Flexibility register description and implementation

D7.2

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Dissemination Level	Public

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 957739

Issue Record

Planned delivery date	28.02.2023
Actual date of delivery	28.02.2023

Version	Date	Author(s)	Notes
0.1	23.10.2022	Rinta-Luoma, Leiskamo, Kukk, Liepnieks, Zikmanis, Maneikis, Seitsamo, Devine, Gildemann, Petron	Version for internal review following the original project timeline
0.15	1.2.2023	Rinta-Luoma, Leiskamo, Gildemann, Sanjab, Marques	Version for internal review following the amended project timeline
0.2	14.2.2023	Rinta-Luoma	Version for quality check
1.0	28.2.2023	Rinta-Luoma	Final version

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About OneNet

The project OneNet (One Network for Europe) will provide a seamless integration of all the actors in the electricity network across Europe to create the conditions for a synergistic operation that optimizes the overall energy system while creating an open and fair market structure.

OneNet is funded through the EU's eighth Framework Programme Horizon 2020, "TSO – DSO Consumer: Large-scale demonstrations of innovative grid services through demand response, storage and small-scale (RES) generation" and responds to the call "Building a low-carbon, climate resilient future (LC)".

As the electrical grid moves from being a fully centralized to a highly decentralized system, grid operators have to adapt to this changing environment and adjust their current business model to accommodate faster reactions and adaptive flexibility. This is an unprecedented challenge requiring an unprecedented solution. The project brings together a consortium of over 70 partners, including key IT players, leading research institutions and the two most relevant associations for grid operators.

The key elements of the project are:

1. Definition of a common market design for Europe: this means standardized products and key parameters for grid services which aim at the coordination of all actors, from grid operators to customers;
2. Definition of a Common IT Architecture and Common IT Interfaces: this means not trying to create a single IT platform for all the products but enabling an open architecture of interactions among several platforms so that anybody can join any market across Europe; and
3. Large-scale demonstrators to implement and showcase the scalable solutions developed throughout the project. These demonstrators are organized in four clusters coming to include countries in every region of Europe and testing innovative use cases never validated before.

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List of Abbreviations and Acronyms

Acronym	Meaning
aFRR	Automatic frequency restoration reserve
ASM	Active System Management
BRP	Balance Responsible Party
BUC	Business use case
CIM	Common Information Model
DEP	Data Exchange Platform
DSO	Distribution System Operator
FFR	Fast frequency response
FCR	Frequency containment reserve
FR	Flexibility Register
FRO	Flexibility Register Operator
FSP	Flexibility Service Provider
IEGSA	Interoperable pan-European Grid Service Architecture
MARI	Manually Activated Reserves Initiative
mFRR	Manual frequency restoration reserve
MO	Market Operator
NEMO	Nominated Electricity Market Operator
NRT-P-E	Near-real time active energy (product in the Northern Demonstrator)
RP	Resource provider
SO	System Operator
SOTA	State-of-the-Art
ST-P-E	Short-term active energy (product in the Northern Demonstrator)
STOR	Short term operating reserve
SUC	System use case
T&D CP	TSO-DSO Coordination Platform
TSO	Transmission System Operator
USEF	Universal Smart Energy Framework
WP	Work Package

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Executive Summary

The goal of this document is present the description and implementation of Flexibility Register in the context of OneNet project's Northern Demonstrator. The Flexibility Register is envisioned as one of the key building blocks of the future flexibility markets of power systems where the same flexible assets are used to provide services for multiple actors and purposes. The Flexibility Register facilitates information exchange related to the overall flexibility market framework and conducts processes related to asset information management and flexibility verification and settlement.

The Flexibility Register concept is currently described in many European projects and initiatives, but it is not yet implemented in scale. The need for the system arises from the energy transition and increasing number of distributed assets, which need to be connected to the power system without compromising the secure operation of the system. That is why electricity System Operators need novel tools and practices to manage the system, one of which is the use of flexibility. The Flexibility Register enables the use of the same resources for multiple grid services through market-based processes by facilitating information exchange and managing information about the resources. This document presents how the Flexibility Register concept is designed in the Northern Demonstrator to achieve the aforementioned goals.

On high-level, the functionalities designed for the Flexibility register include registration and qualification of resources and flexibility service providers, flexibility contract management and flexibility verification and settlement. In the architecture proposed by the Northern Demonstrator, a key aspect is cooperation of different systems and how they share the needed functionalities to facilitate an efficient flexibility market. Thus, the Flexibility Register is closely integrated to TSO-DSO Coordination Platform as well as Market Operator platforms. With this structure the Northern Demonstrator aims to achieve a market framework which enables to use of flexibility and boosts liquidity on the marketplaces.

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1 Introduction

1.1 Task 7.2

This document is the deliverable of Task 7.2 of the OneNet project, in which the Flexibility Register functionalities are developed primarily for the Northern Demonstrator, which is called Work Package (WP) 7 in the OneNet project organisation. The Task 7.2 worked in close collaboration with the other Tasks of WP 7, which first defined the Business Use Cases for the Demonstration to form the scope for the whole demonstrator. After this, the work of Task 7.2 started by reviewing previous projects and initiatives about the Flexibility Register concept. Next, Task 7.2 organised internal workshops to formulate the functionalities for the Flexibility Register needed by the Demonstrator concept. Based on this, the detailed planning and implementation of the functionalities were conducted by the Demonstrator parties.

The objective of the work reported this deliverable is to present the architecture and functionalities of the Flexibility Register in the context of OneNet project's Northern Demonstrator. The work done by the OneNet project, presented in this document, aims to bring more insight to the questions around the functions required to facilitate future flexibility markets.

1.2 Outline of the Deliverable

The chapter 2 of this document gives an overview of the background of the envisioned system, description how the definition work was conducted, and which kind of functionalities were defined to be enabled by the system. Chapter 3 presents more detailed descriptions of two important functionalities of the Flexibility Register, namely the baseline calculation and TSO-DSO cost allocation. This is followed by detailed description of the implementation of the functionalities, which is presented in chapter 4. This implementation works as an important component of the Northern Demonstrator, which is an realization of a multilateral flexibility market, where System Operators can procure market-based flexibility services in a coordinated manner. Finally, the conclusions are presented in chapter 5.

1.3 How to Read this Document

This deliverable is part of the WP 7, the Northern Demonstrator documentation. To understand the whole concept of the Demo, it is advised to acquaint oneself with description of the WP 7 Business Use Cases (BUCs) in the deliverable D2.3 of the OneNet found in [1]. To find out more about the other components of the Northern Demonstration concept, more information can be found from other deliverables of the WP 7, namely D7.1 [2] and D7.4 [3]. The final results of the whole WP7 can be found in the deliverable D7.6, which will be published in the end of the project.

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2 Description of Flexibility Register functionalities

The concept of the Flexibility Register (FR) is elaborated in several European initiatives and projects. The work of the task 7.2 of the OneNet project started by studying the state of the art of the concept by reviewing the documentation of the previous projects. The results of the study are presented in chapter 2.1. The following chapter 2.2 gives an overview to how the FR concept is already applied in different countries. Based on this, the following steps of the task started to define the functionalities to be implemented in the Northern Demo. This was done in collaboration with other tasks and horizontal work packages in an iterative manner. Some of the functionalities first envisioned were left out and some merged with processes as the design work proceeded. This process is described in chapter 2.3 and the results of it in chapter 2.4.

2.1 State of the art review

2.1.1 Active System Management report

Overview

The TSO–DSO Report on An Integrated Approach to Active System Management (ASM) is written by ENTSO-E and four DSO organisations, namely Cedec, E.DSO, Eurelectric and Geode describes as a key set of strategies and tools performed and used by DSOs and TSOs for the cost-efficient and secure management of electricity systems. The use of flexibility is a central part of achieving this [4].

Role of flexibility register in the initiative

The ASM report introduces the concept of Flexibility (Resources) Register to enable coordinated, efficient, and secure Active System Management process. The objective of the Flexibility Register is to gather and share relevant information on potential sources of flexibility, including structural information about the location of resources that can provide flexibility. Visibility for the System Operators of the resources connected to their grid is presented as an important function. Also, settlement of flexibility services between market parties and supporting the use of aggregated bids are mentioned as key functionality. [4]

The ASM report states that the use of the Flexibility Register should be decided nationally and already existing tools should be considered when assessing and developing the register. The report also suggests that the responsibility of the correct representation of the resource information in the register is the responsibility of the connecting System Operator. [4]

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Relevant functionalities

The ASM report envisions a broad range of functionalities to the Flexibility Register, which can be regarded as relevant business use cases. These use cases are mainly just listed or mentioned, not specifically described [4]:

- Manage flexible resource information
- Provide visibility to System Operators about flexible resources in their grid
- Resource prequalification
- Product prequalification
- Store prequalification data
- Evaluate bids in trading phase
- Assess the impact of activating the resource in relation to the current status of the grid
- Share information about congestions to markets
- Verify delivered energy
- Support information exchange of aggregated bids

2.1.2 H2020 INTERRFACE

Overview

The Horizon 2020 project INTERRFACE (TSO-DSO-Consumer INTERFACE aRchitecture to provide innovative grid services for an efficient power system) aims to create a pan-European flexibility market architecture that enables seamless integration of different marketplaces and ensures equal and transparent access to all market parties. An important goal of the project is to enable efficient coordination between system operators in procuring system services. The project started at the beginning of 2019 and last until the end of 2022 [2].

Role of Flexibility Register in the project

The Flexibility Register (FR) is described in the project as one of the four main components of the planned architecture called IEGSA (Interoperable pan-European Grid Service Architecture). As the foundation was laid in the ASM report (see chapter 4.1 of [4]), the main functions of the FR are sharing relevant information about flexible resources and supporting the settlement process and information exchange. The FR is envisioned to enable the efficient functioning of the flexibility market by making it possible to use flexible resources, also on the distribution level, to offer flexibility services [5]. Relevant functionalities from the project's definitions are summarized in the following.

Relevant functionalities

1. Resource qualification

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A resource is registered to the FR by an Flexibility service provider (FSP). In this process the basic information of a resource is collected, and where needed, its information is enriched by System Operators and national datahubs hosting metering point information and metering data. In the same process the FR initiates an initial grid check, which is done against a static grid model in the TSO-DSO Coordination Platform to find out if an activation of the resource can cause congestions at any point in time. The grid model used in this process presents a so called worst case situation in order to show the most critical situations where the congestions could emerge. If this is the result, the resource will be assigned qualification status "qualified with restrictions" and included in the grid check in the Bid Qualification phase. FSP pools its resources into resource groups, which is the unit offered to the markets.

2. Product qualification

Market operators communicate their product requirements to the FR, where the product qualification process is initiated. Resource group characteristics are evaluated against the product requirements and additionally the qualification can be delegated to the market operator (for example in a case where TSO is the market operator and activation test is part of the qualification requirements). Product qualification results are stored in the FR, which is the prerequisite for offering the resource to the respective marketplace.

3. Trading phase and bid qualification

The FR supports the trading phase and bid qualification by providing resource data, like location and resource capacities, to relevant parties and systems including the TSO-DSO Coordination platform and Market Operator. The TSO-DSO Coordination platform's bid qualification process utilizes the information about resources when it checks whether the grid can activate the bids in question. The metering point ID links resources to the grid topology. This is needed to find out nodes in the grid the resources affects. When a trade is concluded, it is reported to the FR for settlement purposes.

4. Settlement phase

The FR receives metering data from the FSPs or the metering data administrator, e.g. a datahub. The FR also receives the activated flexibility amount or baseline from the FSP, depending on which of the two verification alternatives are used. The FR then determines the delivered flexibility per trade. The verification process also takes into account the activation amount per BRP in cases where the resources are aggregated from different BRP balances, in order to make balance corrections.

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2.1.3 H2020 EU-SysFlex

Overview

The EU-SysFlex project identifies issues and solutions associated with integrating large-scale renewable energy and creates a plan to provide practical assistance to power system operators across Europe. Long-term roadmap is provided to facilitate the large-scale integration of renewable energy across Europe. [7]

The EU-SysFlex project brings new solutions to the market by developing new approaches for system operation with high share of renewables to market design and regulatory requirements, as well as integration of new system services and data management plans to cover the pan-European market. The project duration is November 2017 – February 2022. [7]

Demonstration of cross-border and cross-sector data management and exchanges was conducted in Work Package 9 (WP 9). The objective of the work package is to test and demonstrate the data management solutions for flexibility services, developed in WP5. Several demonstrators focus on aspects of data management, including cross-border communication between different data exchange platforms and with different stakeholders in order to facilitate the cross-border exchange of flexibility services. [8]

An application for TSO-DSO flexibility data exchange, called Flexibility Platform, has been developed to facilitate TSO-DSO cooperation to enable efficient and effective supply and use of flexibility services. The interface between this tool and a data exchange platform was developed. The Flexibility Platform is meant to be used by flexibility providers (including aggregators) and flexibility users (system operators). The application facilitates information exchange which is pivotal for the coordinated use of flexibility resources for a variety of ancillary services (congestion management both at transmission and distribution levels, balancing, emergency reserves, among others). The application is considered a necessary tool for facilitating the efficient functioning of the electricity market. [8]

For the data exchange platform the project utilised the Elering's Estfeed platform, which is already used in Estonia and integration platform in the energy sector. The Estfeed connects various data sources, applications and market participants. It provides secure access to consumption and generation data in the electricity and gas data hubs. EU-SysFlex aims to widen the concept of cross-border data exchange. Several demos connect to data exchange platforms, data hubs and applications in different countries. This supports the delivery of energy services across the country's borders, incl. those necessary for flexibility trading. [8]

Role of Flexibility Register in the project

In the SysFlex project, the Flexibility Register functionalities are part of Flexibility Platform (FP). The system role 'Flexibility Platform' is used as a central role in flexibility market use cases. FP enables the trading of different flexibility products and services. The FP is operated by a Market Operator and it is available to System Operators and Flexibility Services Providers. It is used to support the prequalification, the bidding, the activation and the

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verification processes, ensuring coordination between activities undertaken by several operators using the same flexible resources. Several national and regional FPs may exist. [8]-[10]

Relevant functionalities

New big data collection, storage, and processing functionalities identified from the EU-SysFlex use cases in [6] are:

1. Flexibility prediction

Flexibility products are described as either slow (e.g., manual frequency restoration reserve (mFRR) and the UK short term operating reserve (STOR)) or semi-fast (e.g., automatic frequency restoration reserve (aFRR)) or fast (e.g., frequency containment reserves (FCR) and fast frequency response (FFR)) and can provide services for balancing and congestion management at local and national levels for TSOs and DSOs. The assessment of flexibility availability is split into three timeframes: investment planning (3+ years ahead) aims to understand future availability and if the predictions highlight insufficient capacity that needs addressing; operation planning (days to years ahead) aims to predict the short, medium and long term availability of flexible products that have committed to providing service; real-time planning (intraday operation) aims to predict the current availability of flexible products for balancing and congestion management requirements for that day.

2. Flexibility prequalification

The use case describes the process of pre-qualification of the flexibility service providers (aggregators and individual consumption, generation, and storage units) before they can make bids to the market and be activated. Prequalification involves both 'product' and 'grid' prequalification. Thereby the Flexibility Platform acts as a uniting element, which gathers flexibility needs provided by system operators as well as flexibility potentials provided by flexibility service providers (FSPs). For grid prequalification, coordinated actions with optimization operator or system operators are required for 'grid validation' process.

3. Flexibility bidding

The use case describes the bidding process ending with a ranking of flexibility bids, which will then be activated by the system operator (see separate system use case for flexibility activation). Thereby the Flexibility Platform acts as a uniting element, which gathers and registers flexibility bids provided by FSPs. Before including bids in the merit order list, coordinated actions with the optimization operator or the system operator are required for the 'grid validation' process.

4. Flexibility activation

This use case describes data exchanges needed for the initiation of activation of flexibilities bids that previously have been sent to the Flexibility Platform. Delivery of notification of activation requests to the FSPs, in a reliable and timely manner according to the relevant terms and conditions applicable to FSPs. Right before activation, coordinated actions with optimization operator or system operator are required for 'grid validation' process. This use case does not apply to high-speed products in which the flexible units must react automatically to prescribed events in the system (like FCR product applied to immediate frequency deviations).

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5. Flexibility baseline calculation

If a market participant bids flexibility in the flexibility market, the baseline consumption/generation of such market participant needs to be identified for the verification and settlement processes (see SUC 'Verify and settle activated flexibilities'). There are two options for this:

a. A market participant has to declare its power schedule (baseline) ex-ante in such a way to permit the system operator to implement the settlement processes. Such players (FSP) usually declare the baseline directly, but the system operator could provide specific tools to help market participants in the baseline definition, promoting market participation.
b. The Market operator (TSO or DSO or Flexibility Platform operator) calculates the baseline ex-post based on meter data. The methodology to calculate the baseline is transparent and public.

6. Verification of activated flexibilities

The actual flexibility delivered is calculated as the difference between baseline and metered consumption/generation of that FSP. The verification takes place by comparing the delivered flexibility and the flexibility requested by the system operator. A settlement means an FSP faces a penalty if the delivered flexibility is less than the requested flexibility. The imbalance settlement process follows but is out of the scope of this use case.

These functionalities were tested in the Flexibility Platform demonstrator. The high-level architecture of the demonstrator is described in *Figure 2.1*.

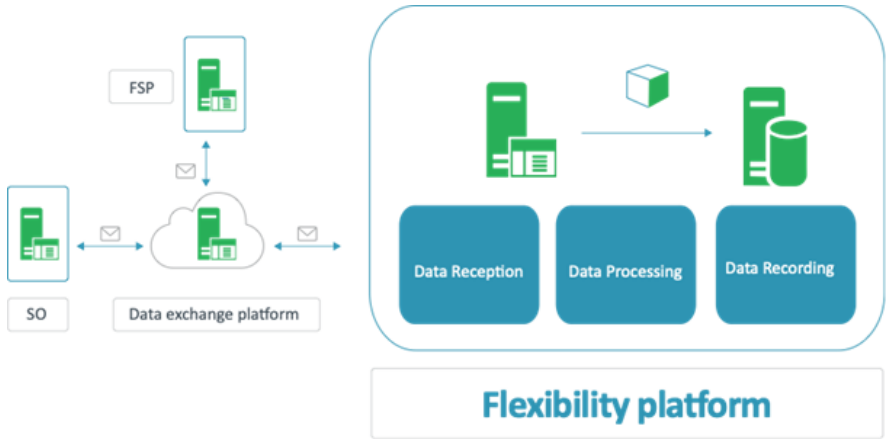

Figure 2.1 High-level architecture of Flexibility platform concept

A list of flexibility related processes that are conducted via market platform ('Flexibility Platform'):

1. Register flexibility need by TSO or DSO
2. Register flexibility potential by FSP
3. Send necessary information for grid impact assessment to system operator/optimization operator – grid constraint check-in prequalification phase
4. Collect the results of grid impact assessment in the prequalification phase

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5. Prequalify FSP based on information provided by FSP in its 'flexibility potential' and based on results of grid impact assessment
6. Set 'long-term restrictions'[1] to the FSPs not passing constraint check-in prequalification phase
7. Register 'long-term restrictions'
8. Publish prequalification results, incl. information about 'long-term restrictions'
9. Register flexibility call for tender opening
10. Receive flexibility bids
11. Send necessary information for grid impact assessment to system operator/optimization operator – grid constraint check-in bidding phase
12. Collect the results of grid impact assessment in the bidding phase
13. Set 'short-term restrictions'[2] to the FSPs not passing constraint check-in bidding phase
14. Rank bids based on merit order principle (taking into account 'short-term restrictions')
15. Register flexibility bid
16. Register flexibility call for tender closure
17. Receive request for flexibility activation
18. Send necessary information for grid impact assessment to secondary system operator / optimization operator – grid constraint check in activation phase
19. Collect the results of grid impact assessment in activation phase
20. In case activation would cause grid constraint to select next set of bids for activation
21. In case activation would cause an imbalance to send information for counteraction to an appropriate role (primary system operator assumed in a use case)
22. Forward request for activation to FSP
23. Register activation request
24. Register activation confirmation received from FSP
25. Receive data (meter data, sub-meter data, external data) for baseline calculation
26. Calculate baseline
27. Record baseline
28. Receive meter data for verification
29. Calculate delivered flexibility
30. Verify delivered flexibility
31. Send information for settlement

[1] 'Long-term restrictions' are limitations set on the flexible resources resulting from the grid impact assessment (grid qualification) in prequalification phase, i.e., long before actual activation.

[2] 'Short-term restrictions' are limitations set on the flexible resources resulting from the grid impact assessment (grid qualification) in bidding phase, i.e., short before actual activation.

