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one network for Europe

Guidelines for TSO Operation and Guidelines for Data Exchange

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About OneNet

OneNet 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.

The project OneNet (One Network for Europe) is funded through the EU's eighth Framework Programme Horizon 2020. It is titled "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)".

While the electrical grid is moving 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. For this reason, the two major associations of grid operators in Europe, ENTSO-E and EDSO, have activated their members to put together a unique consortium.

OneNet will see the participation of a consortium of over 70 partners. Key partners in the consortium include: already mentioned ENTSO-E and EDSO, Elering, E-REDES, RWTH Aachen University, University of Comillas, VITO, European Dynamics, Ubitech, Engineering, and the EUI's Florence School of Regulation (Energy).

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.

Table of Contents

1 Introduction

This report is the final deliverable for the OneNet Work package 4 (T4.1) that provides the "Guidelines for TSO Operation and Guidelines for Data Exchange. This task takes its reference from the activities performed already in various H2020 projects: INTERRFACE, CoordiNet, PlatOne, EUniversal, EU-SysFlex and TDX-ASSIST in defining the interfaces between market and grid operations.

In the first section, the objectives of the WP4 and description of the task 4.1 are presented. Then the methodology used to analyse the previous projects, and map business uses cases from other projects and demonstrations in a generic business process is presented, also detailing the actors and roles. State-of-the-art analysis and the review of the previous projects then are presented. This section also presents the questionaries used to gather information from different partners and use case analysis to identify the business objects. This section is then followed by a section on data exchange at the TSO level (TSO-TSO, TSO-DSO, TSO-Market parties) from the selected projects, where the characteristics and properties of the required data exchange are presented. In particular, the specifications in terms of IT and data exchange at the transmission level are defined to support the work to be performed within WP5. In the same section, we present more information towards the definition of interfaces in terms of information models, timing requirements, and interaction sequences from the TSO perspective. Finally, this section defines the gap analysis from H2020 projects and from OneNet demo use cases.

The following section then presents the recommendations and implementation requirements that are important to be considered in the future developments and within OneNet. This information will also serve the other OneNet work packages to build specific models. Finally, the section about the main conclusions is presented.

This deliverable is also closely related to WP2 (D2.3: Business Use Cases for the OneNet) and WP5 (D5.1: OneNet Concept and Requirements).

1.1 Work Package 4 Objectives

- The main objective of this WP is to link the market activities with grid operation with the target to maximise the integration of FSP (Flexibility Serive Providers) e.g. RES (Renewable Energy Sources). The goal is to achieve both at TSO and DSO levels while also the customer perspective is considered.
- Ensure a future secure and affordable energy supply, active system management that is detailed out from each grid perspective: TSO – DSO – Customer.
- Define interfaces in terms of information models, timing requirements and interaction sequences in the context of e.g. pre-qualification, schedules, maintenance etc., whilst covering mainly the operational challenges that arise with the introduction of new products and markets as analysed in WP2 and WP3.
- Analysis of cybersecurity measures focused on the device level will be part of the proposed integration plan, since an integrated active energy system can only provide necessary observability and controllability of the grid, with distributed sensors and controllers, that might increase the system's vulnerability.
- The solutions proposed consider scalability and replicability requirements by design for EU wide implementation.

1.2 Description of Task 4.1

Task 4.1 (Flexibility services integration and data exchange at TSO level for interoperability towards the distribution system) takes its reference from the activities performed already in INTERRFACE, CoordiNet, PlatOne, Euniversal, EU-SysFlex and TDX-ASSIST in defining the interfaces between market and grid operations. Starting from these available solutions, this task sets the technical requirements to enable the flexibility services and products (identified in previous work packages) provided by generation, storage or consumption, that are connected either at transmission or distribution level

In addition, this task explores the opportunities for using already existing models and tools for data exchange that were developed in the above-mentioned research projects. Among other, results in terms of forecasting tools coming from these projects will be adopted in OneNet as well. The results will be used by market operators and market participants, such as system operators, to help them implement new market and operational interfaces based on IEC standards (CIM, 61850) supporting the grid codes to potentially help vendors develop products to provide ICT solutions. In particular, the specifications in terms of IT and data exchange at the transmission level are defined in support of the work to be performed within WP5 for the standard API definition.

Task 4.1 is mainly connected with WP2 and WP5. The outputs of task T4.1 as presented in the deliverable aspire to constitute an input for the development of specific data model activities under the WP5.

