementation on cloud / Time of implementation for a DERMS on Premise	Data collected from the platform during deployment and demo.	Demo leaders	Report	SCHN/SAP/RWTH	End of the project	Scenario to compare is according to SCHN experience, DERMS deployments on premise.

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