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Description of data exchange use cases based on IEC 62559 methodology are described in [10]:

- Calculate flexibility baseline[3]
- Manage flexibility activations[4]
- Manage flexibility bids[5]
- Predict flexibility availability[6]
- Verify and settle activated flexibilities[7]

2.1.4 H2020 CoordiNet

Overview

The CoordiNet project aims at demonstrating how DSOs and TSOs shall act in a coordinated manner to procure and activate grid services in the most reliable and efficient way through the implementation of three large-scale demonstrations. The project is centred on three main objectives: demonstrating TSO – DSO coordination for more reliable and ecological supply of electricity to customers, defining standard products and developing a platform for TSO-DSO-Consumer cooperation and pan-European markets. The project lasted from 2019 to 2022 [11]

Role of Flexibility Register in the project/initiative

The Flexibility Register is not described as such in the CoordiNet project's architecture. All the functionalities including coordination and market functions are done on a single central platform called the CoordiNet platform (Spanish and Greek demos). Also, many of the Flexibility Register-related functionalities in are performed by other roles, such as the System Operator or Market Operator [11].

Relevant functionalities

In the deliverable D2.1 [11] the functionalities of the different tools of the three demonstrators are described. As mentioned, the processes perceived as Flexibility Register related are mainly integrated to other roles or "tools" as they are described in the document.

[3] EU-SysFlex, "Calculate flexibility baseline". Available in https://eu-sysflex.com/wp-content/uploads/2020/10/Task-5.2-use-case-Calculate-flexibility-baseline.pdf

[4] EU-SysFlex, "Manage flexibility activations". Available in https://eu-sysflex.com/wp-content/uploads/2020/10/Task-5.2-use-case-Manage-flexibility-activations-Alt-1.pdf

[5] EU-SysFlex, "Manage flexibility bids". Available in https://eu-sysflex.com/wp-content/uploads/2020/10/Task-5.2-use-case-Manage-flexibility-bids-Alt-1.pdf

[6] EU-SysFlex, "Predict flexibility availability". Available in https://eu-sysflex.com/wp-content/uploads/2020/10/Task-5.2-use-case-Predict-flexibility-availability.pdf

[7] EU-SysFlex, "Verify and settle activated flexibilities". Available in https://eu-sysflex.com/wp-content/uploads/2020/10/Task-5.2-use-case-Verify-and-settle-activated-flexibilities.pdf

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Regarding the functionalities regarded as Flexibility Register related, D2.1 presents a thorough analysis of different flexibility verification methods, focusing on baseline methodologies. [11] This analysis was considered when the verification process of FR was designed for the Northern Demonstrator.

2.1.5 Piclo concept

Overview

Piclo is an independent online flexibility marketplace helping system operators (DSOs and TSOs) to procure flexibility. The platform started out as an R&D project (UK Government funded) to help DSOs in the UK procure flexibility and has since been commercialised for use in the UK and Slovenia [12].

Role of Flexibility Register in the initiative

The platform allows system operators to advertise their flexibility needs and run competitive auctions (Competitions) for qualified FSPs to win flexibility contracts. A System Operator can choose to link Competitions to a Dynamic Procurement System also known as Company qualification. This is a simple process by which Piclo helps System Operators to pre-qualify FPS companies before competitions take place. The Company qualification is valid for an extended period of time (usually 3-5 years) for that specific System Operator.

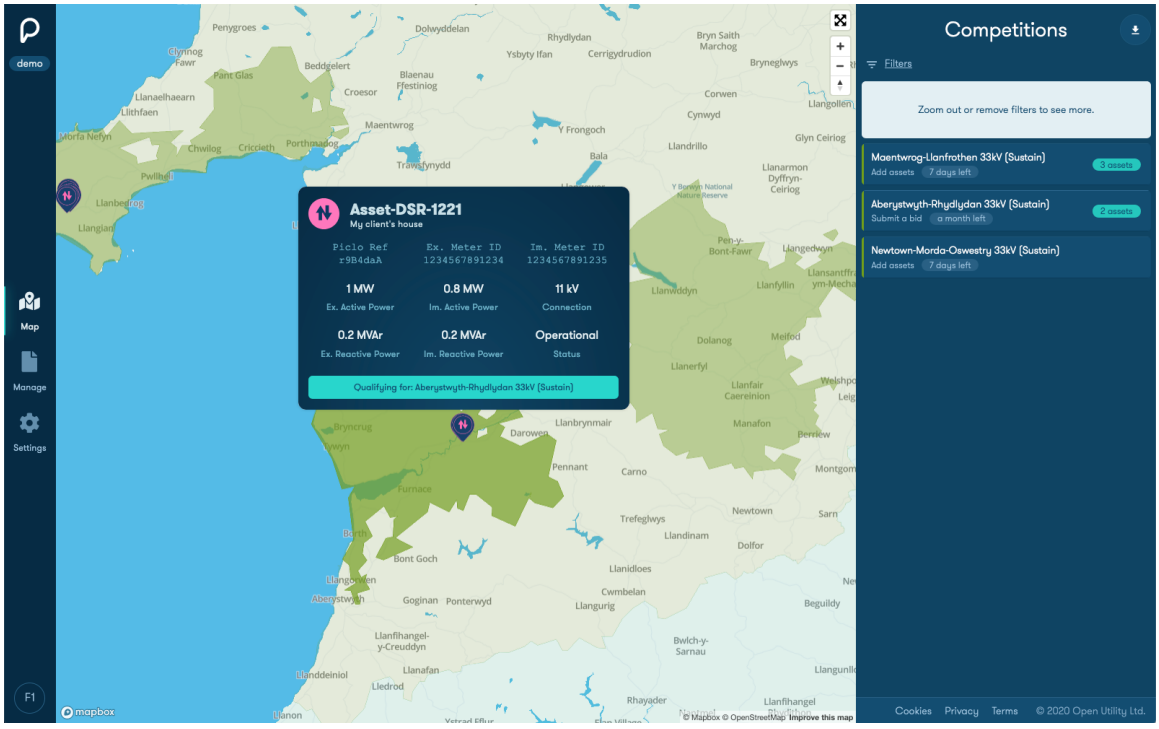

Figure 2.2 – Asset information on Piclo user interface

In order for FSPs to qualify for these Competitions, their company and asset data must be verified and checked against the flexibility needs of the system operator. FSPs must register their company and upload their

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asset data[8] to the Piclo platform in order to participate in Competitions. The Piclo platform then facilitates the transfer of relevant data to the system operator if it passes an initial pre-qualification done by Piclo. The system operator can then review the company and asset data to ensure the FSP could meet the flexibility requirements.

FSPs can only see asset data uploaded by their own company but not data uploaded by other FSPs. The system operators have a limited view of the asset data (asset type, capacity, connection voltage, status, meter ID) via the website user interface, but cannot see more detailed information on the assets (company, detailed technical parameters, post code, etc.) unless the asset passes a set of pre-qualification criteria (located in an active Competition area, connected at the right voltage level, able to provide the correct flexibility).

Relevant functionalities

1 Registration – allows FSPs and SOs to register company account, all users within the same company have individual logins connected to the same company account.
2 Company qualification – allows SOs to qualify a company either per competition or per SO for an extended period of time via DPS[9].
3 Visibility – allows SOs to publish flexibility needs[10] to the market.
4 Competitions (auctions) - allows SOs to run competitive auctions for qualifying FSPs to bid in with their flexibility to meet published need.
5 Asset registration – allows FSPs to upload assets to see where they pre-qualify for SOs' flexibility need.
6 Asset qualification –Allows SOs to see pre-qualified assets and qualify or disqualify to participate in competitions.
7 Bidding – qualified assets[11] can bid into competitions to win flexibility contract.
8 Contract management – bids won are stored as "Contracts" in Piclo account so an assets availability can be updated.

2.1.6 Universal Smart Energy Framework

Overview

The Universal Smart Energy Framework (USEF) was founded in 2014 by seven key players (ABB, Alliander, IBM, STEDIN, DNV GL, ICT, Essent) in the smart energy industry with the main goal to accelerate the establishment of an integrated smart energy system which benefits all stakeholders, from energy companies to consumers, by developing smart energy technologies and services and bringing them together. USEF seeks to contribute to the harmonization of these flexibility mechanisms throughout Europe: describing a standard for

[8] Additional information on Piclo Flex APIs – Assets V1. Available in https://support.picloflex.com/article/14-how-to-add-assets
[9] Additional information on Piclo Flex DPS / Company Qualification Setup. Available in https://support.picloflex.com/article/61-dps-setup
[10] Additional information on Competition Setup. Available in https://support.picloflex.com/article/53-competitions
[11] Additional information on Piclo Flex Qualified Assets. Available in https://support.picloflex.com/article/64-qualified-assets

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unlocking the value of energy flexibility by making it a tradeable commodity and delivering the market structure, associated processes and rules required to make the trading of flexibility effective. USEF operate in a neutral role, without commercial or political bias [13]-[15].

USEF aims to facilitate effective coordination across all the different actors involved in the electricity market by providing a common, standardized role model and market design while describing communication requirements and interactions between market roles. USEF turns flexible energy use into a tradeable commodity available for all energy market participants, separate from (but in coordination with) the traditional electricity supply chain, to optimize the use of resources. To facilitate the transition towards a cost-effective and scalable model, the framework provides the essential tools and mechanisms to redefine existing energy market roles, add specific roles and to specify interactions and communications between them [14].

Role of Flexibility Register in the project/initiative

The concept of Flexibility Register is not described in USEF.

USEF defines the role of the Common Reference Operator (CRO), which operates a Common Reference - repository containing information about connections and congestion points in the network. Congestion management in the grid refers to avoiding the thermal overload of system components by reducing peak loads. Appropriately registered market participants have access to the Common Reference to optimize their services and exchange information. For example, the Common Reference can be accessed by the aggregators to assess whether they have sufficient flexibility from their customers in a congested area to provide to the DSO, and to explore new flexible resources to add to their portfolio, by contracting new customers within the congested area. Also, the Common Reference can be used for matchmaking between DSOs seeking to procure flexibility in an area and aggregators offering flexibility in the same are [16].

The Common Reference consists of a database with a logical structure, for which the CRO accepts updates from DSOs, aggregators, Balance Responsible Party (BRP). If operating in open mode, the CRO will accept updates from any USEF-compliant participants implementing the DSO role. In closed mode, participants will need to be pre-configured in order for updates to be accepted. The Common Reference is not a marketing instrument and safeguards both Prosumer privacy and DSO security requirements. Aggregators can only see the information on all Congestions Points for which they serve connections. Implementing the Common Reference this way ensures that the DSO does not need to share details of its grid topology, since the DSO only shares details about Congestion Points [16], [17].

CRO main use cases in operation with Common Reference and other market participants [18]:

- Receive DSO congestion point update.
- Receive aggregators connection update.
- Receive BRP connection update.

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- Send congestion points and BRPs to aggregators.
- Send active aggregators to DSO.
- Send active aggregators to BRP.
- Send active aggregators to Meter Data Company (MDC).

Relevant functionalities

USEF provides a standardized high-level common framework designed to be implemented on top of current energy markets such as wholesale, retail and capacity markets without enough detailed description [19]:

- Common terminology
- Framework for explicit demand side flexibility, with a focus on:
    - Roles and responsibilities
    - Market coordination of flexibility
    - Standardized market processes and information exchange
    - Measurement, validation and settlement
    - Facilitation of different aggregator implementation models, incl. independent aggregation
    - Product design, with a focus on DSO grid capacity management
- Exchange of experiences and best practices through USEF's user community:
    - Exchange on product design, business cases, implementation aspects, etc.
    - Capture of best practices in future releases of the framework.

The USEF market design aims to create well-functioning electricity markets, where flexibility is dispatched based on market signals to where it is most essential and valuable. Market coordination mechanism builds on top of existing European market arrangements and consists of five phases [13]:

Figure 2.3 – USEF market phases

- Contract: prosumers define the average flexibility of their energy use in line with their own individual needs and comfort settings. The sum of this contracted flexibility is the starting point for the aggregator, who will contact the BRP and DSO to inform them about his capability to activate flex.
- Plan: the aggregator looks at his portfolio of clients, each with their own individual needs and flexibility preferences and makes a forecast for the next day of needed energy and flexibility could be offered.
- Validate: in interaction with one or more BRPs and the DSO, the offered Flex can be utilized to optimize portfolios or to ease congestion.

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- Operate: USEF prescribes what the interaction between parties should look like and how this actual usage and flexibility delivered can be measured.
- Settle: USEF supports the exchange and the settlement of Flex with transparent and unambiguous data.

In USEF smart energy projects adopted across Europe[12] all details and low-level processes (for example, information sent between market participants and Common Reference) are not clearly described, that is why is not possible to find process descriptions relevant to the FR in OneNet project's context.

2.1.7 Conclusions of the analysis

The FR concept is part of many ongoing and recent European projects and initiatives. The functionalities and the role of FR is somewhat varying between the different initiatives, but on high level, the need for the system is similar in enabling an efficient flexibility market by managing, processing and sharing relevant data about flexible assets. What can also be observed from the different initiatives is the slightly differing scope of FR. The approach used in the H2020 INTERRFACE, and what is envisioned also for OneNet, is the separation of responsibilities between the FR functionalities and TSO-DSO coordination. These two roles have been combined in some initiatives, and sometimes connecting some Market operator functionalities to the same system. From this perspective the OneNet approach follows mostly the architecture presented by the INTERRFACE project.

Studying the aforementioned projects gave a firm basis to developing the FR concept for the OneNet project's Northern Demo

2.2 Status of flexibility registries in Europe

To understand better how the FR concept would fit existing market framework, and the systems and platforms implementing it, the demo group studied the situation in the participating countries regarding the use of different flexibility-related registries. The reviewed countries were:

- Finland
- Estonia
- Latvia
- Lithuania
- Sweden
- United Kingdom
- Belgium

[12] More information at USEF. Available in https://www.usef.energy/implementations/

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Based on the overview of the situation in the reviewed countries, it is possible to conclude, that the introduction of flexibility markets brings new requirements to facilitating the markets, some of which can be considered Flexibility Register-related, as described in this document. TSOs are often considered the party responsible for this kind of functions and actions. Although, as the energy transition brings also the DSOs to the same flexibility market landscape, the multilateral nature is required to be taken into account. The role of DSOs is also highlighted in the Article 32 of Electricity Market Directive ((EU) 2019/944), proposing new responsibilities to the DSOs in enabling flexibility markets [20].

Today, commercial parties, as well as regulated entities, have their registers for their own purposes. These collect, for example, the information needed to participate in a specific marketplace. Although these kinds of registers are needed and inevitable, access to certain data for other parties as well is important in avoiding unnecessary information asymmetry in the markets. This helps in fostering competition and customers' possibility to choose and change their service providers.

Datahubs are planned in many countries. More specifically, they focus on information exchange and data management in the electricity retail markets. The close connection of datahubs and the new requirements of the flexibility markets are clear on one hand, but on the other the needed functionalities are yet to be defined. In many countries the role of datahub is being considered with regards to the novel functionalities.

Flexibility Register, per se, was not implemented in any of the reviewed countries except Belgium, which has been a front runner on this topic. This so-called Flex Data Hub supports the use of distributed resources on the mFRR market including information about the location of the resources in addition to metering and activation data.

2.3 Detailed need assessment

In addition to the state-of-the-art review presented above, partner-specific needs related to Flexibility Register were gathered by the OneNet's Northern Demonstrator partners. This was done commonly in workshops of the demonstration group. All of the partners were engaged to get a broad overview about the expectations towards the Flexibility Register from the Northern Demonstrator partners. Based on these studies, the following list of functionalities was identified as relevant for the Flexibility Register:

1. Qualification and management of market parties and assets
    a. Registration of parties
    b. Registration of assets
    c. Resource qualification
    d. Product qualification
2. Settlement and verification

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   a. Metering data management
   b. Baseline calculation
   c. Determining realized flexibility volumes
   d. Reporting of verification results
3. Access management and data sharing
   a. Providing interfaces to data access
   b. Managing access rights to data
4. Forecasting and visualization
   a. Providing a forecasting service
   b. Providing a visualization service
5. Enabling secondary market
   a. Supporting the trading of contracts

The following topics were also identified as central design requirements to be considered:

1. Interaction between different registers, markets and platforms
2. Information exchange standards and data models
3. Cyber security and GDPR

This information was combined to the work of the Northern Demonstrator to define the overall process architecture of the demonstration.

2.4 Flexibility register design process in the Northern Demo

Parallel to task 7.2 work, the Northern Demonstration group started to work on the Business Use Case (BUC) of the entire demo. General description of the BUCs can be found in [1]. This included high-level end-to-end process, which completes the aim and the scope of the demonstration. After this, the work was continued under the different tasks that focused on different system components to define System Use Cases (SUCs). The SUCs of the FR can be found in the appendices of this document. The task 7.2 focused on the functionalities of the Flexibility Register (FR) component. The design was conducted in close collaboration with the whole WP 7, which ensures seamless cooperation and interoperability of the overall system.

The role of the OneNet middleware as the facilitator of information exchange between different system roles is included in the SUCs by referring to a more general role of Data Exchange Platform (DEP).

The SUCs related to the FR were split into three phases that reflect the proceeding of the overall process. The defined phases are:

- Preparation for flexibility trading
- Procurement and delivery

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- Verification and settlement

During this phase of the demonstrator planning, some the functionalities were left out of the final scope of the system. These were forecasting, visualisation and real-time monitoring.

The chosen FR process phases are presented on high level in the following chapters, while the whole SUCs with detailed process description can be found in the appendices.

2.4.1 Preparation for flexibility trading phase

The role of Flexibility Register in process phases prior to flexibility trading is described in this SUC. The processes include managing flexibility contracts, registering FSPs and their resources and conducting product prequalification. The entire SUC can be found in Annex 7.1.

The objective of this use case is to enable the preparation of Flexibility service providers (FSPs) for flexibility trading in the context of the OneNet Northern demonstration's scope. The FSP is the party initiating the process. FSPs aggregate multiple resources, such as demand response of industrial and residential customers, storage and small-scale (RES) generation, together. Still, the process and systems are designed to allow parties to become FSPs themselves and deliver flexibility directly to the SOs via flexibility markets. The prequalification process is a prerequisite for the following process steps of multilateral flexibility trading and coordinated flexibility procurement by SOs. The use case comprises of two phases, namely the Flexibility contract management phase and the Prequalification phase. The sequence diagrams can be found in *Figure 2.4* and *Figure 2.5* respectively.