2 Methodology

An important part of the deliverable for the expert group under Task 4.1 and Task 4.2 of the OneNet project is to describe the methodology and generic business process (GBP) to build up results based on the outcomes of the past projects and integrating at the same time those of new projects. The aim of this methodology is also to enable the interoperability of flexibility assets by integrating and consolidating the lessons learned from international projects, use cases, maintaining a set of recommendations, and best practices. This methodology follows the example and approach developed by European Horizon 2020 Bridge Project [1].

The methodology will rely on the input from H2020 projects and OneNet demos where the use cases and the architecture are well defined. To reach these objectives, several activities and analyses are performed as listed below:

- The methodology is defined to allow the use-case analysis and implementation of projects by mapping them to a reference framework.
- The reference framework is generated for cross-project analysis, integration of input from H2020 projects in terms of data exchange and interfaces. It generates outcomes that results on specific actions: e.g map of standards, identified gaps, update of technical specification, etc.
- The generic business processes are defined by sequential functions and interactions involving different business actors: TSOs, DSOs, market operators, flexibility service providers.
- The methodology incorporates the analysis of inputs obtained from selected H2020 projects and OneNet demos.

This methodology has the main objective to incorporate recommendations, learnings, and conclusions from the reviewed projects to formulate recommendations in the context of OneNet to increase the flexibility integration within the network, ensure the interoperability of flexibility assets, identify gaps and assess specific standards or technical specifications. The expert group under T4.1 and T4.2 of the OneNet project identified also the main barriers and challenges. For example, fast evolution of the requirements and solutions means that the learnings and recommendations should be often updated based on the feedback and progress in other projects. Different projects are developing or using specific solutions and correspondingly it may be difficult to directly compare and merge results.

2.1 Reference Framework

Figure 1 shows the General Architecture of the proposed Methodology that enables the comparison and harmonisation of the contributions from different projects with different technical solutions. The methodology produces the reference framework that will be regularly updated and used to analyse the lessons learned from international projects, map of standards and assessment, and gaps identification.

The General Architecture is composed of three sections each describing the specific activities taken to finalize the work. The first section lists the main input information that comes from the Horizon 2020 projects, interaction with OneNet work packages and OneNet demo use cases. The input information is mapped in the generic business process diagram which is placed in the middle of the architecture. The generic business process diagram is the main connection between the input information and output results. The last section lists the main outcomes of this deliverable where gap identification enables to write the recommendations, guidelines, and map standards or specifications. This outcome will also be used to set several requirements and all output results will support other OneNet work packages with modelling.