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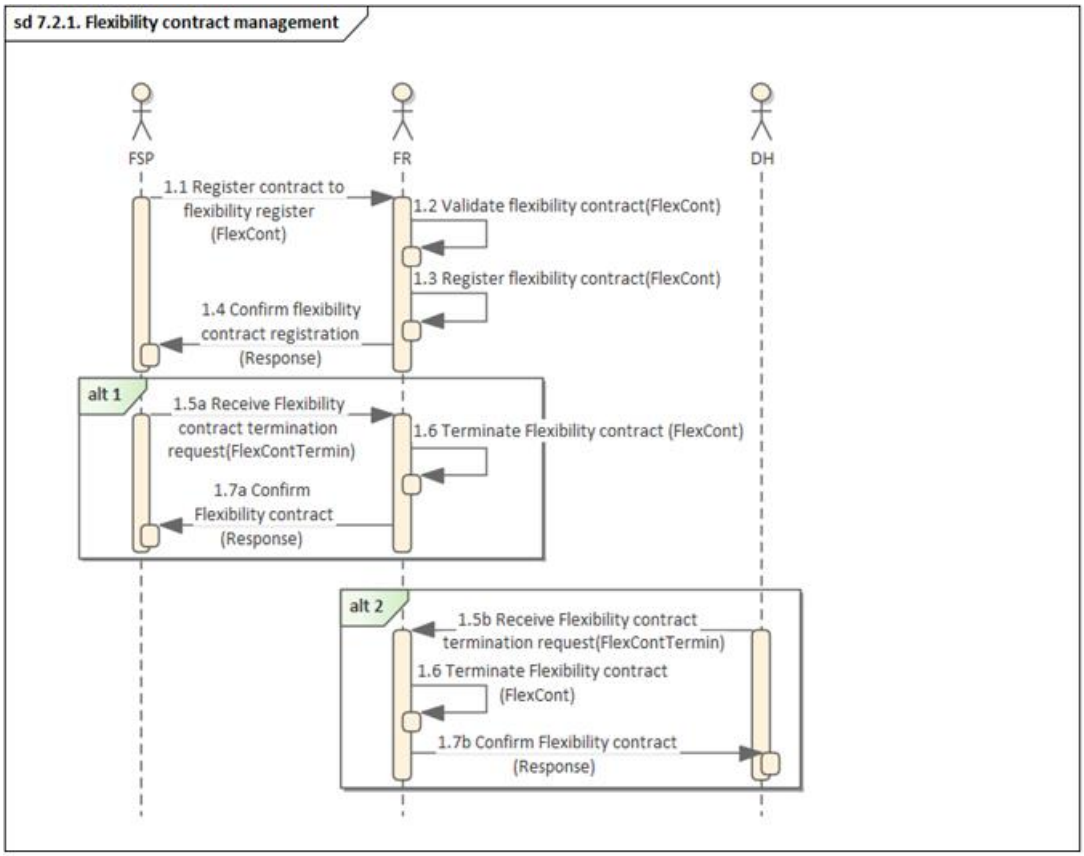

Figure 2.4 Sequence diagram for flexibility contract management

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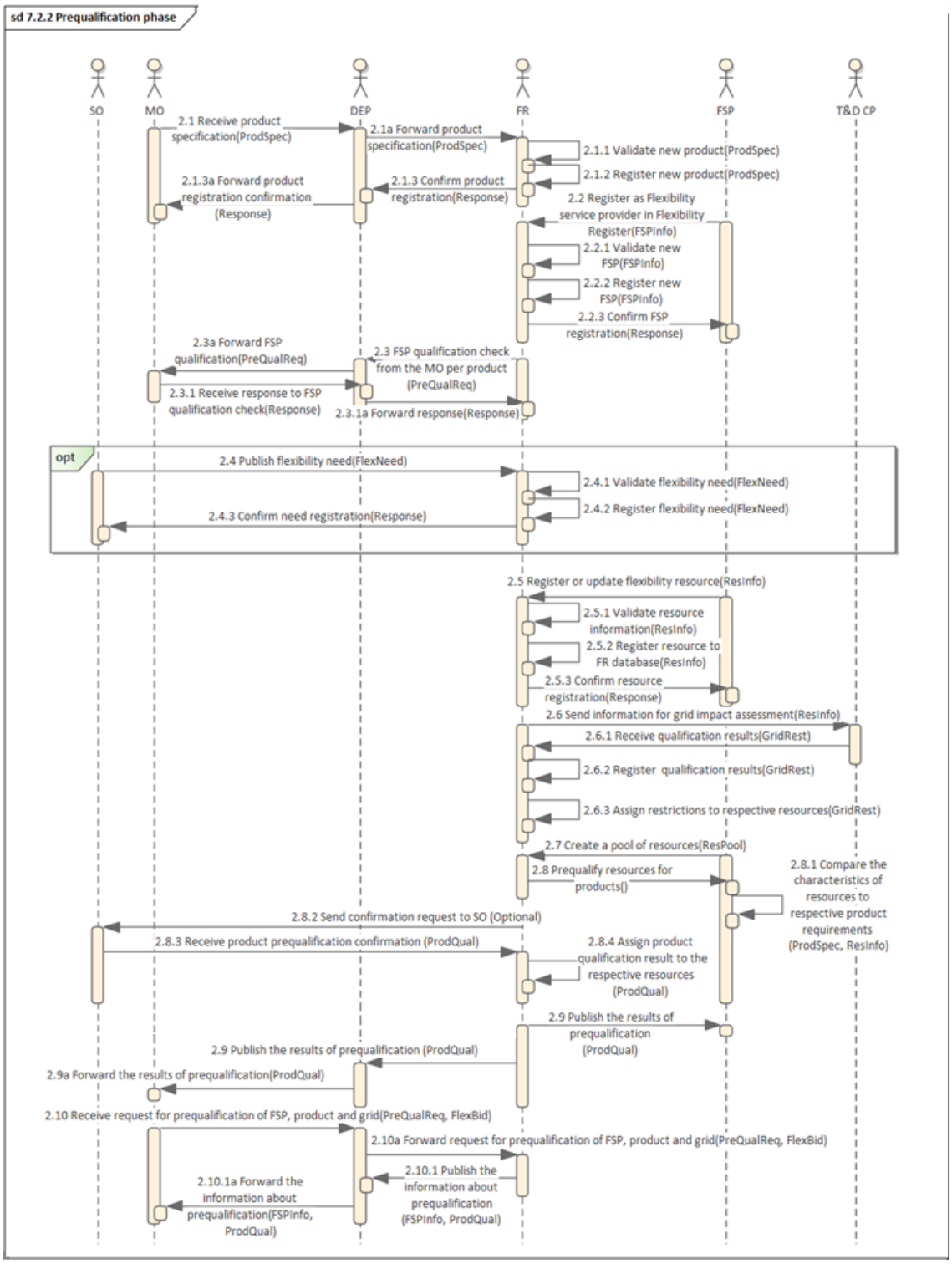

Figure 2.5 Sequence diagram for prequalification phase

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2.4.2 Procurement and delivery phase

The role of Flexibility Register in process phases during flexibility trading and delivery is described in this SUC. The objective of this use case is to enable the FSPs to efficiently offer their resources on different markets and the SOs to procure the flexibilities in the context of OneNet Northern demonstration scope. Here, the role of the FR is mainly to facilitate required information exchange with other system roles, so that they are capable of performing their processes. This process is a prerequisite for the settlement and verification phases. The sequence diagram for the use case can be found in *Figure 2.6*. The entire SUC can be found in Annex 7.2

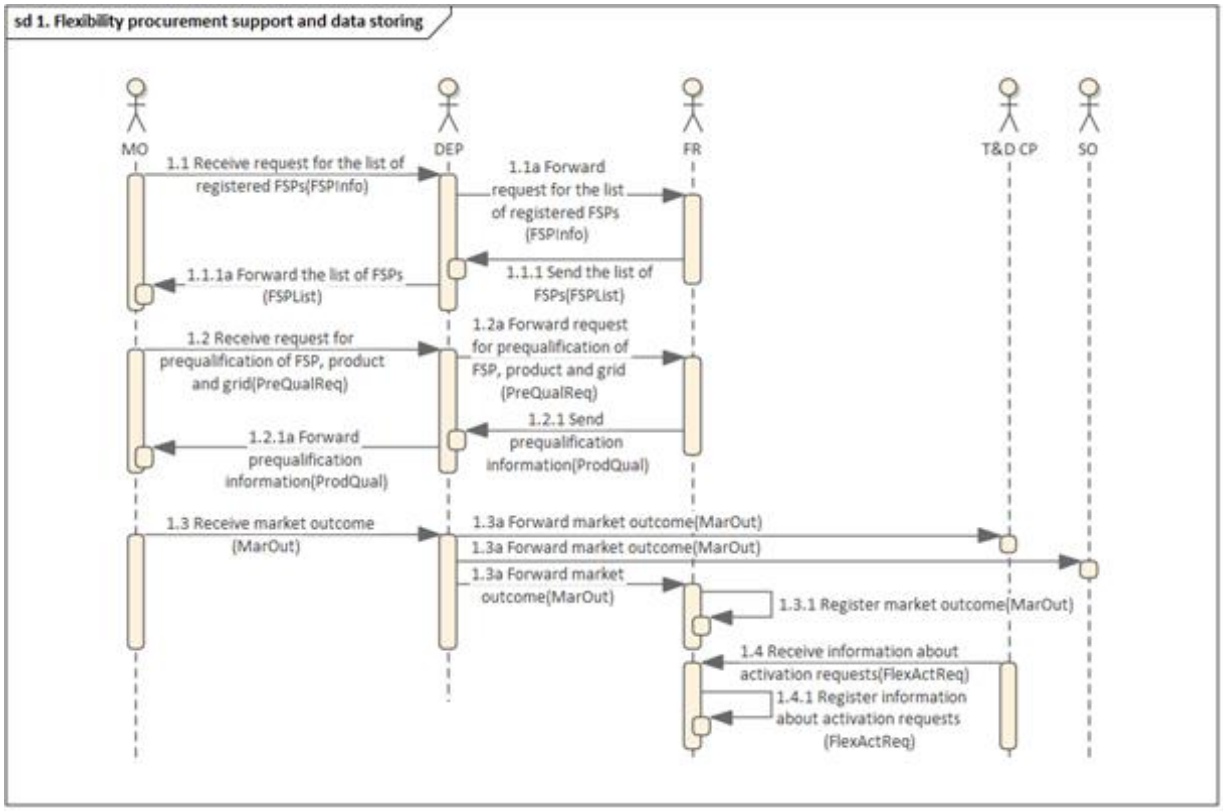

Figure 2.6 Sequence diagram for procurement and delivery phase

2.4.3 Verification and settlement phase

The role of Flexibility Register in process phases after flexibility trading is described in this SUC. The verification process quantifies the delivered flexibility and settlement process uses this information to conclude financial and imbalance settlement done partly outside of FR. The sequence diagram for the use case can be found in *Figure 2.7* while the entire SUC can be found in annex 7.3.

The objective of this use case is to quantify the delivered flexibility volumes and support the financial and imbalance settlement based on the results in the context of OneNet Northern demonstration scope. This is one of the FR's core functionalities.

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This process also includes the calculation of a baseline, which is conducted by the FR based on historical metering data. The Northern Demonstration concept presented two alternatives for establishing the reference value for metering data of resources, against which the behaviour of the resources is evaluated in the verification process. These two are the baseline calculated by the FR and schedules sent by the FSP operating the respective resources.

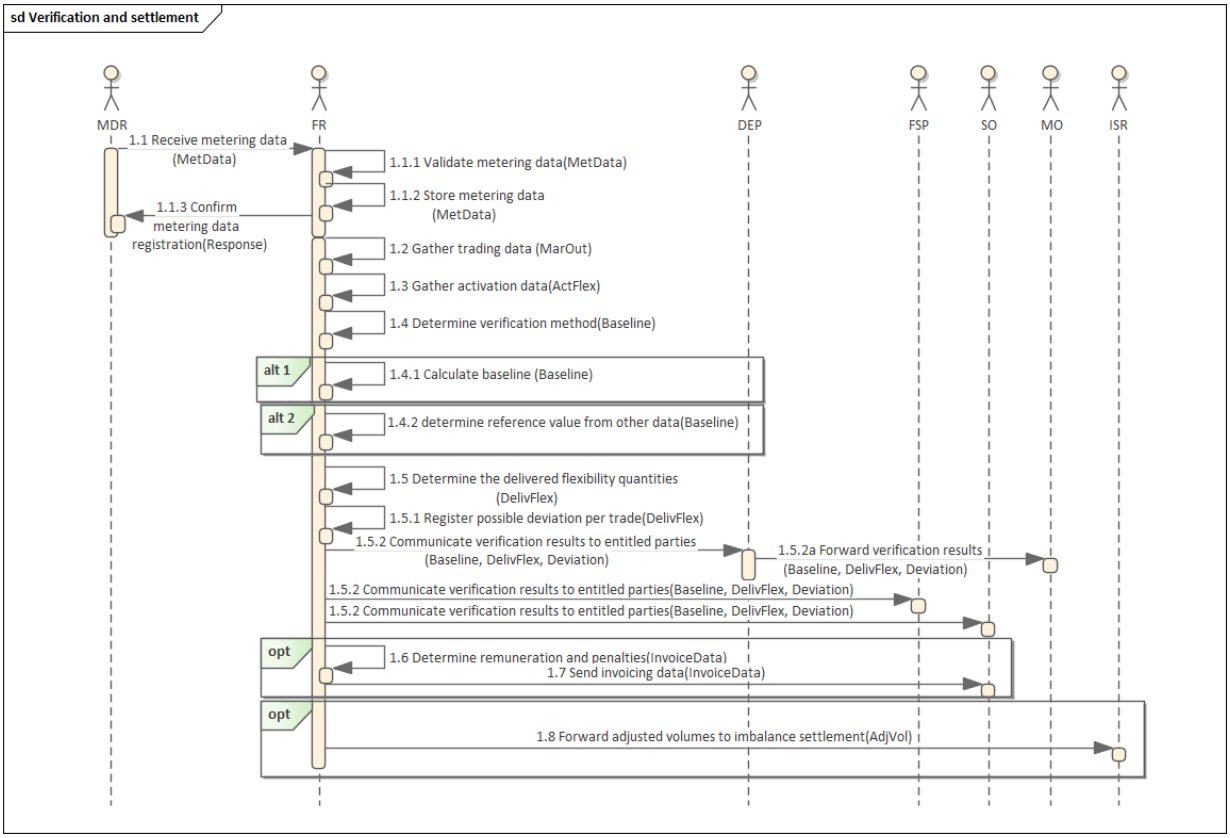

Figure 2.7 Sequence diagram for verification and settlement phase

2.5 Functionality descriptions

In this chapter the functionalities performed by the FR is explained in greater detail. High level overview of the functionalities supported by the Flexibility Register are:

1. Resource registration and qualification phase

   A resource is registered to the FR by an FSP. In this process, the basic information of a resource is collected, and where needed, its information is enriched by System Operators and Metering Data Responsible parties. FR pools the FSP resources into resource groups based on respective product requirements, but FSP has full control over managing the resource groups and changing them when appropriate. A resource group is the unit offered to the markets in the flexibility procurement process.

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This information is enabled to be shared with SOs in case an SO wants to perform an initial grid check and decide if they allow a specific resource group to be used in their network flexibility trading or if the activation of the resource group resources can cause congestion at any point in time. If the SO decides to perform the prequalification, the resource group will be assigned qualification status “qualified” or “not qualified” and based on this will be included or excluded in the Trading and bid qualification phase.

2. Product qualification

Market operators communicate their product requirements to the FR, where the product qualification process is initiated. Resource group characteristics are evaluated against the product requirements and formed accordingly. As a future extension, additional product resource group qualification can be delegated to the market operator (for example in a case where TSO is the market operator and wants to do an activation test). Product qualification results are stored in the FR, and a resource group matching to product requirements is the prerequisite for offering the resource to the respective marketplace.

3. Trading and bid qualification phase

The FR supports the trading phase and bid qualification by providing resource data, like resource capacities, to relevant parties and systems, including the TSO-DSO Coordination platform and Market Operator. The TSO-DSO Coordination platform’s bid qualification process utilizes the information about resource groups created in FR when it checks whether the grid can allow the activation of the bids in question. This is done through the metering point ID that links resources to the grid topology. This is needed to find out which nodes in the grid each of the resources is affecting. When a trade is concluded, it is identified in the FR through delivered flexibility verification for market settlement purposes.

4. Settlement phase

The FR receives metering data from the FSPs or the metering data responsible party, e.g., a datahub. The FR also potentially receives schedule information from the FSP, or the baseline is calculated by the FR, depending on which of the two verification alternatives are used. The FR then determines the delivered flexibility per trade. The verification process also calculates the delivered activation amount per BRP. To conclude the process, the information is forwarded to Market Operators.

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3 Methodologies for Flexibility register's internal functionalities

This chapter presents more closely how two of the Flexibility register's internal processes were designed. The two processes are baseline calculation model and cost allocation model.

3.1 Baseline calculation model

During the work of the Northern Demonstrator a master's thesis was written on the topic of verification methods. This study presented the literature on the topic and the most common methods used and tested different methods using the metering data of an office building. Based on the study, the high X of Y method was chosen to the implementation of the FR in the Northern demonstrator. The whole thesis can be found in [21].

The high X of Y method means more specifically, that X number of days that have the highest daily average measurement values are chosen from Y relevant days before the point in time for which the baseline is calculated. Relevant days in this case means that if the baseline is calculated for a working day, then weekends and public holidays are discarded. In the implementation, a choice was made to use the values used are X = 2 and Y = 4 for weekends and holidays, and X = 5 and Y = 10 for weekdays. Days with flexibility activations are also discarded when calculating the baseline.

The thesis also proposed to use an adjustment factor with the high X of Y method. The aim of this factor is to scale the profile of the baseline using measurements before the time period of the calculated baseline. In practice, the adjustment method calculates average measurement 3 to 1 hours before the start of the examined hour and compares it to the baseline of that same 2-hour period's baseline to form a coefficient, which again is multiplied with the baseline value of the examined hour. [21]

One aspect of using the described baseline method is that it needs quite a lot of historical metering data. In many cases this is not an issue, but for example when on-boarding a new flexible resource, there might not be enough historical data to begin with.

In *Figure 3.1* you can see how the high 5 of 10 method performs with real metering data. The data is from an electrically heated Finnish household and has 48 hours of hourly metering values. When both the actual measurement and the calculated baseline is depicted in the same figure, the difference between them is can be considered as the error of the baseline, since no flexibility was activated. In the figure one can notice that the method works relatively accurately in a consumption point that has a clearly repetitive consumption profile.

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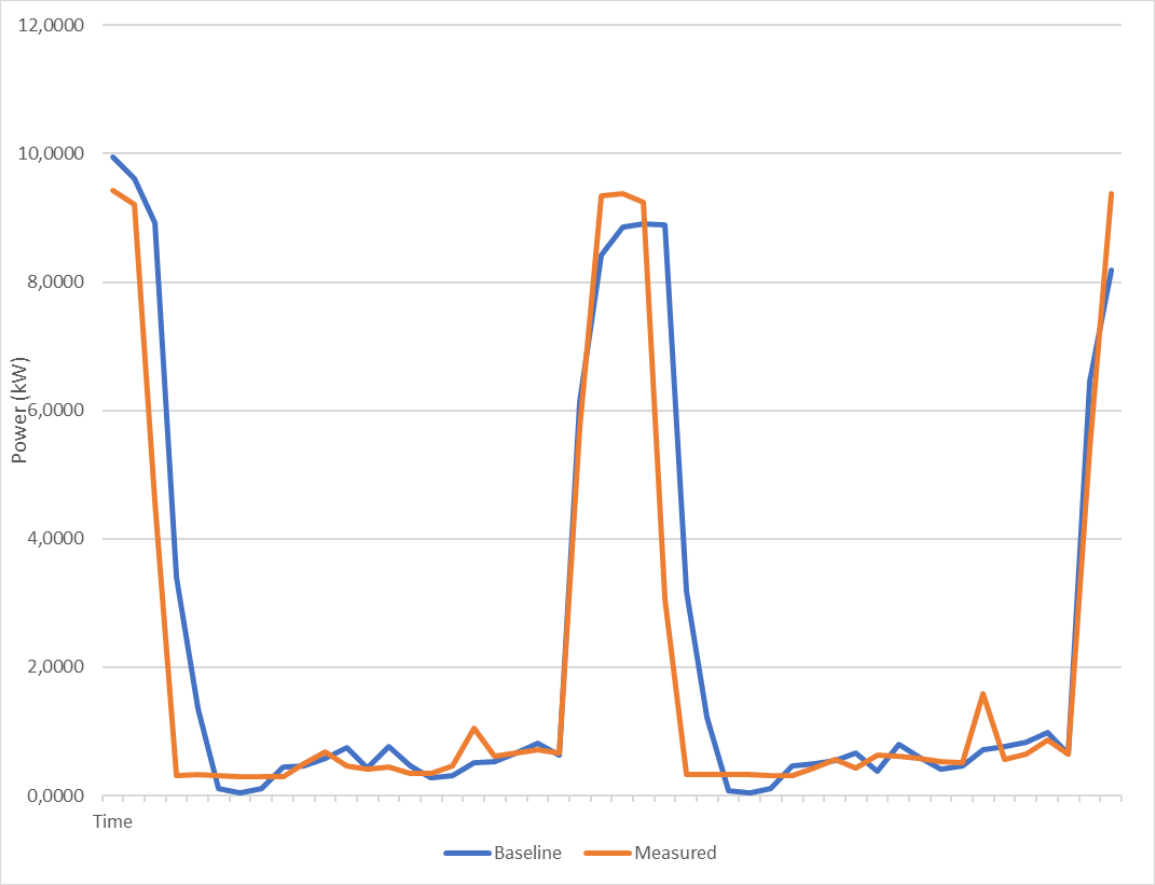

Figure 3.1 Example how the adjusted high 5 of 10 baseline method performs with real metering data.

3.2 TSO-DSO cost allocation model for jointly procured flexibility

The OneNet northern demonstrator approach considers a setting in which multiple system operators (SOs) – including transmission system operators (TSOs), and distribution system operators (DSOs) – can jointly procure flexibility to meet their individual grid needs (e.g., congestion management and its associated effects on balancing) while abiding by the grid constraints of all the grids involved. This joint co-optimized procurement mechanism aims at maximizing the value stacking potential of the offered flexibility (i.e., maximizing procurement efficiency by taking into consideration the effects of each bid activation not only on its local grid but also on all interconnected grids, and taking that into consideration in the decision of the optimal set of bids to – partially or fully – purchase). This is referred to as the common market setting [3], whose optimization-based market clearing is depicted in Figure 3.2. When an SO joins a common market (i.e., a participating coalition of SOs), its flexibility needs are met jointly with the others, hence benefiting from the pool of flexibility available within the grids of the participating coalition of SOs. At the same time, the flexibility available from that SO's grid is in its turn also made available as part of the flexibility pool, hence, also benefiting the coalition of participating SOs. Both such elements have an implication on the costs borne by each SO.

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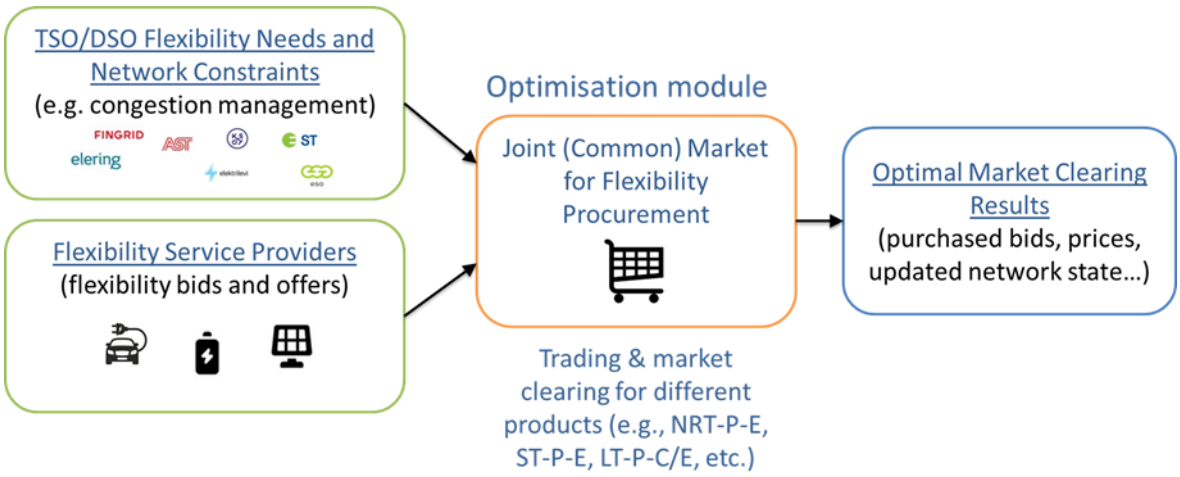

Figure 3.2 Joint TSO-DSO Co-Optimized Procurement of Flexibility (source: OneNet D7.4)

For example, consider the context of short-term active energy (ST-P-E) or near real-time active energy products (NRT-P-E), a setting in which a TSO and a DSO jointly purchase flexibility offered through flexibility bids originating from flexibility resources connected at either grid levels, to resolve congestions at the transmission and distribution levels, while also having a controlled impact on the balancing position of the grid (i.e. contribution to partially meeting the balancing need of the transmission grid) [3]. The optimal set of bids purchased would collectively (and optimally) meet the TSO(s)´ and DSO(s)´ needs and would lead to a combined total cost of flexibility provision. In this respect, the question arises as to how the TSO(s) and DSO(s) would split this total cost as part of an ex-post market stage of financial settlements.

This TSO-DSO cost allocation has been analyzed recently in the literature as part of the CoordiNet project, where a number of allocation methods that differ in complexity and properties has been proposed [22],[23]. Some of the key mathematical properties with the most salient practical implications include:

- Efficiency, which captures whether the cumulative costs allocated to each system operator add up to the cost of the jointly procured flexibility (when the total sum exceeds the total costs, this implies that the SOs have collectively overpaid, and when the total sum falls short of the total required costs, this implies that the SOs' contributions are not enough to cover the total cost of the purchased flexibility);

- Stability, which captures whether the costs allocated to the SOs incentivize each to remain in the participating coalition of SOs as compared to setting up their own independent market (this dimension also captures a measure of fairness, indicating that each SO is not overpaying compared to the value/volume of the service it is receiving);

- Complexity, which refers to the computational complexity of the algorithm required for computing the cost allocated to each system operator (this captures how, e.g., the number of computational steps and

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computational time required grow with the size of the problem, such as with the number of SOs considered, etc.);

- Simplicity, which captures how simple it is to understand and implement the method in practice and how easy it is to track and trace its outcomes.

A number of additional mathematical properties used to assess and classify different cost allocations – including properties such as additivity, anonymity, and symmetry, are introduced and detailed in [23]. As analyzed in [23] a tradeoff between the ability to meet some properties at the cost of missing on the others practically arises.

Indeed, a set of cost allocation methods have been proposed and analyzed in [23], including the "Shapley value", the "normalized Banzhaf index", the "cost gap allocation method", the "Lagrangian based method", the "equal profit method", and the "proportional cost allocation method", where a classification of each with respect to meeting a set of desired properties is performed. Each of those methods considers a different mathematical concept to split the total cost among the participating SOs. In this regard, the proportional cost allocation method has been shown in [23], to offer a high practical potential as it offers low computational needs and is fairly simple to understand and implement. In a nutshell, the goal of the proportional cost allocation method is to allocate the costs to the SOs proportionally, depending on the proportion of the total purchased flexibility which contributed to solving their needs. This proportion would quantify the "effective flexibility need" of that SO, which take into account the possible alignment between the flexibility needs of a certain SO. For example, consider a line l1 (connecting nodes 1 and 2) and line l2 (connecting nodes 2 and 3), and consider that each has a 1 MW overflow (i.e., the flow over each line is anticipated to surpass its maximum limit by 1 MW, hence requiring congestion management). The summation of their overflows would be 2 MW, which can be viewed as a nominal need of the SO in whose grid those lines are situated. However, an upward flexibility bid at node 3 of 1 MW can reduce the flow on both l1 and l2 by 1 MW each, hence, resolving both their congestions concurrently and meeting the entire "2MW" need (that would be the case if, e.g., the power transfer distribution factor (PTDF) elements of node 3 with respect to lines l1 and l2 are both equal to -1)[13]. Hence, in this case, the effective flexibility need of that SO would be 1 MW, while the summation of overflows is an upper-bound on how much flexibility is needed. To determine this effective need, the optimization results (i.e. the bids' clearing) have to be used and mapped back to how they contributed to reducing the flows in each of the congested lines (hence quantifying the "effective flexibility need" of each SO). This is performed through ex-post settlement calculations, and hence, can be performed outside the limited market clearing time requirements.

[13] The grid-impact assessment of procured flexibility in the northern demo is quantified using power transfer distribution factors of the grid involved. This process if detailed in Section 4.2 of D7.4 of OneNet [3].

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A proportional cost allocation is envisioned for the financial settlement and split of costs of the jointly procured flexibility between the different SOs for a certain market run of a certain product. This proportional split of cost is expanded beyond its standard form to capture additional specifications within the flexibility market of the OneNet Northern demonstrator. The two main drivers for the required adaptations are the following:

1. Balancing need: in different products such as, e.g., the NRT-P-E and ST-P-E, a balancing need can be included as part of the purchase offer submitted by the SOs [3]. This balancing need is not an exact balancing requirement (as was the case in CoordiNet [22], [23]) but is rather a range specified by a "min", "max" allowed imbalance amount. In other words, the procurement of flexibility for congestion management can have a direct impact on the system imbalance position (e.g. in the case in which the cumulative upward and downward flexibility volumes procured are not equal). To have a control over this impact, the SOs when submitting their purchase offers, can specify what the system's current anticipated imbalance position is (denoted as "actual") and the range within which this imbalance position must remain during the congestion management process (where the lower-end of the range is specified by a "min" entry, and the upper-end of the range is specified by a "max" entry). In the most strict sense, if the SOs aim to balance the system while performing congestion management, they would specify min=max=0. If the SOs would like the congestion management not to have any impact on the imbalance position, they would specify min=max=actual. In a less strict sense, if the SOs do not aim to restrict the effects on the imbalance position they would not specify the min and max values (equivalently, the min and max can be chosen as arbitrarily low and large number, respectively). As such, the balancing aspect is taken as a "bounded" by-product of the congestion management process rather than a directly specified need, and the balancing of the system is fully taken into account in a subsequent stage through the Manually Activated Reserves Initiative (MARI) platform. In addition, the by-product balancing does not necessarily lead to an increase in the congestion management cost, but can rather lead to incurred savings in the congestion management process. For example, if the balancing position is restricted to stay the same before and after the congestion management (i.e., by setting a min=max=actual), the congestion management process will be forced for every flexibility purchased to resolve congestions to also purchase an equal flexibility in the opposite direction to keep the balancing position stable, which can lead to additional costs. Consider that the TSO predicts a 100 MW upregulation need (i.e., actual = -100MW) for the upcoming market period and specifies an allowed range of min=-100 MW, max=-25MW, thus enabling an allowed upward change in the balance position between 0 and 75 MW. As such, this would drive the congestion management process to decreases the balancing need sent to MARI after the congestion management stage, which could be considered to qualify as an exclusive value to the TSO, in which case it would then be added to the portion of the costs covered by the TSO. However, allowing for the imbalance position to change

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between min=actual and max=actual+75MW may lead to decreasing the total congestion management costs which would then benefit all impacted SOs (not necessarily exclusively the TSO). These aspects would need to be taken into account when specifying the proportion of the procured flexibility that would be covered exclusively by the TSO's cost contribution due to the impact on reducing the system's balancing position.

2. The volume of available bids submitted from each system may not be sufficient to resolve all congestion management needs (Chapter 4 of D7.4 of OneNet provides more details on this setting [3]). Hence, this is a challenge in quantifying the total cost an SO would incur when not joining the coalition of participating SOs, which would typically be taken into account as part of the calculation of the standard proportional cost allocation, as that would require assigning a cost to the flexibility need that was not met and translating this part in the cost allocation process.

A methodology for proportional cost allocation is being developed as part of the OneNet Northern demonstrator aiming at adequately quantifying the "effective flexibility" procured by each SO, decoupling balancing and congestion management when needed, and, hence quantifying the portions of the flexibility cleared that meets the TSO needs from that which meets each DSO's needs, and taking that into account in the split of cost for the ex-post TSO-DSO financial settlement.

In this respect, the additional cost incurred exclusively for the purpose of balancing is quantified. This cost would be borne by the TSO, as it reflects savings in subsequent balancing costs. Then the remaining cost, which captures the total cost of jointly resolving congestions on all the grid involved, is split proportionally between the SOs, depending on the portion of the procured flexibility that served to resolving congestions in each of the system. This process is performed ex-post (complemented by additional optimization runs) by inspecting the optimization/market-clearing solution and tracing the procured flexibility bids back to the congestions they contributed to resolving, and accordingly implementing a proportional split of the collective costs.

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4 Technical implementation of the Flexibility register

The technical setup of the OneNet Flexibility Register is done according to the architecture and functional descriptions presented in this document. For the OneNet demonstration an implementation of the system has been completed mainly by OneNet partner Cybernetica AS in cooperation with other OneNet partners.

4.1 High-level architecture of the Flexibility Register

The FR is an integral part of the Flexibility Platform IT-system developed in the Northern Demonstrator of the OneNet project. It is designed to work seamlessly with the other components and system roles of the demo implementation. The Flexibility Platform IT-system consists of 2 main components – Flexibility Register (FR) and TSO-DSO Coordination Platform (T&D CP), which has interfaces for market stakeholders, like System Operators and Market Operators systems. The FR has an interface also to the OneNet Middleware ecosystem. T&D CP Market Operator Services API also allows integration with other potential flexibility trading platforms like MARI.

FR's main purpose is to provide interfaces for integrating with FSPs' and/or other stakeholders' (like Metering Data Responsible, Consent Administrator, etc.) systems data exchange for Resource, Contract, Consent, and Metering data. FR is tightly integrated with T&D CP, and supports the resource and grid prequalification process, and the bid validation and optimization process with respective Resource and Resource group information. FR also performs the regular delivery verification and calculation process, by fetching relevant Cleared bids and Activation Orders information from T&D CP, calculating delivered flexibility quantities, and matching the expected delivery quantities with the actual delivery quantities for calculating deviations. FR performs the actual delivered quantity calculation based on a pre-defined verification method, using reference values from either FSP-provided schedules, or calculating the baseline from historical metering data. The high-level architecture of the Flexibility Platform of the Northern demonstrator is presented in Figure 4.1.

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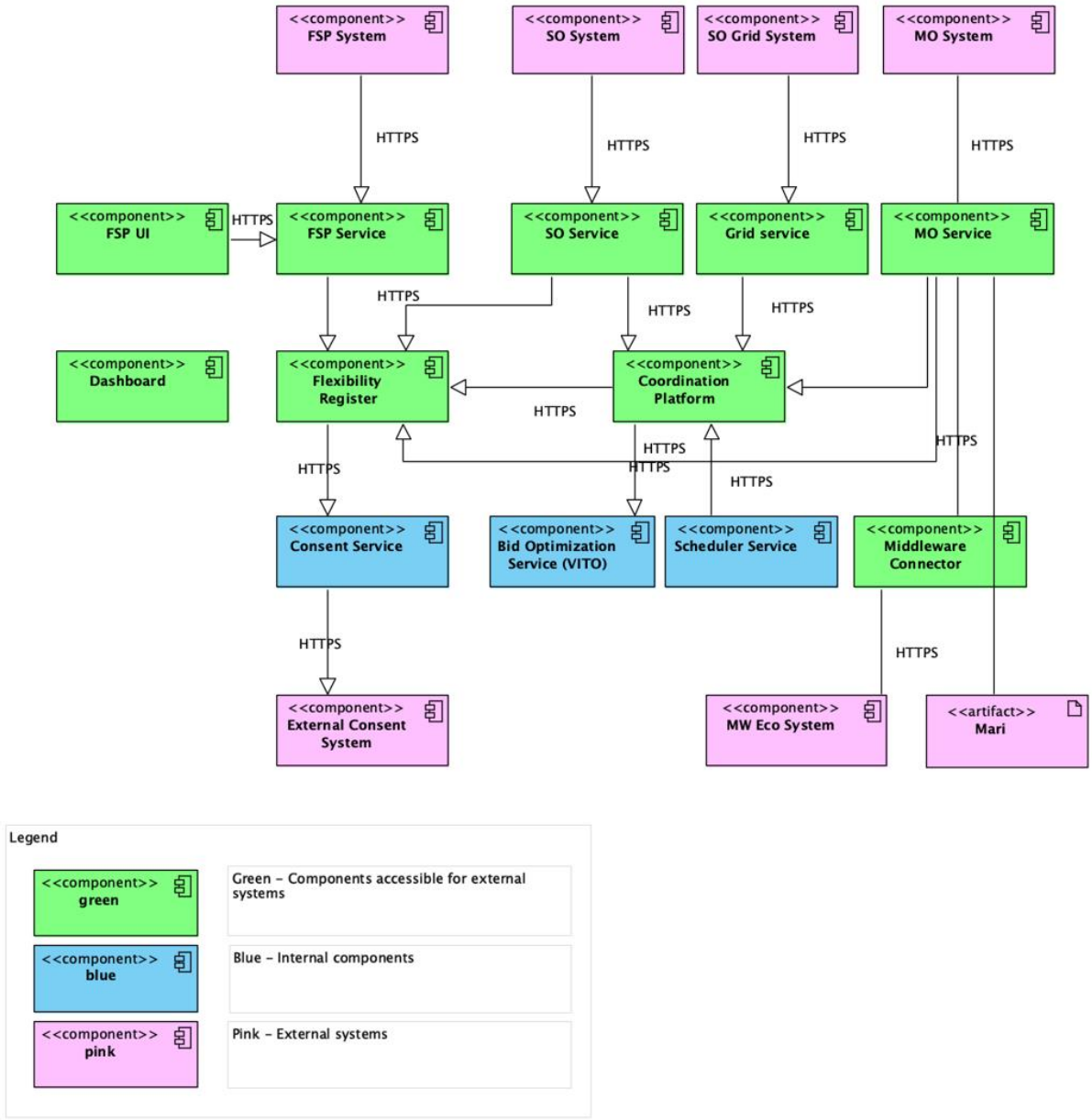

Figure 4.1 High level technical architecture of the Northern demonstrator platform.

4.2 Implementation of the Flexibility Register functionalities

The Flexibility Register acts as an information hub to enable the same flexible assets to be used to provide services for multiple system operators and multiple flexibility products' procurement purposes. The objective of the Flexibility Register is to collect and share relevant information about potential sources of flexibility, including information about the technical capabilities of the resources that can provide flexibility, and also to handle information about resource owner consent and flexibility contracts.

The key functionalities of the FR are:

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- to conduct processes related to resource information management
- to provide visibility for the Market Operators about active Flexibility Service Provides and their mediated resources available for flexibility procurement
- to provide resource groups information for product qualification and bid validation purposes
- to verify the delivered flexibility quantities for the settlement of flexibility services between market parties.

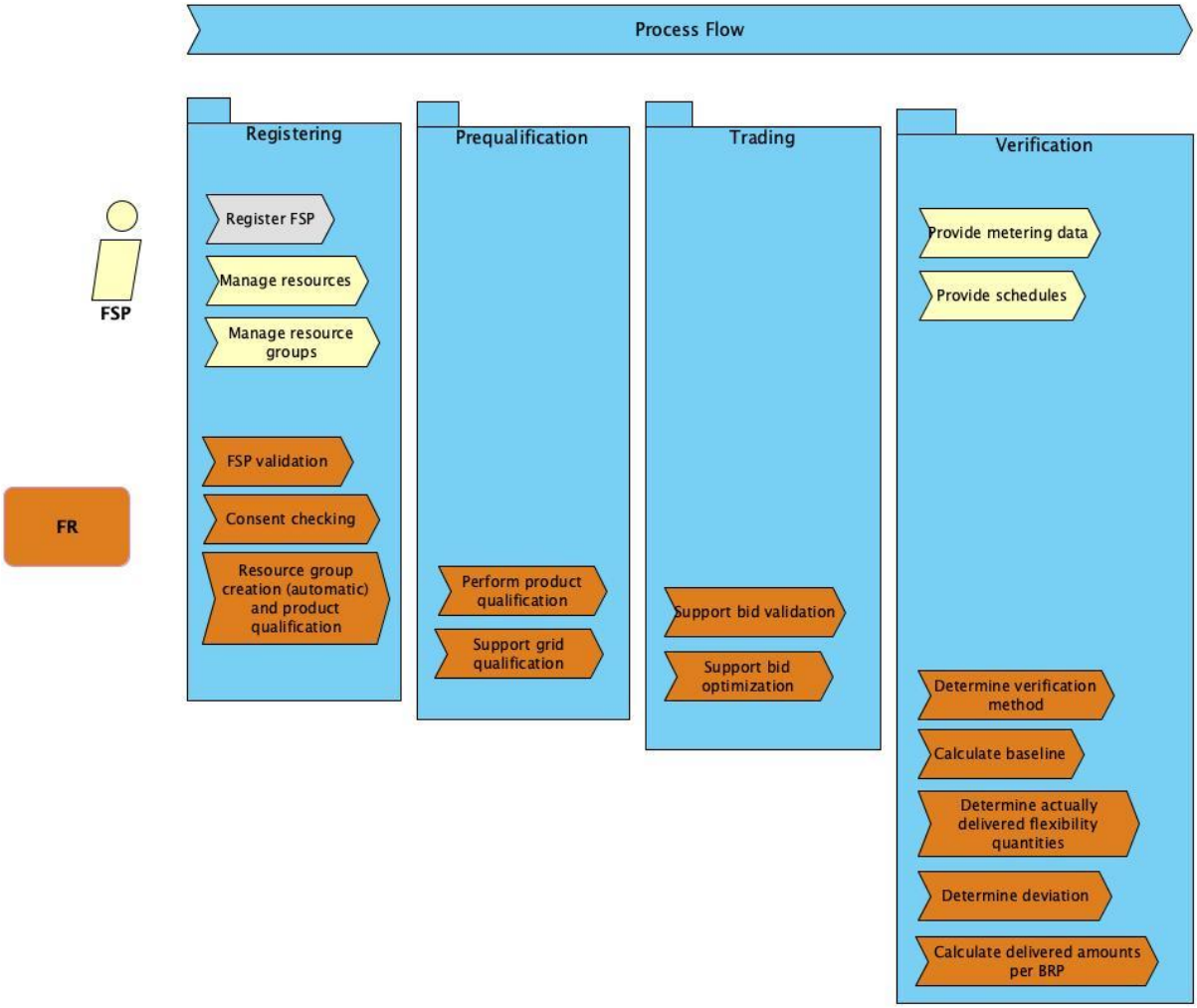

Figure 4.2 Flexibility register functionalities in different process phases

4.2.1 Flexibility Service Provider registration and qualification

In the demonstrator implementation the Flexibility Service Provider registration and qualification process is handled manually outside of the scope of FR. As part of the FR functionality design, a light-weight registration process will be enabled where new FSPs can sign up and share information about their flexibility resources to SOs in order to initiate the contract signing process.