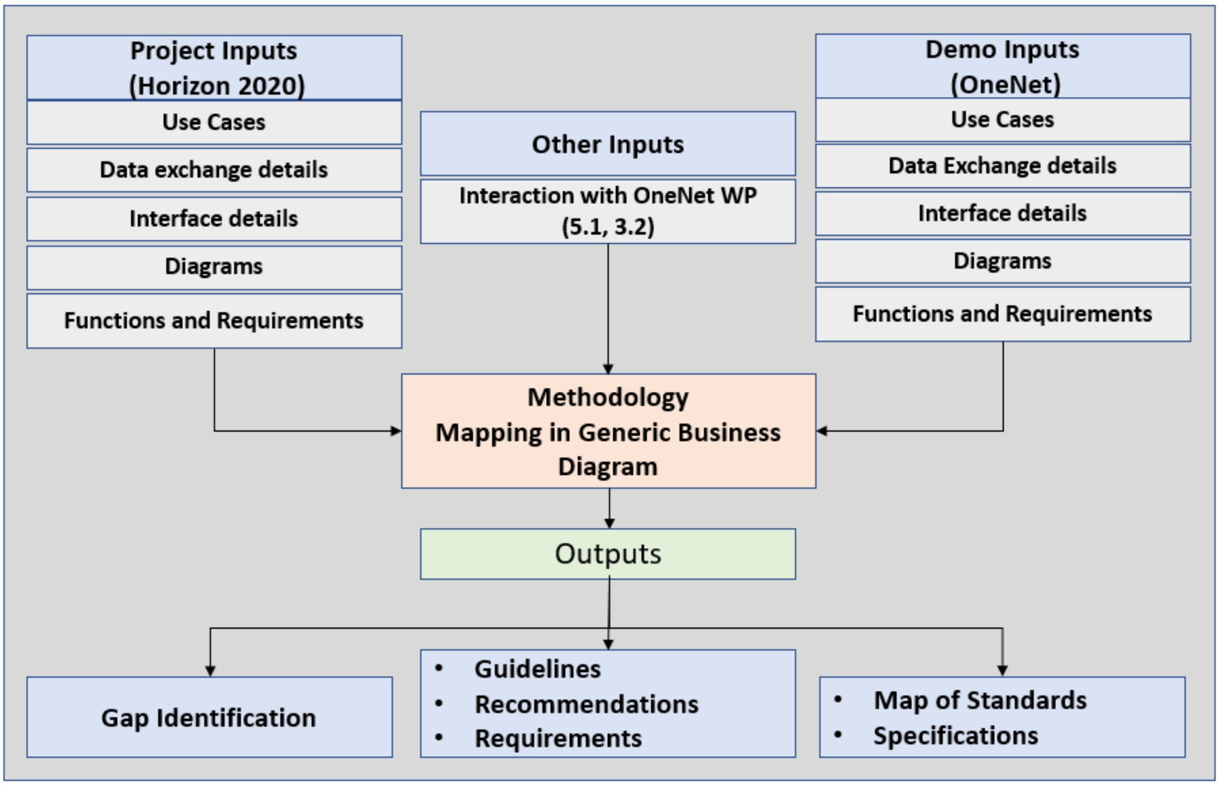

Figure 1. General architecture of the proposed methodology

2.2 Generic Business Process

Generally, a use case could be defined as a sequence of events that describes the use of a particular system. Following the IEC 62559, a Use Case is defined as "a specification of a set of actions performed by a system which yields an observable result that is of value for one or more actors or other stakeholders of the system." The goal is to explain how a specific user or set of users interacts with a given system to achieve a particular purpose. The description also presupposes defining the system, process and product requirements. A system, in turn, corresponds to a "set of interrelated elements considered in a defined context as a whole and separated from their environment".

The generic business process is developed to enable the mapping of different use cases and technical solutions. The figure below provides a general approach of how the different steps and processes followed by the OneNet WP4 (T4.1) team are expected to contribute to the mapping of various use cases in the generic business process diagram.

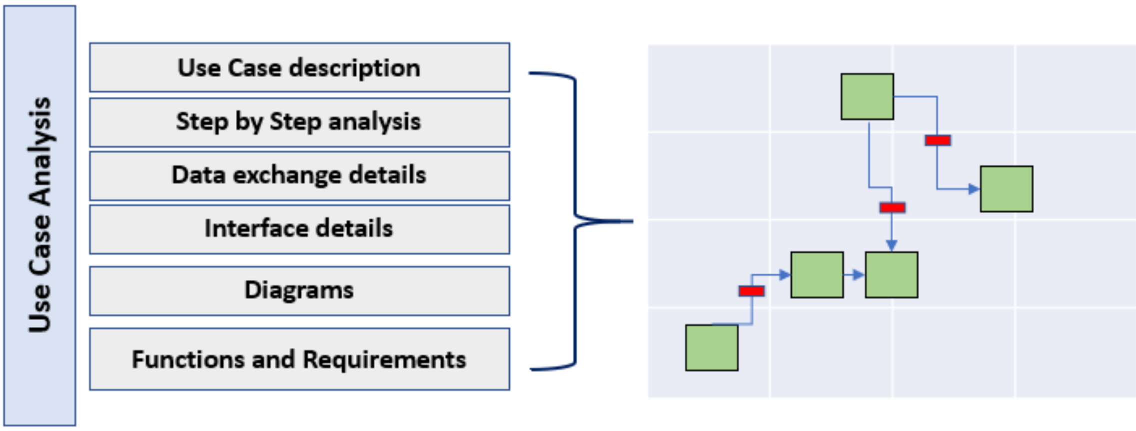

Figure 2. Standardised use case methodology described by IEC-62559 standard.

As the main goal of this task is to identify data exchange and interfaces at the TSO level, the generic business process follows the approaches recommended by the international standards. Figure 2 represents the standardised use case methodology described by IEC-62559 standard, which is being used by several previous EU-funded projects. As highlighted in **Error! Reference source not found.**, this standard works with templates that define the structure of a use case.