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4.2.2 Resource registration

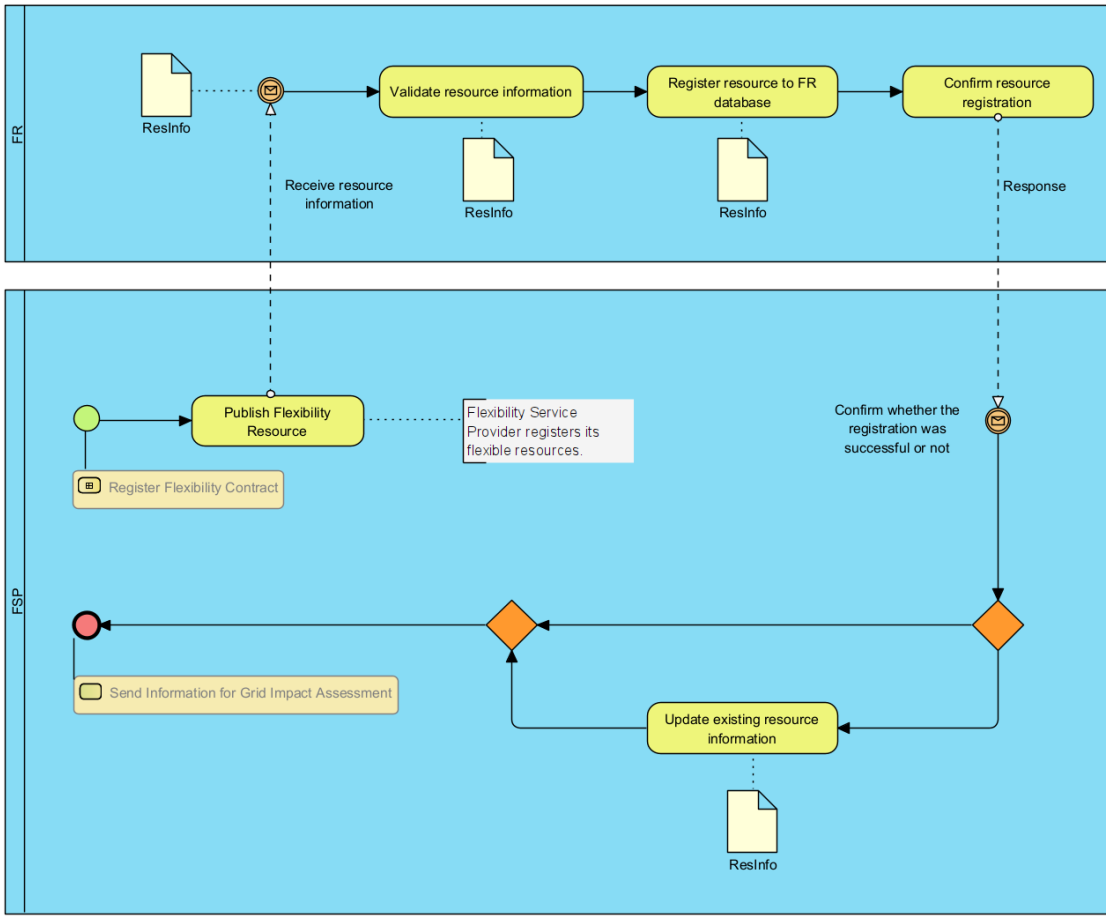

Figure 4.3 Resource registration process

The Flexibility Register provides resource registration and resource information management functionality to FSPs. In the Resource registration process, basic information about each resource is collected and stored in the FR system. Where needed, FR supports grid qualification for the resource. In this case, FR sends resource information to T&D CP where the resource is checked against SO grid information. Additionally, any SO can require that all resources are sent to manual SO check and testing before a resource is qualified for participating in the product qualification and entering the flexibility trading.

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4.2.3 Flexibility contract management

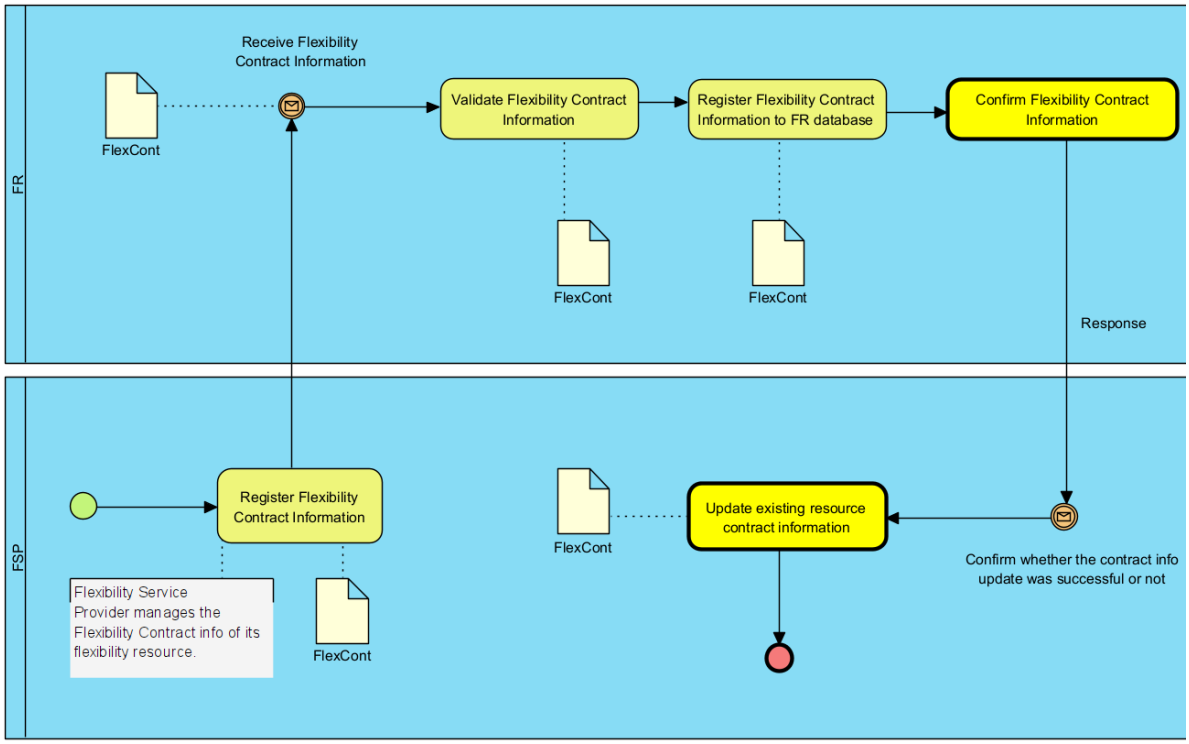

Figure 4.4 Flexibility contract management process

Flexibility Register provides Flexibility contract management functionality to FSPs. To be able to use a Resource in the flexibility trading activities, an FSP must ensure that they have a valid Flexibility Contract, and update that information on FR for each Resource in case the Flexibility Contract validity information changes.

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4.2.4 Flexibility resource group management and product qualification

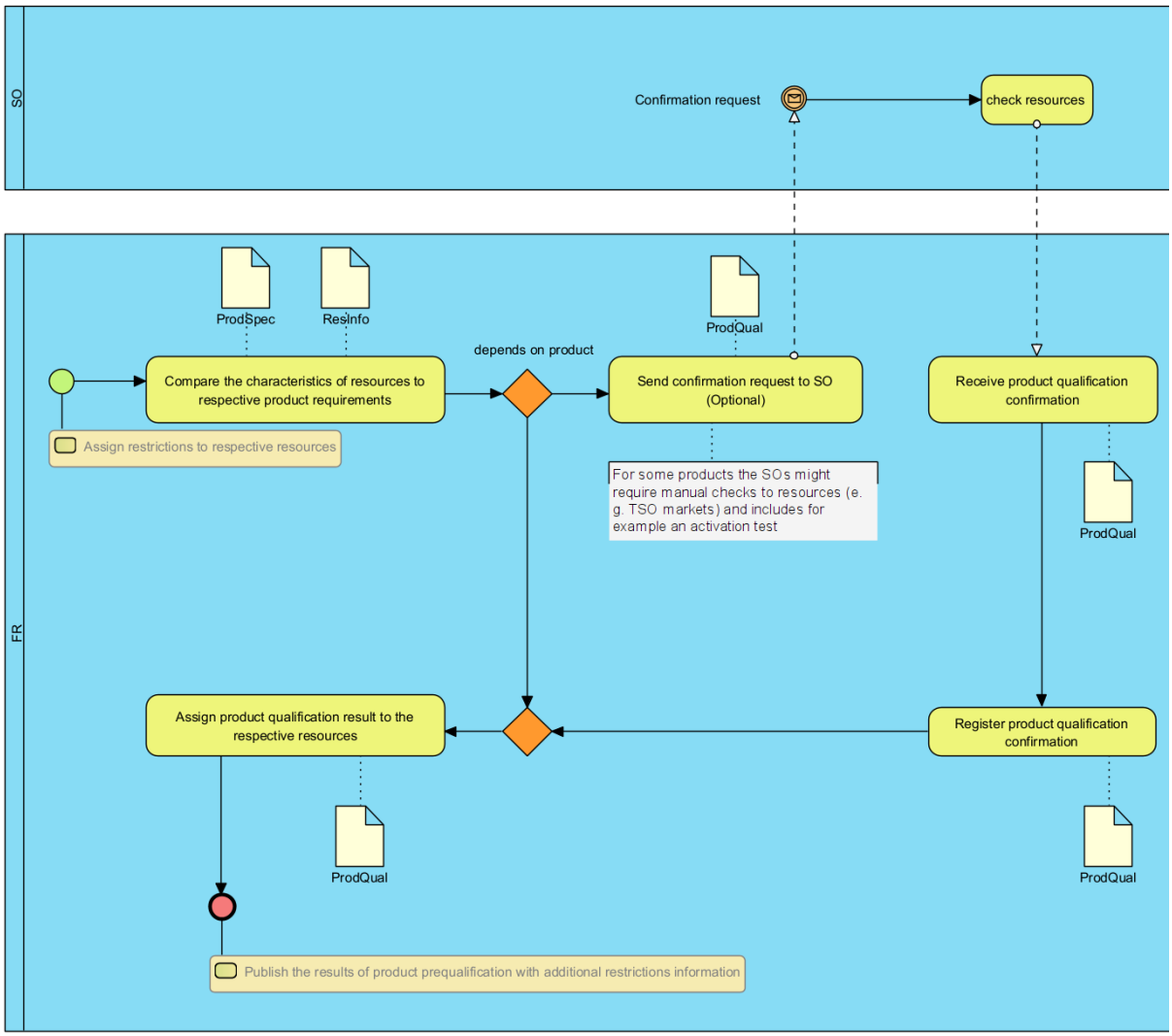

Figure 4.5 Flexibility resource group management and product qualification process

FR provides the capability to automatically define suitable resource groups that qualify for a product. In such a case, a number of resources are pooled together, in order to match the technical parameters of the flexibility product as it has been defined by a specific Market Operator. An FSP can always update and change the automatically created resource groups by manually adding of removing Resources from a group. Each resource group product qualification is then performed by FR. In some cases, specific SOs may require that a resource group is also manually qualified by an SO. In such cases, FR automatically sends new or updated resource group information to a SO and collects SO qualification response before a resource group is qualified to offer a specific flexibility product.

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4.2.5 Verification process

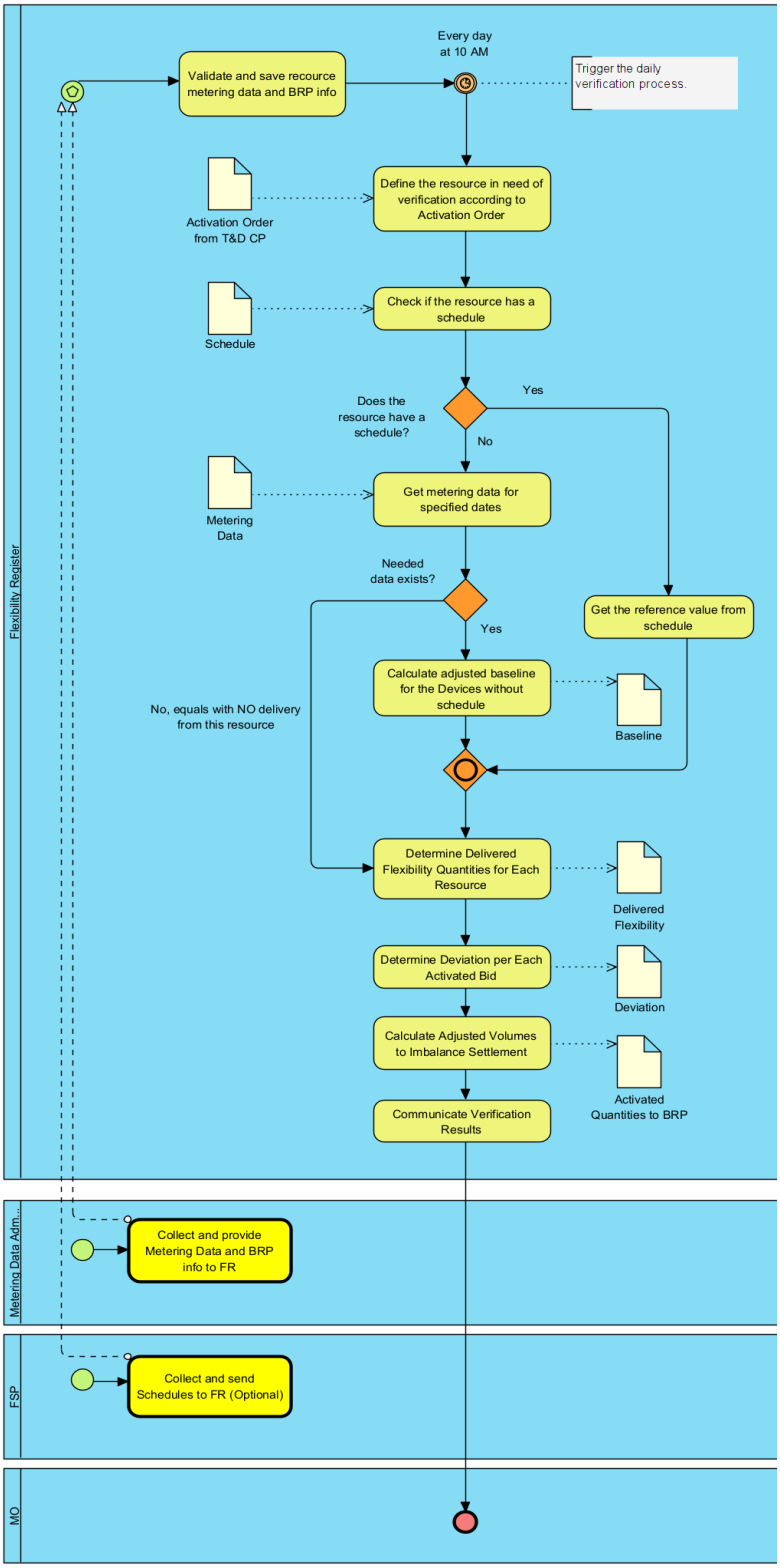

Figure 4.6 Verification process

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In the trading phase, the FR supports the trading and bid qualification process by providing resource data, like resource capacities, to relevant parties and systems including the TSO-DSO Coordination platform and Market Operator for bid validation, qualification, and optimization. After a successful procurement, the FR performs activated quantity calculation, which is called the verification process. The verification process is a daily scheduled process, automatically triggered by a timer in FR. During the verification process, FR collects information from T&D CP about all cleared bid activation orders as input. FR checks if each resource delivered the expected flexibility amount according to activation order, using schedules provided by an FSP, or by first calculating a baseline reference value based on historical metering data determined by the respective resource verification method. The baseline calculation method was presented in chapter 3.1.

After determining the delivered flexibility, the FR communicates the amounts and potential deviations together with the cost allocation between different SOs to MO, who performs the remuneration and penalties calculation and communicates respective information to FSPs and SOs. The methodology for allocating the costs between SOs was described in chapter 3.2. FR also sends information about delivered quantities to SO. In case no schedule and no historical metering data are available, resource flexibility delivery quantities cannot be determined, and FR considers this as a non-delivery.

4.2.6 Determination of remuneration and penalties

The verification process acts as a basis for the financial settlement. In context of OneNet's Northern Demonstration, it is possible that several SOs participated in the common flexibility procurement. In this case it is needed to determine how the costs are allocated between the SOs.

Remuneration and penalties determination is done by the Market Operator, based on the Verification Results that are communicated to the MO by FR for every Bid Activation Order. FR provides MO information about the delivered quantities as well as the deviation information based on Bid Activation Order information. In case of partial or non-delivery, the MO can then calculate the expected penalties as well as remuneration for full delivery based on the Bid price and the contractual agreements between the FSP and the MO.

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4.3 Flexibility register user interface

Flexibility Register has a graphical user interface (GUI) for FSPs to provide the main capabilities – managing resources and flexibility contracts information. Examples of the GUI screens are provided in the following figures.

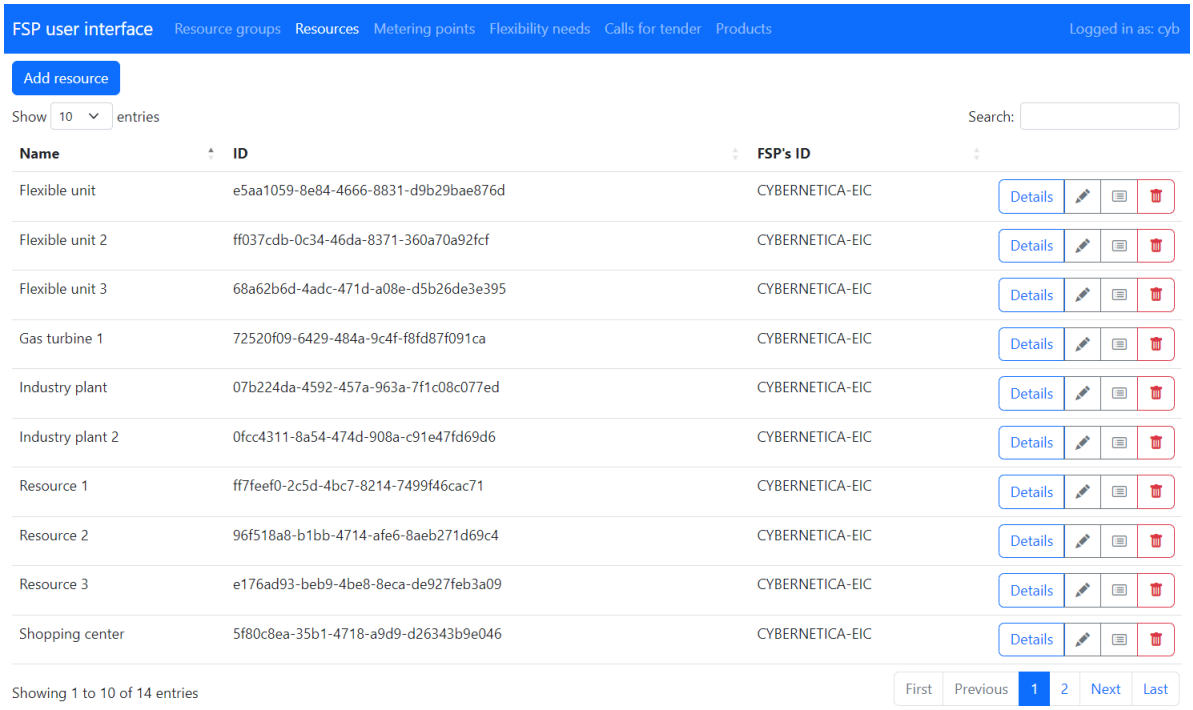

Figure 4.7 FSP can see the List of resources

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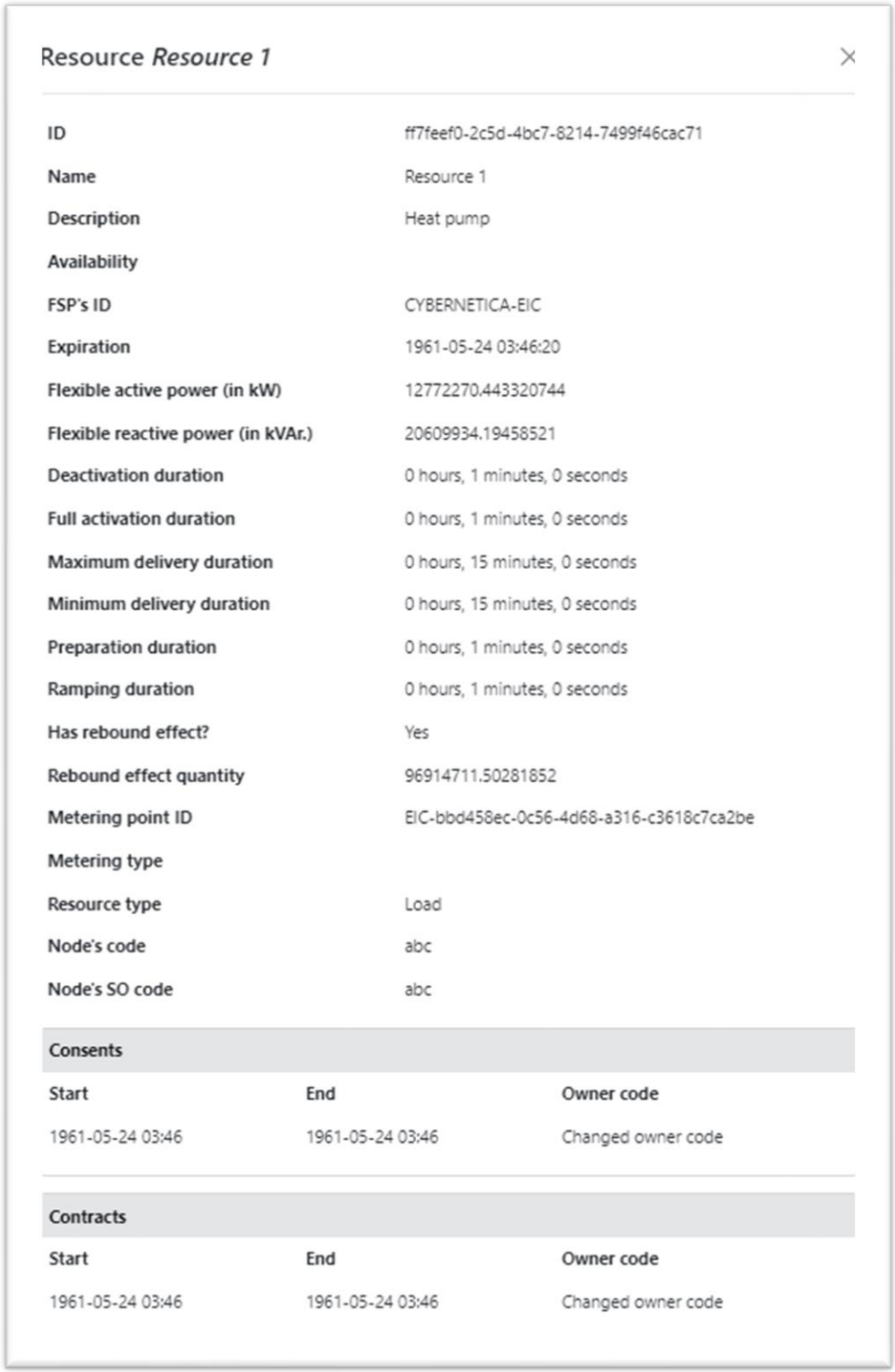

Figure 4.8 FSP can review Resource details

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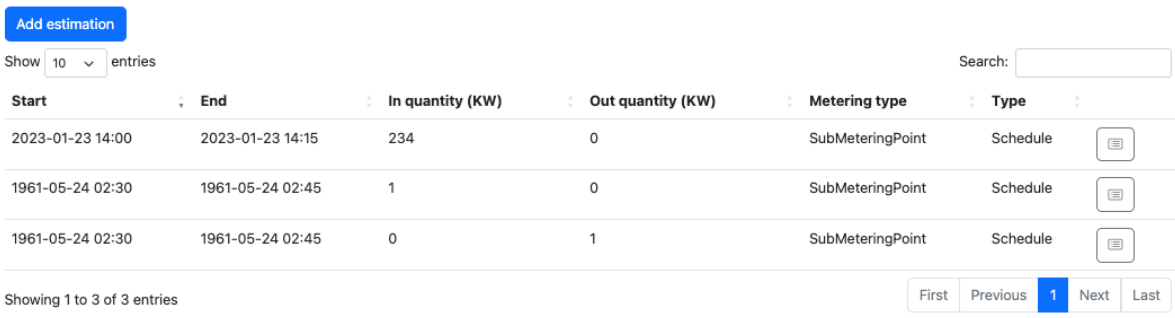

Figure 4.9 FSP can define Resource schedule

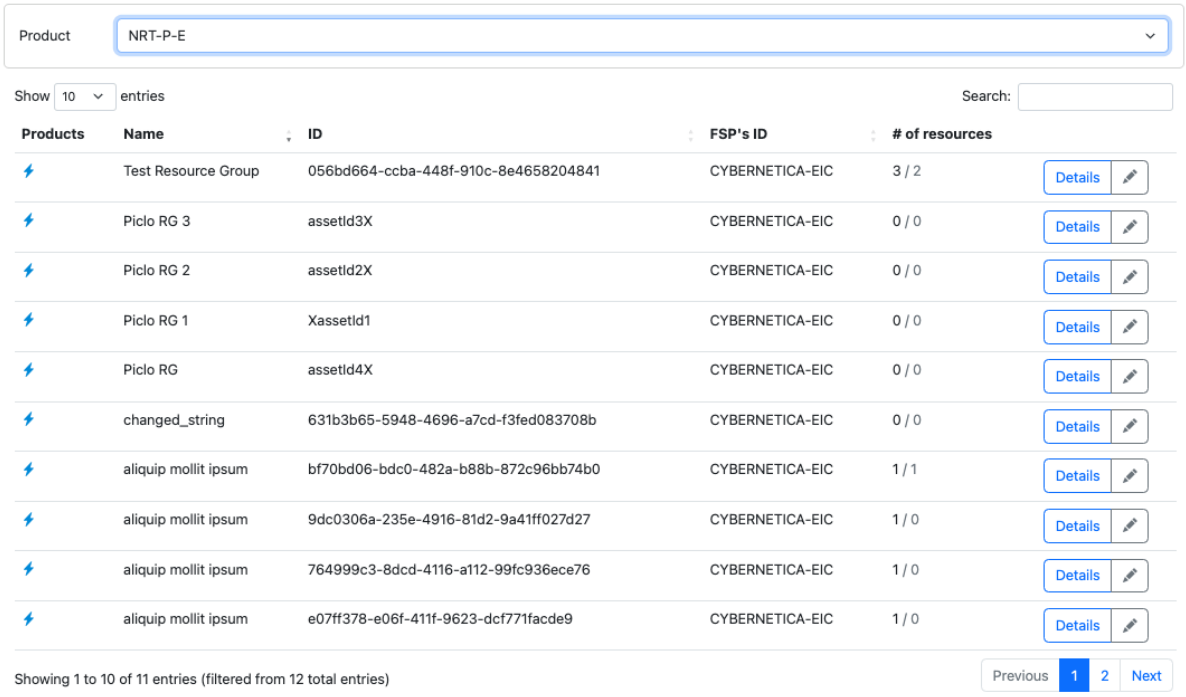

Figure 4.10 FSP can see the List of Resource Groups

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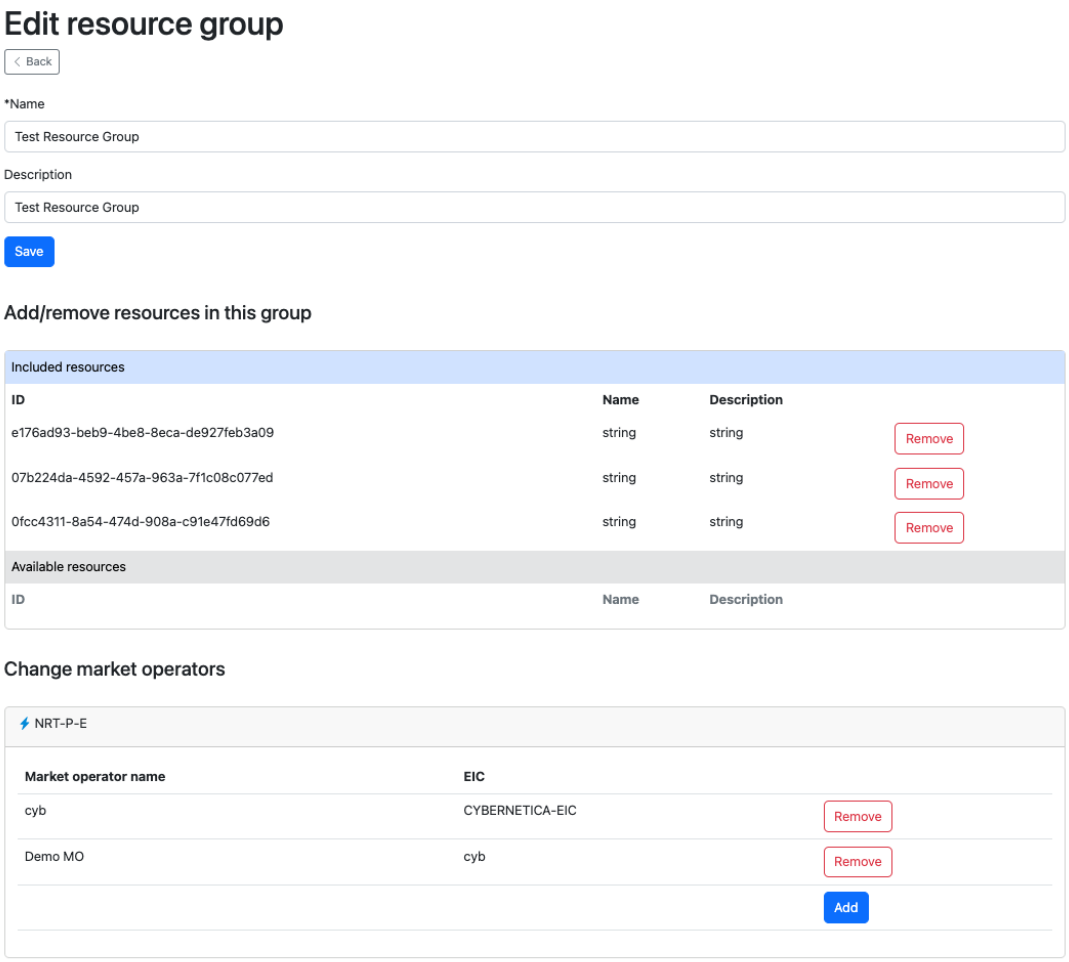

Figure 4.11 FSP can Edit Resource Group

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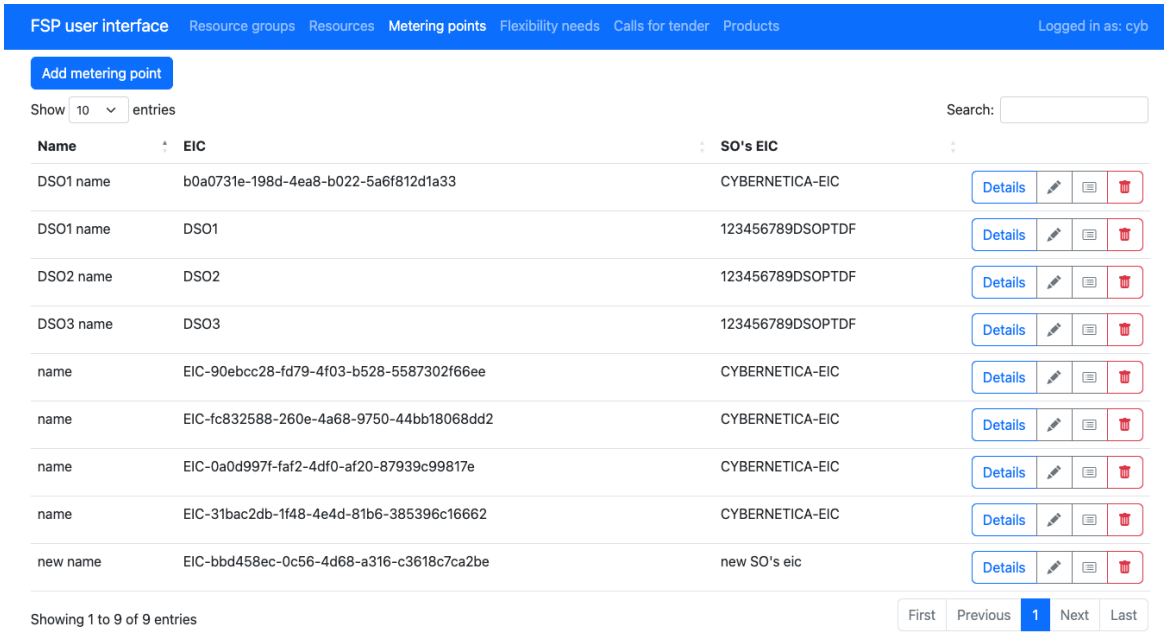

Figure 4.12 FSP can add and see Metering points

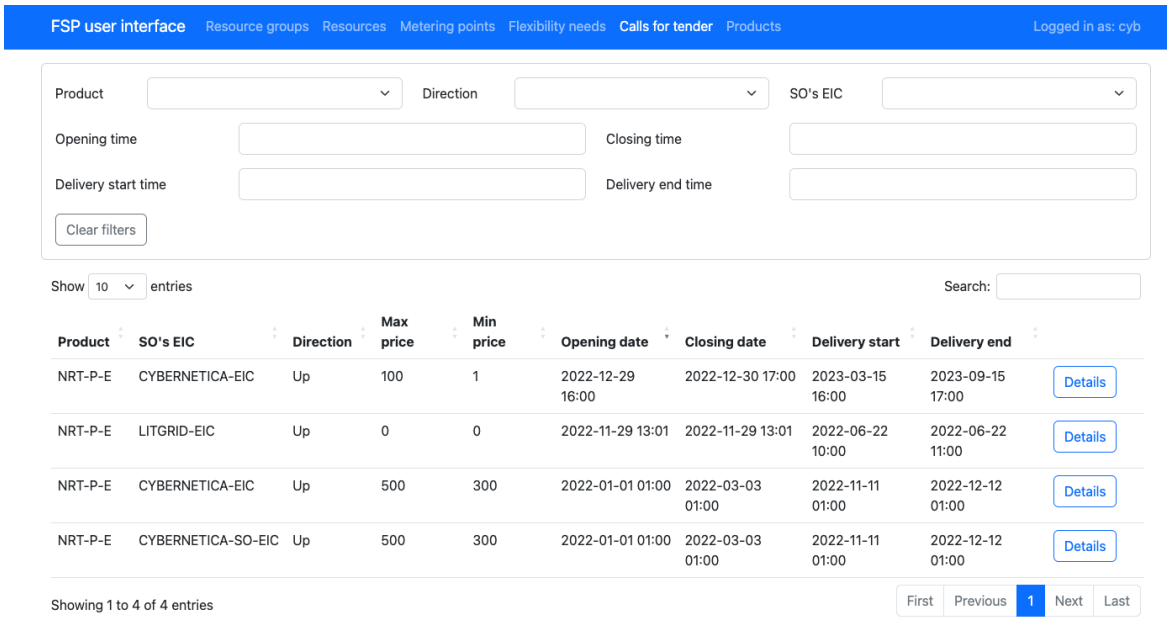

Figure 4.13 FSP can view the List of Calls for Tender

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In addition to a GUI, the FR has REST APIs that FSPs can use for automating the resource, contract, and consent information exchange processes, including integrating those with an FSP system, or bulk-uploading resource information.

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5 Conclusions

The design process and planned implementation of the Flexibility Register (FR) in the context of OneNet project's Northern Demonstrator was described in this document. The FR is one of the core components of the designed demo platform and it is needed to enable grid services through demand response of industrial and residential customers, storage and small-scale renewable generation. The basis for the functionalities and architecture was formed by studying previous projects. In addition, several demo group workshops were held to agree on a detailed level how the functionalities should work and how the system interacts with other systems, like TSO-DSO coordination platform or market operator platforms. The FR specific functionalities include:

- Flexibility Service Provider registration and qualification
- Resource registration
- Flexibility contract management
- Flexibility resource group management and product qualification
- Verification process
- Determination of remuneration and penalties

It can be concluded that the system described in this deliverable is only part of a larger set of processes. The functioning of this entirety is reported in the OneNet D7.6 deliverable.

The physical and business needs that flexibility register is capable to support are related to power system balancing (frequency control) and power network congestion management (thermal constraints) in both TSO and DSO networks. In these cases, the Flexibility Register can support all parties related to the flexibility services and power system management, from network and system operators, market operators and flexibility service providers and their underlying customers such as small-scale resource owners.

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7 Appendix

7.1 Annex 1: SUC 1 Preparation for flexibility trading

Flexibility Register System Use Case

Description of the use case

Use case identification		
ID	***Area(s)/Domain(s)/Zone(s)***	***Name of use case***
7.2.1	Flexibility market, Flexibility Register	Preparation to flexibility trading

Version management

Version management				
Version No.	***Date***	***Name of author(s)***	***Changes***	***Approval status***
1	19.4.2021	Jukka Rinta-Luoma, Taneli Leiskamo	First draft	Discussed in task 7.2 meeting on 19 April 2021
2	17.5.2021	Jukka Rinta-Luoma, Taneli Leiskamo	Second draft based discussion and comments provided in task 7.2 meeting	Discussed in task 7.2 meeting on 20 May 2021
3	31.5.2021	Jukka Rinta-Luoma	Updates and additions from discussions between WP7 parties and previous task meeting	Discussed in task 7.2 meeting on 22 June 2021
4	17.11.2021	Jukka Rinta-Luoma	Draft of the final version	Discussed in task 7.2 meeting on 17 November
5	22.11.2021	Jukka Rinta-Luoma	Changes accepted and document attached to Milestone report 21	
6	30.11.2021	Kalle Kukk	Inclusion of 'OneNet system'	
7	11.02.2022	Kaja Trees	Updated diagrams to common format	
8	14.2.2023	Jukka Rinta-Luoma	Final update before D7.2 publishing.	To be attached to the D7.2

Scope and objectives of use case

Scope and objectives of use case	
Scope	The role of Flexibility Register in process phases prior to flexibility trading is described in this document. The processes include managing flexibility contracts, registering FSPs and their resources and conducting product prequalification.
Objective(s)	The objective of this use case is to enable the preparation of FSPs and their resources for flexibility trading in the context of OneNet Northern demonstration scope. Prequalification process is a

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	prerequisite for the following process steps of multilateral flexibility trading and coordinated flexibility procurement by SOs.
Related business case(s)	Northern regional flexibility market

Narrative of Use Case

Narrative of use case
Short description
In order to prepare FSP for flexibility trading, firstly, the FSP needs to be registered on the FR. This use case also includes the steps for registering new products sent by the market operator, registration of the FSP and the SO flexibility need. These are needed later by the overall processes including flexibility trading and TSO-DSO coordination. After these steps the resource information can be registered by the FSP, which initiates the prequalification process. Information is sent to T&D CP for grid impact assessment for which the results are stored in the FR. Next, the resource or a group of resources is product prequalified by comparing their characteristics to the product requirements. In some cases, the product prequalification is confirmed by the or System Operator. Again, these results are stored in the FR and shared to parties when needed.
Complete description

Key performance indicators (KPI)

Key performance indicators			
ID	***Name***	***Description***	***Reference to mentioned use case objectives***
	Level of automation of SUC process steps	The Flexibility register facilitates the process of preparing FSPs and their resources before market phase can start. This process has many steps, many of which might require manual tasks from different parties. The aim of the process definitions has been to automatize these processes.	This use case aims to enable the preparation of FSPs and their resources for flexibility trading. In order to achieve this in most efficient way, it is desirable to make the process as easy as possible for the parties involved by automizing as many steps as possible.

Use case conditions

Use case conditions	
Assumptions	
1	Flexibility market framework and its components described by the OneNet Northern Demonstrator are in place usable by the actors.
2	Solutions for consent management for sharing private data are in place in all countries of the region.
Prerequisites	
1	Cross-border acknowledgement of consents is enabled.
2	The FR has access to metering data and BRP information.