The generic business process corresponds to the characterization of a data exchange between business roles (e.g., aggregator, DSO, TSO, market operator). Each function characterizes the information exchange between roles (interfaces). These functions may also require external data (e.g., metering) or external command capabilities (e.g., load control). This business process description allows covering both the function and information layers of the SGAM (Smart Grid Architecture Model), aiming to analyse the interoperability of flexibility assets. The naming "generic" means that the methodology is independent of any technical solution adopted in each project. A simple sequence diagram represents the generic business process, which describes the interactions among business roles to perform flexibility services. Each row corresponds to a role, while functions are represented through rectangles and data exchanges/interfaces as arrows (Figure 3).

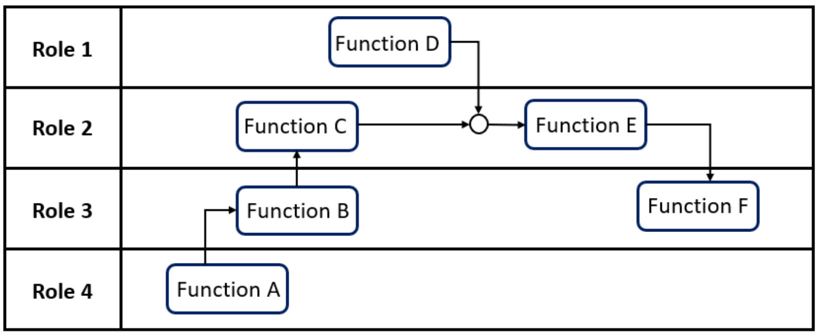

Figure 3 Example of a generic business process diagram.

Concerning the functions, they represent each of the business process steps. They receive inputs from the previous function, use external data or command, and finally provide outputs to the following function (Figure 4).

X1 / Function name	
Description	This cell describes the purpose of the function.
Inputs / Outputs	This cell indicates the inputs received from the previous function and the outputs provided to the following function.
Subfunction	This cell describes the decomposition of the function into subfunctions.

Figure 4. Template for function description.

The interfaces allow the identification of the information exchanged between the functions, as described in the following table. The mapping of the use cases from the selected H2020 projects is performed through the function and information layers (Figure 5).

X1 -> Y1	
Involved Roles	This cell lists the involved roles
List of exchanged data	This cell lists the exchanged data, e.g., "Flexibility offer"
Data Models	This cell indicates the standards used for data exchange.
Communication Protocols	This cell indicates the standard of communication protocols used for data exchange.

Figure 5. Template for interface description.

The generic business process enables the link between the data exchanges described in the SGAM information layer and the interfaces. Figure 6 shows the mapping between a system architecture and the adequate generic business process.

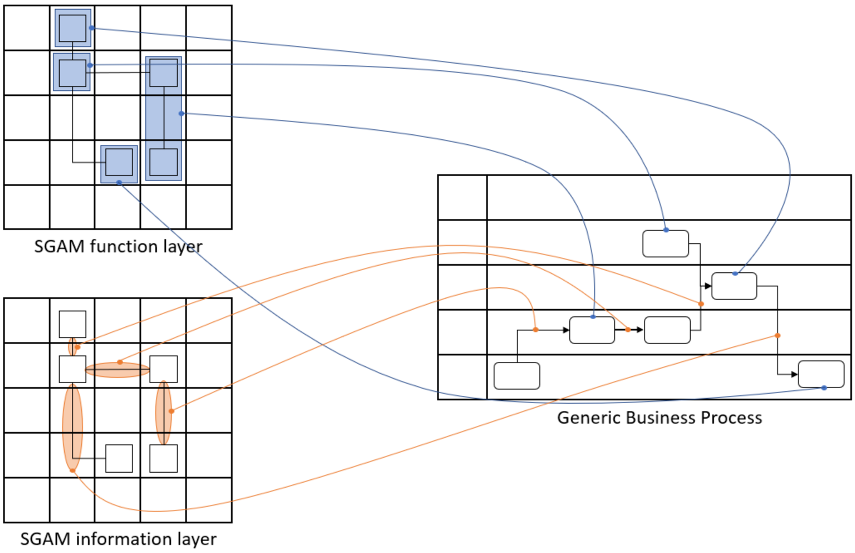

Figure 6. Mapping between a system architecture and the adequate generic business process

With this mapping, each function and interface of the selected use cases enable the identification of the following aspects:

- what solutions/standards are used;
- when the standard-based solutions are adopted if extensions/modifications to the standards are required;
- if the solutions/standards fully fulfil the needs for the procurement of flexibility services;
- which gaps are present or if there is no existing solution for specific functions or interfaces;
- what type of solutions have been put in place to deal with gaps and no existing solutions for data exchange and interface.