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Further information to the use case for classification/mapping

Classification information
Relation to other use cases
Other system use cases related to TSO-DSO coordination, Flexibility Register, Customer onboarding and Market Operator
Level of depth
Prioritisation
Generic, regional or national relation
Nature of use case
System use case
Further keywords for classification

General remarks

General remarks

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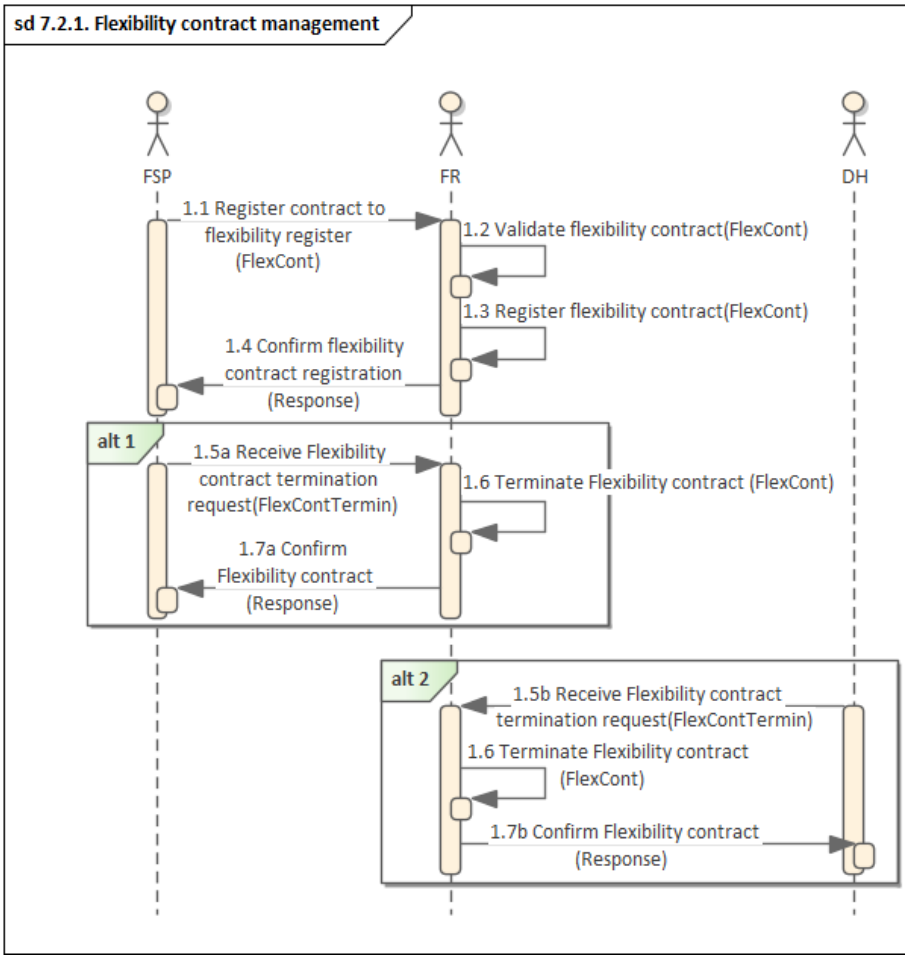
Diagrams of use case

Diagram(s) of use case
1. Flexibility contract management 

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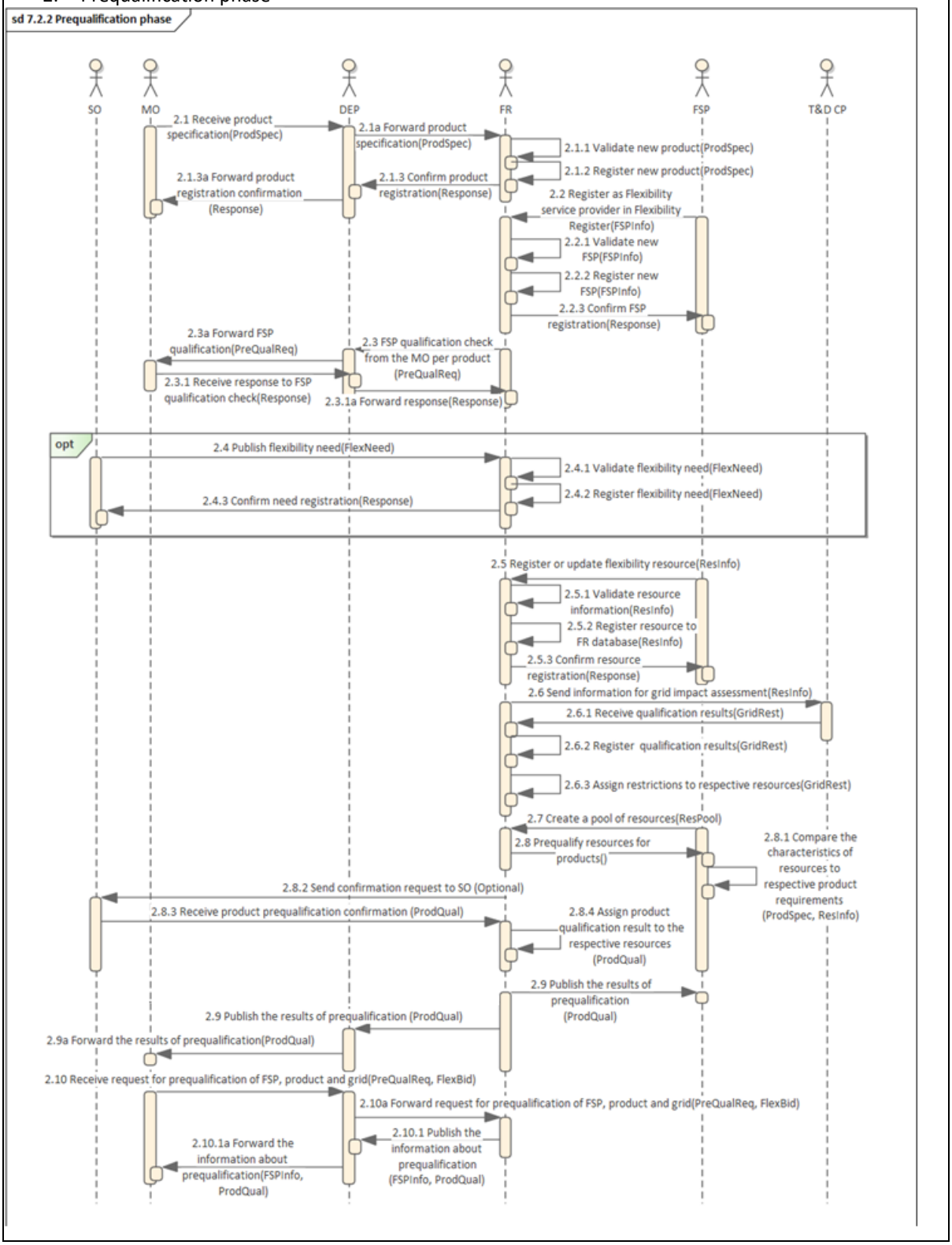
2. Prequalification phase



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Technical details

Actors

Actors			
Grouping		***Group description***	
Actor name	***Actor type***	***Actor description***	***Further information specific to this use case***
TSO-DSO coordination platform (T&D CP)	System	System that is designed to avoid, through grid impact assessment, activation of flexibilities which either do not contribute to solving system needs or even worsen the situation (constraint setting process) as well as to find the best value-stack of available flexibilities to be activated (optimization process).	
Flexibility Register (FR)	System	System that stores information about flexibility assets, results of qualification (both product and grid), market results, grid information as well as perform flexibility verification and settlement, aggregates flexibility information, allocates access rights to the various actors and controls the level of access.	Based on BRIDGE proposal for Flexibility Register Operator definition.
System Operator (SO)	Business	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.	HEMRM definition.
Market Operator (MO)	Business	A market operator is a party that provides a service whereby the offers to sell electricity **or electricity flexibility** are matched with bids to buy electricity **or electricity flexibility**.	HEMRM definition with extensions (in bold) proposed by BRIDGE. Includes also TSOs and DSOs performing the role of MO.
Resource Provider (RP)	Business	A role that manages a resource and provides production/consumption schedules for it, if required.	HEMRM definition.
Consent Administrator (CA)	Business	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.	HEMRM definition.
Datahub (DH)	Business	The datahub is an IT solution for supporting electricity retail market processes and it is implemented or planned in many European countries. Datahub includes generally metering data information from customer accounting points in addition to contract and party information.	HEMRM definition not available.
Data Exchange Platform (DEP)	System	A communication platform the basic functionality of which is to secure data transfer (routing) from data providers (e.g. data hubs, flexibility service providers, TSOs, DSOs) to the data users (e.g. TSOs, DSOs, consumers, suppliers, energy service providers). DEP stores data related to its services (e.g.	BRIDGE proposal.

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		cryptographic hash of the data requested). The DEP does not store core energy data (e.g. meter data, grid data, market data) while these data can be stored by data hubs.	

References

References						
No.	***Reference Type***	***Reference***	***Status***	***Impact on use case***	***Originator / organisation***	***Link***
	Report	ASM report		Investigation of relevant use cases	Cedec, Edso, Eurelectric, Geode and ENTSO-E	https://www.entsoe.eu/Documents/Publications/Position%20papers%20and%20reports/TSO-DSO_ASM_2019_190416.pdf
	Report	INTERRFACE use cases		Investigation of relevant use cases	Horizon2020 project INTERRFACE	http://www.interrface.eu/sites/default/files/publications/INTERRFACE_D3.2_v1.0.pdf
	Report	CoordiNet use cases		Investigation of relevant use cases	Horizon2020 project CoordiNet	https://private.coordinet-project.eu/files/documentos/6033b5fe475cdCoordiNet_WP2_D2.1_Markets%20for%20DSO%20and%20TSO%20procurement%20of%20innovative%20grid%20services_V1.0_20.02.2021.pdf
	Report	EU-SysFlex SUCs		Investigation of relevant use cases	Horizon2020 project EU-SysFlex	https://eu-sysflex.com/wp-content/uploads/2020/10/EU-SysFlex-Task-5.2-D5.2-FINAL.pdf
	Report	USEF		Investigation of relevant use cases	USEF Foundation	https://www.usef.energy/app/uploads/2016/12/USEF_TheFrameworkSpecifications_4nov15.pdf

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Steps – Scenarios

Scenario								
Scenario name		1. Flexibility contract management						
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		Register contract to flexibility register	Send information of a flexibility contract between FSP and RP. This information makes it possible for an FSP to offer the resource to markets.		FSP	FR	FlexCont	
1.2		Validate flexibility contract	Validation includes contract period, customer consent and technical validity		FR	FR	FlexCont	
1.3		Register flexibility contract	Store information about the contract between an FSP and customer if validation and consent check are successful		FR	FR	FlexCont	
1.4		Confirm flexibility contract registration	Confirm whether contract registration was successful or not		FR	FSP	Response	
1.5		Receive Flexibility contract termination request	End flexibility contract between FSP and RP triggered externally (RP ending contract via FSP, FSP ending contract, contract expiration, customer move-out (from Datahub))		FSP, DH	FR	FlexContTermin	
1.6		Terminate Flexibility contract			FR	FR	FlexCont	
1.7		Confirm Flexibility contract	Confirm whether contract		FR	FSP, DH	Response	

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		terminatio n	termination was successful or not					

Scenario								
Scenario name		2. Prequalification 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***
2.1		Receive product specification	Specification includes qualification, verification and remuneration information		MO	DEP	ProdSpec	
2.1.a		Forward product specification	OneNet system (DEP) is applied to facilitate data exchange with MOs.		DEP	FR	ProdSpec	
2.1.1		Validate new product	Technical check of data content		FR	FR	ProdSpec	
2.1.2		Register new product	If validation is successful.		FR	FR	ProdSpec	
2.1.3		Confirm product registration	Inform MO whether the product was registered successfully or not.		FR	DEP	Response	
2.1.3 .a		Forward product registration confirmation	OneNet system (DEP) is applied to facilitate data exchange with MOs.		DEP	MO	Response	
2.2		Register as Flexibility service provider in Flexibility Register			FSP	FR	FSPInfo	
2.2.1		Validate new FSP	Make sure that required information is included…		FR	FR	FSPInfo	
2.2.2		Register new FSP	Store information if validation is successful		FR	FR	FSPInfo	
2.2.4		Confirm FSP registration	Inform FSP whether the		FR	FSP	Response	

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			registration was successfully or not.					
2.3		FSP qualification check from the MO per product	Qualification check for the FSP concerning financial and legal liability, and technical ability to meet product requirements (e.g. information exchange) per product from the respective MO(s)		FR	DEP	PreQualReq	
2.3.a		Forward FSP qualification	OneNet system (DEP) is applied to facilitate data exchange with MOs.		DEP	MO	PreQualReq	
2.3.1		Receive response to FSP qualification check			MO	DEP	Response	
2.3.1.a		Forward response	OneNet system (DEP) is applied to facilitate data exchange with MOs.		DEP	FR	Response	
2.4		Publish flexibility need (optional)	SO communicates its (short-term) flexibility needs so that FSPs can more accurately answer to the location-specific demand		SO	FR	FlexNeed	
2.4.1		Validate flexibility need			FR	FR	FlexNeed	
2.4.2		Register flexibility need			FR	FR	FlexNeed	
2.4.3		Confirm need registration	Inform SO whether the need registration was successfully or not.		FR	SO	Response	
2.5		Register flexibility resource	Flexibility Service Provider registers its flexible resources		FSP	FR	ResInfo	

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2.5.1		Validate resource information	Make sure that required information is provided including a valid flexibility contract.		FR	FR	ResInfo	
2.5.2		Register resource to FR database	Store information if validation is successful		FR	FR	ResInfo	
2.5.3		Confirm resource registration	Confirm whether the need validation was successfully or not		FR	FSP	Response	
2.5.4		Update existing resource information	Repeat steps 2.4.1-2.4.5		FSP	FR	ResInfo	
2.6		Send information for grid impact assessment	Information about flexibility resource		FR	T&D CP	ResInfo	
2.6.1		Receive qualification results			T&D CP	FR	GridRest	
2.6.2		Register qualification results			FR	FR	GridRest	
2.6.3		Assign restrictions to respective resources			FR	FR	GridRest	
2.7		Create a pool of resources	FSP pools resources into groups to answer a need on the market		FSP	FR	ResPool	
2.8		Prequalify resources for products	Based on the information submitted in FPS's flexibility resources, FRO prequalifies the ability of the resource to deliver flexibility with respect to product specifications		FSP	FR	-	
2.8.1		Compare the characteristics of resources to respective			FR	FR	ProdSpec ResInfo ResPool	

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		product requirements						
2.8.2		Send confirmation request to SO (Optional)	For some products the SOs might require manual checks to resources (e.g. TSO markets) and includes for example an activation test		FR	SO	ProdQual	
2.8.3		Receive product prequalification confirmation			SO	FR	ProdQual	
2.8.4		Assign product qualification result to the respective resources	After assigning the product qualification results, the contracted FSP can offer it to the qualified market places.		FR	FR	ProdQual	
2.9		Publish the results of prequalification	Publish information to the entitled parties		FR	FSP, DEP	ProdQual	
2.9.a		Forward the results of prequalification	OneNet system (DEP) is applied to facilitate data exchange with MOs.		DEP	MO	ProdQual	
2.10		Receive request for prequalification of FSP, product and grid			MO	DEP, SO	PreQualReq FlexBid	
2.10.a		Forward request for prequalification of FSP, product and grid	OneNet system (DEP) is applied to facilitate data exchange with MOs.		DEP	FR	PreQualReq FlexBid	
2.10.1		Publish the information about prequalification			FR	DEP	FSPInfo ProdQual	
2.10.1.a		Forward the information about prequalification	OneNet system (DEP) is applied to facilitate data exchange with MOs.		DEP	MO	FSPInfo ProdQual	

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Information exchanged

Information exchanged			
Information exchanged, ID	***Name of information***	***Description of information exchanged***	***Requirement, R-IDs***
FlexCont	Flexibility contract	Information about the contract between an FSP and RP. Information doesn't contain commercial agreements of the parties, but rather the existence of such contract, which is relevant for offering the resource to the markets.	
ProdSpec	Product specification	Information about product's characteristics including requirements for product qualification.	
FSPInfo	Flexibility service provider information	Information about FSP, which is needed to register to the flexibility register	
ResInfo	Resource information	Information about resources characteristics, which is used to describe the capabilities of the resource to enable grid and product qualification	
FlexNeed	Flexibility Need	System operator's future need for flexibilities.	
GridRest	Grid Restrictions	Constraints assigned to flexibilities which cannot be (fully or partially) activated without causing congestions in the grid.	
ProdQual	Product qualification information	Information needed to perform product qualification for a (pool of) resource(s)	
PreQualReq	Pre-Qualification Request	FSP, product and grid Prequalification info	
FlexContTermin	Flexibility Contract Termination	Request for flexibility contract termination	
ResPool	Resource Pool information	Information about which Resources are included in a Resource Pool.	
Response	Response	Positive or negative reply to a request.	
FlexBid	Flexibility Bid		

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7.2 Annex 2: SUC 2 Procurement and activation support

Flexibility Register System Use Case

Description of the use case

Use case identification		
ID	***Area(s)/Domain(s)/Zone(s)***	***Name of use case***
7.2.2	Flexibility market, Flexibility Register	Procurement and activation support

Version management

Version management				
Version No.	***Date***	***Name of author(s)***	***Changes***	***Approval status***
1	19.4.2021	Jukka Rinta-Luoma, Taneli Leiskamo	First draft	Discussed in task 7.2 meeting
2	17.5.2021	Jukka Rinta-Luoma, Taneli Leiskamo	Second draft based on discussion and comments provided in task 7.2 meeting	Discussed in task 7.2 meeting on 20 May
3	31.5.2021	Jukka Rinta-Luoma	Updates and additions from discussions between WP7 parties and previous task meeting	Discussed in task 7.2 meeting on 22 June
4	17.11.2021	Jukka Rinta-Luoma	Draft of the final version	Discussed in task 7.2 meeting on 17 November
5	22.11.2021	Jukka Rinta-Luoma	Changes accepted and document attached to Milestone report 21	To be sent as a part of MS21 to Coordinator for approval
6	30.11.2021	Kalle Kukk	Inclusion of 'OneNet system'	
7	11.02.2022	Kaja Trees	Updated diagrams to common format	
8	10.2.2023	Jukka Rinta-Luoma	Final adjustments to finalize the document	To be attached to the D7.2

Scope and objectives of use case

Scope and objectives of use case	
Scope	Role of Flexibility Register in process phases during flexibility trading and delivery is described in this document.
Objective(s)	The objective of this use case is to enable the FSPs efficiently offer their resources on different markets and the SOs to procure the flexibilities in the context of OneNet Northern demonstration scope. This process is a prerequisite for the settlement and verification phases.
Related business case(s)	Northern regional flexibility market

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Narrative of Use Case

Narrative of use case
Short description
In the procurement phase the role of the FR is to support the MO and T&D CP by sharing relevant information and receiving the outcome of the procurement to later enable the verification and settlement.
Complete description

Key performance indicators (KPI)

Key performance indicators			
ID	***Name***	***Description***	***Reference to mentioned use case objectives***
	-		

Use case conditions

Use case conditions	
Assumptions	
1	Flexibility market framework and its components described by the OneNet Northern Demonstrator are in place usable by the actors
2	Solutions for consent management for sharing private data are in place in all countries of the region.
Prerequisites	
1	Prequalification process is concluded successfully
2	Cross-border acknowledgement of consents is enabled

Further information to the use case for classification/mapping

Classification information
Relation to other use cases
Other system use cases related to TSO-DSO coordination, Flexibility Register, Customer onboarding and Market Operator
Level of depth
Prioritisation
Generic, regional or national relation
Nature of use case
System use case
Further keywords for classification

General remarks

General remarks

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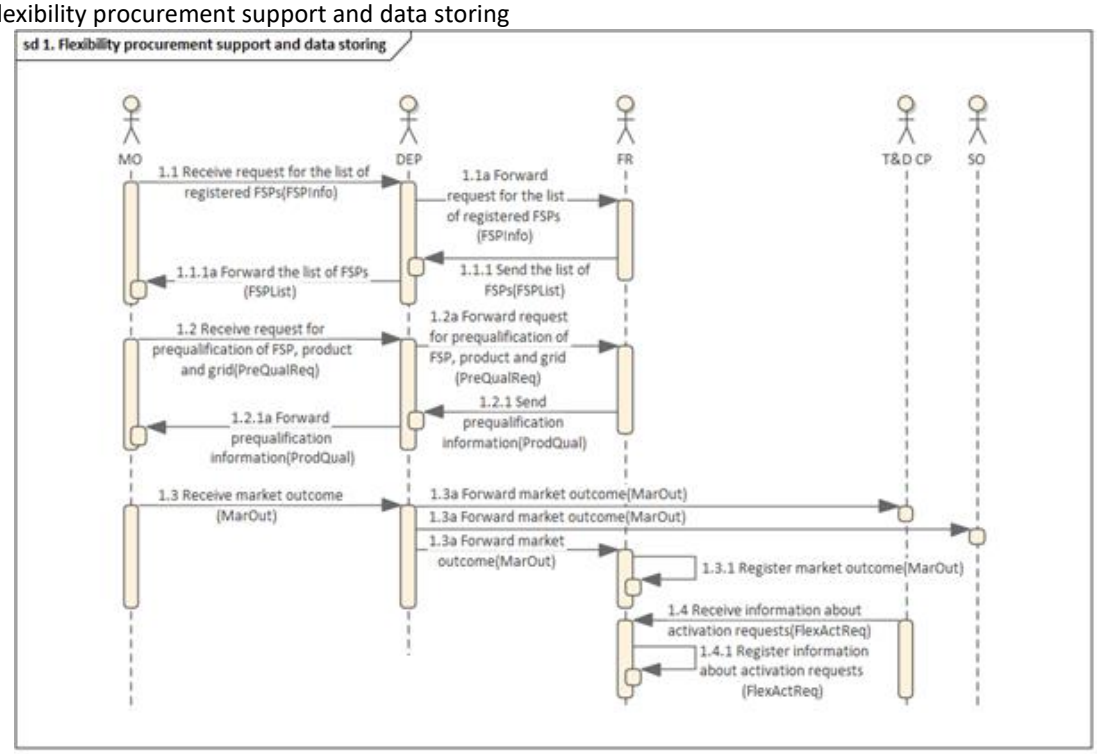
Diagrams of use case

Diagram(s) of use case
1. Flexibility procurement support and data storing 

Technical details

Actors

Actors			
Grouping		***Group description***	
Actor name	***Actor type***	***Actor description***	***Further information specific to this use case***
TSO-DSO coordination platform (T&D CP)	System	System that is designed to avoid, through grid impact assessment, activation of flexibilities which either do not contribute to solving system needs or even worsen the situation (constraint setting process) as well as to find the best value-stack of available flexibilities to be activated (optimization process).	
Flexibility Register (FR)	System	System that stores information about flexibility assets, results of qualification (both product and grid), market results, grid information as well as perform flexibility verification and settlement, aggregates flexibility information, allocates access rights to the various actors and controls the level of access.	Based on BRIDGE proposal for Flexibility Register Operator definition.