2.3 Definition of roles and actors

Concerning the role model, the use case describes how several actors interact among them within a system to reach the goals. Thus, the definition of the actor becomes essential in the generic business process. Usually, the description of the role is closely related to the definition of party and role. A simple scheme to explain these principles is depicted in Figure 7.

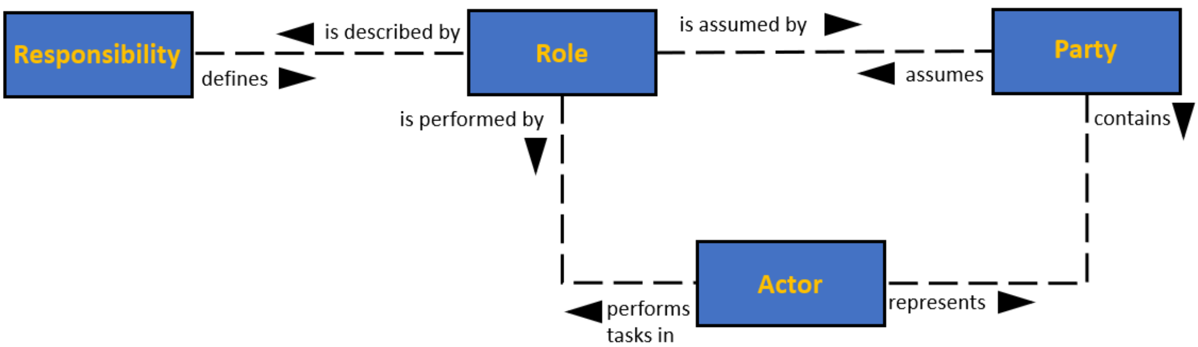

Figure 7. Concepts related to actors and roles [2]

<u>Responsibility</u>: Responsibilities define external behaviour to be performed by parties (ex: Nominate Energy, operate a grid, Determine the market energy price after applying technical constraints...).

Role: A Role represents the intended external behaviour (i.e. responsibility) of a *party*. *Parties* cannot share a *role*. Parties carry out their activities by assuming *roles*, e.g. system operator, trader. *Roles* describe external business interactions with other *parties* in relation to the goal of a given business transaction (ex: Balance Responsible Party, Grid Operator, Market Operator…).

Party: Parties are legal entities, i.e. either natural persons (a person) or judicial persons (organisations). Parties can bundle different roles according to their business model (ex: real organisations, stakeholders…)

Actor: An Actor represents a *party* that participates in a (business) transaction. Within a given business transaction an *actor* performs tasks in a specific *role* or a set of *roles* (ex: Employee, Customer, Electrical vehicle, Demand-response system…). The term *Actor* can be used in other contexts within smart grids methodology, particularly discussions around technology. If it helps, in the context of the discussion, the type of actor can be qualified, such as *business actor* in the role model and *system actor* when referring to technological systems.

3 State of the Art Analysis

This chapter conducts a state-of-the-art analysis of the outcomes and research activities of H2020 research projects, describes the interfaces between market and grid operations, as well as existing models and tools for data exchange developed within these projects. This analysis is the starting point, which we will be used as base to define the guidelines for the TSO operation and for the data exchange that will ensure the integration of flexibility services and the interoperability towards the distribution system.

To conduct this analysis, this section starts with presenting the findings from the reviewed projects and then continues with analysing the selected use cases to identify the respective business objects. In the last part of this section, the recommendations for OneNet project derived from this analysis are reported.

3.1 Selection of TSO projects

A first list of projects was selected based on the focus of TSO-DSO coordination interfaces, standards and data models for information exchange among different actors to integrate system services. Based on the first list of identified projects, a review by task partners was performed to select only those which consider the topics of interest.

Once this previous assessment was done, a list of selected projects was further analysed following a questionnaire included in Annex. These projects are: INTERRFACE, CoordiNet, EU-SysFlex, Osmose, Flexitranstore, Crossbow, PlatOne, Euniversal, Farcross, InteGrid, TDX-Assist and SmartNet.

In the next step, the analysis was further refined to filter the relevant project reviews based on various factors. Therefore, the relevance of each project for the scope of the task was evaluated in terms of interfaces, standards and models, tools and role models as presented in Figure 8.

Some of the projects have a DSO focus with none or limited involvement of the TSO. These projects are PlatOne, Euniversal, InterFlex and InteGrid. Therefore, they are not further analysed in this document but in D4.2. Figure 8 presents the projects selection process.

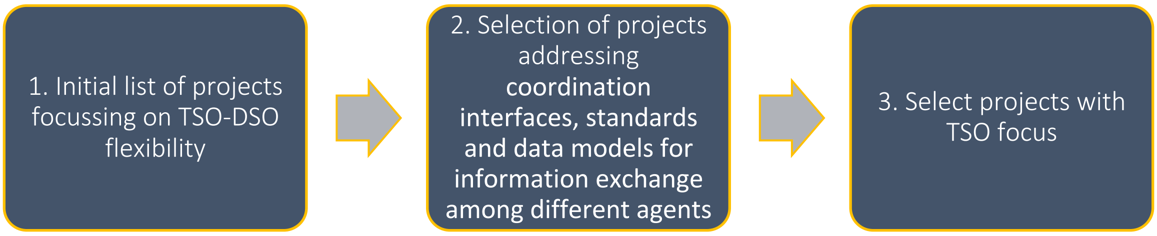

Figure 8. Stages for selecting the projects relevant for the review of TSO coordination interfaces, standards and data models for information exchange with different agents

3.2 Review of previous projects – TSO perspective

An overview of the status of the selected projects is presented in the Table 1. Our review focused on the interfaces, tools, standard models and role models explored within these H2020 projects. This information is depicted in Table 1.

Table 1: List of reviewed projects

Project Name	Interfaces	Tools	Standard model	Data model	New role models	SUCs
CoordiNet	YES	YES	YES	NO	NO	NO
Crossbow	YES	YES	YES	NO	YES	YES
EU-SysFlex	YES	YES	YES	YES	YES	YES
FARCROSS	YES	YES	YES	NO	NO	YES
FLEXITRANSTORE	YES	YES	YES	NO	NO	NO
INTERRFACE	YES	YES	YES	YES	YES	YES
Osmose	YES	YES	NO	NO	NO	NO
Synergy	YES	YES	Not yet	Not yet	Not yet	YES
TDX-Assist	YES	YES	YES	YES	YES	YES

The second stage of our analysis included a more thorough analysis for each one of these elements individually. Regarding the interfaces developed in each of the reviewed projects, we focus on the interfaces that facilitate TSOs' participation to the market or enable TSO-DSO-FSP information exchange. The reviewed interfaces, as well as the involved actors are reported in the following tables:

Project Name	Coordinet
Interface name	Interoperable Platforms
Interface description	The description of interfaces is done in terms of information models, timing requirements and interaction sequences. The results may be used by TSOs, DSOs, and market participants to help them implement new interfaces based on IEC standards.
Actors and Roles	TSOs, DSOs, and market participants

Project Name	EU-SysFlex
Interface name	Flexibility platform interface
Interface description	This interface platform performs flexibility prediction, baseline calculation based on two different options (ex-ante and ex-post), FSPs' prequalification and bidding process. In addition, it initiates the flexibility activation by SO and performs the verification process.
Actors and Roles	TSOs, DSOs, MOs, DEP (Data Exchange Platform) Operators, Aggregators, FSPs, DER Operators, Data Hub Operators

Project Name	INTERRFACE	
Interface name	ENTSO-E Communication & Connectivity Service Platform (ECCo SP)	Custom JSON API
Interface description	ECCo SP is a proprietary communication interface developed by ENTSO-E independently from the project. The project foresees the usage of ECCo SP, as is without further development, for communication platform and exchange of data encapsulated in CIM compliant format.	Custom APIs are created for tools operated by TSO/DSO/MO in order to exchange data with tools developed by the project. The custom APIs are based on JSON and intended as pilot solutions for the initial tool developments. These custom APIs will be reviewed and replaced by CIM compliant APIs in the next Platform releases
Actors and Roles	DSO, TSO, MO	DSO, TSO, MO

Project Name	OSMOSE
Interface name	Modelling the TSO-DSO Interface using open data only
Interface description	Improved methodology to represent flexibilities on the distribution grids from a transmission grid point of view.
Actors and Roles	TSO, DSO

The interfaces reported for TDX-Assist project focus on DSO and thus are not reported in this deliverable. In addition to the interfaces, a review of the tools used or developed for data exchange in each project, and which are relevant to TSO operations was conducted. These tools are reported in Table 2.