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System Operator (SO)	Business	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.	HEMRM definition.
Market Operator (MO)	Business	A market operator is a party that provides a service whereby the offers to sell electricity **or electricity flexibility** are matched with bids to buy electricity **or electricity flexibility**.	HEMRM definition with extensions (in bold) proposed by BRIDGE. Includes also TSOs and DSOs performing the role of MO.
Resource Provider (RP)	Business	A role that manages a resource and provides production/consumption schedules for it, if required.	HEMRM definition.
Consent Administrator (CA)	Business	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.	HEMRM definition.
Data Exchange Platform (DEP)	System	A communication platform the basic functionality of which is to secure data transfer (routing) from data providers (e.g. data hubs, flexibility service providers, TSOs, DSOs) to the data users (e.g. TSOs, DSOs, consumers, suppliers, energy service providers). DEP stores data related to its services (e.g. cryptographic hash of the data requested). The DEP does not store core energy data (e.g. meter data, grid data, market data) while these data can be stored by data hubs.	BRIDGE proposal.

References

References						
No.	***Reference Type***	***Reference***	***Status***	***Impact on use case***	***Originator / organisation***	***Link***
	Report	ASM report		Investigation of relevant use cases	Cedec, Edso, Eurelectric, Geode and ENTSO-E	https://www.entsoe.eu/Documents/Publications/Position%20papers%20and%20reports/TSO-DSO_ASM_2019_190416.pdf
	Report	INTERRFACE use cases		Investigation of relevant use cases	Horizon2020 project INTERRFACE	http://www.interrface.eu/sites/default/files/publications/INTERRFACE_D3.2_v1.0.pdf
	Report	CoordiNet use cases		Investigation of relevant use cases	Horizon2020 project CoordiNet	https://private.coordinet-project.eu/files/documentos/6033b5fe475cdCoordiNet_WP2_D2.1_Markets%20for%20DSO%20and%20TSO%20procurement%20of%20innovative%20grid%20services_V1.0_20.02.2021.pdf
	Report	EU-SysFlex SUCs		Investigation of relevant use cases	Horizon2020 project EU-SysFlex	https://eu-sysflex.com/wp-content/uploads/2020/10/EU-SysFlex-Task-5.2-D5.2-FINAL.pdf

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	Report	USEF		Investigation of relevant use cases	USEF Foundation	https://www.usef.energy/app/uploads/2016/12/USEF_TheFrameworkSpecifications_4nov15.pdf

Steps – Scenarios

Scenario								
Scenario name		1. Flexibility procurement support and data storing						
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		Receive request for the list of registered FSPs	MO need to have the list of the FSP to inform them about the call opening		MO	DEP	FSPInfo	
1.1.a		Forward request for the list of registered FSPs	OneNet system (DEP) is applied to facilitate data exchange with MOs.		DEP	FR	FSPInfo	
1.1.1		Send the list of FSPs			FR	DEP	FSPInfo	
1.1.1.a		Forward the list of FSPs	OneNet system (DEP) is applied to facilitate data exchange with MOs.		DEP	MO	FSPInfo	
1.2		Receive request for prequalification of FSP, product and grid			MO	DEP	PreQualReq	
1.2.a		Forward request for prequalification of FSP, product and grid	OneNet system (DEP) is applied to facilitate data exchange with MOs.		DEP	FR	PreQualReq	
1.2.1		Send prequalification information			FR	DEP	ProdQual	
1.2.1.a		Forward prequalification information	OneNet system (DEP) is applied to facilitate data exchange with MOs.		DEP	MO	ProdQual	
1.3		Receive schedules	Submit schedules (production/consumption plans) in cases		FSP	FR	RefValue	

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			where it is used for verification					
1.4		Receive market outcome			MO	DEP	MarOut	
1.4.a		Forward market outcome	OneNet system (DEP) is applied to facilitate data exchange with MOs.		DEP	FR, T&D CP, SO	MarOut	
1.4.1		Register market outcome			FR	FR	MarOut	
1.5		Receive information about activation requests	Products that are separately activated need this step to initiate the verification process.		T&D CP	FR	FlexActReq	
1.5.1		Register information about activation requests			FR	FR	FlexActReq	

Information exchanged

Information exchanged			
Information exchanged, ID	***Name of information***	***Description of information exchanged***	***Requirement, R-IDs***
MarOut	Market outcome	The results of matching the offers and bids by MO.	
RefValue	Reference value	Resource base performance reference value provided before delivery as a schedule by the FSP or calculated after delivery by the platform.	
ActFlex	Activated flexibility	FSP's response to activation request. Includes the amount which the FSP manage to activate	
FSPInfo	Flexibility service provider information	Information about FSP, which is needed to register to the flexibility register	
PreQualReq	Pre-Qualification Request	FSP, product and grid Prequalification info	
ProdQual	Product qualification		
FlexActReq	Flexibility Activation Request		

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7.3 Annex 3: SUC 3 Flexibility verification and settlement

Flexibility Register System Use Case

Description of the use case

Name of use case

Use case identification		
ID	***Area(s)/Domain(s)/Zone(s)***	***Name of use case***
7.2.3	Flexibility market, Flexibility Register	Flexibility verification and settlement

Version management

Version management				
Version No.	***Date***	***Name of author(s)***	***Changes***	***Approval status***
1	19.4.2021	Jukka Rinta-Luoma, Taneli Leiskamo	First draft	Discussed in task 7.2 meeting
2	17.5.2021	Jukka Rinta-Luoma, Taneli Leiskamo	Second draft based discussion and comments provided in task 7.2 meeting	Discussed in task 7.2 meeting on 20 May
3	31.5.2021	Jukka Rinta-Luoma	Updates and additions from discussions between WP7 parties and previous task meeting	Discussed in task 7.2 meeting on 22 June
4	17.11.2021	Jukka Rinta-Luoma	Draft of the final version	Discussed in task 7.2 meeting on 17 November
5	22.11.2021	Jukka Rinta-Luoma	Changes accepted and document attached to Milestone report 21	To be sent as a part of MS21 to Coordinator for approval
6	30.11.2021	Kalle Kukk	Inclusion of 'OneNet system'	
7	11.02.2022	Kaja Trees	Updated diagrams to common format	
8	10.2.2023	Jukka Rinta-Luoma	Final update before D7.2 publishing.	To be attached to the D7.2

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Scope and objectives of use case

Scope and objectives of use case	
Scope	The role of Flexibility Register in process phases after flexibility trading is described. The verification process quantifies the delivered flexibility and settlement process uses this information to conclude financial and imbalance settlement done partly outside of FR.
Objective(s)	The objective of this use case is to enable quantifying the delivered flexibility volumes and support the financial and imbalance settlement based on the results in the context of OneNet Northern demonstration scope.
Related business case(s)	Northern regional flexibility market

Narrative of Use Case

Narrative of use case
Short description
One of the core functionalities of the FR is to conduct the verification and settlement of the flexibility bids being traded on the market. Verification means the quantification of the delivered flexibility. This is done by gathering metering data and comparing it to either a calculated baseline or predefined schedules. The product in question specifies which method is to be used. After the verification, the results are shared to parties involved in the trades. The FR can also in some cases determine the remuneration and penalties if these are described within the product specification. The FR also communicates possible adjustments to BRPs' balance position to the Imbalance Settlement Responsible.
Complete description

Key performance indicators (KPI)

Key performance indicators			
ID	**Name**	**Description**	**Reference to mentioned use case objectives**
	Verification method accuracy	Assess the accuracy of the reference value (e.g., computed baseline) compared to the energy/power consumer/injected into the grid, when no flexibility activation was conducted	Verification of flexibility events is one of the core functionalities of the FR in this use case. This KPI assesses the quality of the implemented solution.

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Use case conditions

Use case conditions	
Assumptions	
1	Flexibility market framework and its components described by the OneNet Northern Demonstrator are in place usable by the actors
2	Solutions for consent management for sharing private data are in place in all countries of the region.
Prerequisites	
1	Prequalification phase is concluded successfully
2	Procurement phase is concluded successfully
3	Cross-border acknowledgement of consents is enabled.

Further information to the use case for classification/mapping

Classification information
Relation to other use cases
Other system use cases related to TSO-DSO coordination, Flexibility Register, Customer onboarding and Market Operator
Level of depth
Prioritisation
Generic, regional or national relation
Nature of use case
System use case
Further keywords for classification

General remarks

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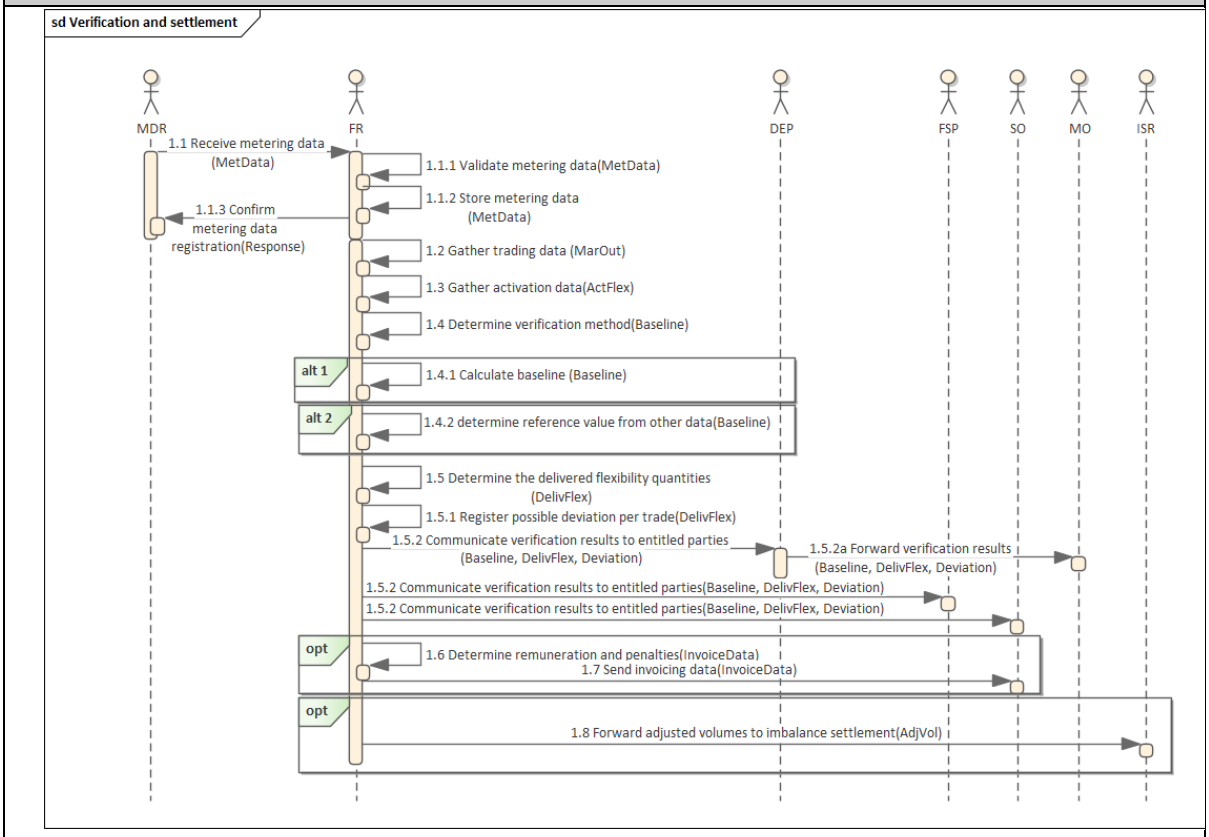
General remarks

Diagrams of use case

Diagram(s) of use case


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Technical details

Actors

Actors			
Grouping		***Group description***	
Actor name	**Actor type**	**Actor description**	**Further information specific to this use case**
TSO-DSO coordination platform (T&D CP)	System	System that is designed to avoid, through grid impact assessment, activation of flexibilities which either do not contribute to solving system needs or even worsen the situation (constraint setting process) as well as to find the best value-stack of available flexibilities to be activated (optimization process).	
Flexibility Register (FR)	System	System that stores information about flexibility assets, results of qualification (both product and grid), market results, grid information as well as perform flexibility verification and settlement, aggregates flexibility information, allocates access rights to the various actors and controls the level of access.	Based on BRIDGE proposal for Flexibility Register Operator definition.
System Operator (SO)	Business	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.	HEMRM definition.
Market Operator (MO)	Business	A market operator is a party that provides a service whereby the offers to sell electricity or electricity flexibility are matched with bids to buy electricity or electricity flexibility.	HEMRM definition with extensions (in bold) proposed by BRIDGE. Includes also TSOs and DSOs performing the role of MO.
Resource Provider (RP)	Business	A role that manages a resource and provides production/consumption schedules for it, if required.	HEMRM definition.
Consent Administrator (CA)	Business	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.	HEMRM definition.
Metered Data Responsible (MDR)	Business	A party responsible for the establishment and validation of metered data based on the collected data received from the Metered Data Collector. The party is responsible for the history of metered data for a Metering Point.	HEMRM definition
Data Exchange Platform (DEP)	System	A communication platform the basic functionality of which is to secure data transfer (routing) from data providers (e.g. data hubs, flexibility service providers, TSOs, DSOs) to the data users	BRIDGE proposal.

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		(e.g. TSOs, DSOs, consumers, suppliers, energy service providers). DEP stores data related to its services (e.g. cryptographic hash of the data requested). The DEP does not store core energy data (e.g. meter data, grid data, market data) while these data can be stored by data hubs.	

References

References						
No.	**Reference Type**	**Reference**	**Status**	**Impact on use case**	**Originator / organisation**	**Link**
	Report	ASM report		Investigation of relevant use cases	Cedec, Edso, Eurelectric, Geode and ENTSO-E	https://www.entsoe.eu/Documents/Publications/Position%20papers%20and%20reports/TSO-DSO_ASM_2019_190416.pdf
	Report	INTERRFACE use cases		Investigation of relevant use cases	Horizon2020 project INTERRFACE	http://www.interrface.eu/sites/default/files/publications/INTERRFACE_D3.2_v1.0.pdf
	Report	CoordiNet use cases		Investigation of relevant use cases	Horizon2020 project CoordiNet	https://private.coordinet-project.eu/files/documentos/6033b5fe475cdCoordiNet_WP2_D2.1_Markets%20for%20DSO%20and%20TSO%20procurement%20of%20innovative%20grid%20services_V1.0_20.02.2021.pdf
	Report	EU-SysFlex SUCs		Investigation of relevant use cases	Horizon2020 project EU-SysFlex	https://eu-sysflex.com/wp-content/uploads/2020/10/EU-SysFlex-Task-5.2-D5.2-FINAL.pdf
	Report	USEF		Investigation of relevant use cases	USEF Foundation	https://www.usef.energy/app/uploads/2016/12/USEF_TheFrameworkSpecifications_4nov15.pdf

Steps – Scenarios

Scenario								
Scenario name		7. Verification and settlement						
Step No	**Event**	**Name of process/activity**	**Description of process/activity**	**Service**	**Information producer (actor)**	**Information receiver (actor)**	**Information exchanged (IDs)**	**Requirement, R-IDs**
1.1		Receive metering data	Receive generation and consumption data measured by		MDR	FR	MetData	

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			certified meters data and sub-meters					
1.1.1		Validate metering data	Technical validation		FR	FR	MetData	
1.1.2		Store metering data	Store information if validation is successful		FR	FR	MetData	
1.1.3		Confirm metering data registration	Inform sender whether metering data registration was successful or not		FR	MDR	Response	
1.2		Gather trading data	Volumes of traded flexibilities previously stored in FR		FR	FR	MarOut	
1.3		Gather cleared bid data	Volumes of cleared and activated flexibility bids previously stored in FR		FR	FR	ClearedBids	
1.4		Determine verification method	The verification method depends on the product.		FR	FR	RefValue	
1.4.1		Alt 1: Calculate baseline	In case the product requires FR to calculate a baseline with the baseline model used by the respective product		FR	FR	RefValue	
1.4.2		Alt 2: determine reference value from other data	Based on product definition, this can include plan sent beforehand etc.		FR	FR	RefValue	
1.5		Determine the delivered flexibility quantities	Calculation of the delivered amount by comparing baseline/reference value to metering data.		FR	FR	DelivFlex	
1.5.1		Register possible deviation per trade	Register the result for each trade separately. In some cases deviation per resource might be needed		FR	FR	DelivFlex	
1.5.2		Communicate verification			FR	FSP / SO / DEP	RefValue/ DelivFlex	

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		results to entitled parties						
1.5.2.a		Forward verification results	OneNet system (DEP) is applied to facilitate data exchange with MOs.		DEP	MO	RefValue/ DelivFlex	
1.6		Optional: Determine remuneration and penalties	Calculation of penalties for the over/under delivered flexibilities based on the specification of the respective product. Done only if the respective product requires.		FR	FR	InvoiceData	
1.7		Optional: Send invoicing data	Send results from step 7.6 to the buying party, which conducts the actual billing.		FR	SO, FSP	InvoiceData	
1.8		(Optional) Forward adjusted volumes to imbalance settlement	Report adjusted volumes to imbalance settlement, if the respective product requires this. (For example, not needed when offering from own portfolio, or if product doesn't have energy component)		FR	Imbalance Settlement Responsible (ISR)	AdjVol	

Information exchanged

Information exchanged			
Information exchanged, ID	**Name of information**	**Description of information exchanged**	**Requirement, R-IDs**
MarOut	Market outcome	The results of matching the offers and bids by MO.	
MetData	Metering data		
ClearedBids	Cleared bids	Result of the market clearing done by the optimization function.	

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RefValue	Reference value	Resource base performance reference value provided before delivery as a schedule by the FSP or calculated after delivery by the platform.	
DelivFlex	Delivered flexibility amount	Difference between baseline/reference value and metering data	
InvoiceData	Invoicing data	Data that includes information about the parties the remuneration amounts	
AdjVol	Adjusted imbalance volumes (transfer of energy)	Energy amount that affects the open supplier of the resource, which is communicated to imbalance settlement to compensate the energy effect to the BRP.	
Response	Response	Positive or negative reply to a request.	

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