Table 2: Data exchange tools developed or used in H2020 projects

Project Name	Tools
CoordiNet	**Aggregation tool:** Enables the participation of small and medium-sized (< 1 MW) FSPs in local and common markets. The objective of the tool is to estimate dynamically the flexibility of the aggregated DERs, transform that flexibility into bids to send to the markets and finally, operate the DERs in order to fulfil market assignments. Some of this tool's functionalities are the flexibility bids creation for the participation of aggregated FSPs into the common balancing market and the data exchange with other actors/platforms.
	FSP interface:

	Enables/facilitates market participation for all FSPs. The functionalities of this tool include production/consumption plan upload, FSP notification and data exchange with other actors/platforms.
Crossbow	**Intraday market platform:** Represents a wholesale electricity market, where market participants (MPs) can trade based on closed contracts. A closed contract represents an agreement where the details of the trade are determined in advance. The quantity and price of the supplied energy is agreed on before the delivery. Deviations of the delivered energy from the quantity agreed in the closed contract are subjected to imbalance settlement. The ID platform could offer its MPs 24/7 trading with predefined energy products. The ID platform will enable cross-border trading among multiple countries and increase the efficiency compared to the single cross-border intraday trading that is sometimes still present in the countries of the SEE.
	System market platform for the mFRR: The system market platform for mFRR (mFRR platform) will represent an ancillary services market intended for the TSOs to procure the balancing energy. The platform will make use of a TSO – TSO model, where Balancing Service Providers (BSPs) will be able to send their offers to the TSO and the TSOs will forward them to the platform.
	System market platform for the aFRR: The aFRR platform would represent an Ancillary services market intended for the TSOs to procure the balancing energy. The platform will make use of a TSO – TSO model, where BSPs will be able to send their offers to the TSO and the TSOs will forward them to the platform.
	Measurement of energies within aFRP: The main idea in the proposed solution is based on the measurement of energy using one-minute load profiles, recorded in metrology meters, to measure the energy used in the aFRP frequency-power control (f-P). Increased accuracy and metrology principles will increase BSP's confidence, improving fairness and transparency in the measurement of these services, following a transparent competition that will lead to the development and maturity of the balancing market and, implicitly, to increased consumer safety.
EU-SysFlex	**Flexibility platform:** Flexibility Platform (FP) for System Operators and Flexibility Service Providers that enables the trading of different flexibility products and services. A FP is operated by a Market Operator. It is used to support the prequalification, the bidding, the activation and the verification processes, ensuring coordination between activities undertaken by several operators using the same flexible resources. Several national and regional FPs may exist.
	Data Exchange Platform: Existing Elering's DEP is used. Further data services were developed to enable secure exchange of different types of data – e.g., flexibility bids, activation requests, etc. Data exchange platform (DEP) is 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. Several DEPs may exist in different countries and inside one country.
INTERRFACE	**TSO-DSO Coordination Platform:** The TSO-DSO coordination platform acts as the gateway through which the operators (TSOs and DSOs) can access the IEGSA platform. It allows data exchange with operators through well-defined and interoperable APIs. Thus, it facilitates coordination between TSOs and DSOs. This module will support the qualification process (both grid and product). Regarding the grid qualification, either it will delegate the request to the respective operator, or –if

	the required models are provided – it will be able to calculate the qualification results internally. The TSO-DSO Coordination platform will communicate with the flexibility register in order to exchange relevant data. Moreover, it will empower system operators to publish flexibility needs on the various markets.
	Single Interface to Market: It is a gateway and a point of connection of the IEGSA platform to market platforms (commercial or project created). It consists of a complex API which allows data exchange between IEGSA and the market platforms. It communicates the flexibility needs of the operators to the market and returns and stores market results to the flexibility register. Depending on the special needs of each market it might be responsible for transferring other data to the market as well (e.g., grid topology, grid constraints, etc.). It should become clear that the Single Interface to markets is just an API and not a user interface for market players to be able to bid to the different markets.
	Settlement Unit: The module is responsible for calculating the settlement, i.e., the difference between the contracted quantities and the realized quantities of energy products for the Balance Responsible Parties in a Scheduling Area. The module will be gathering all data that are necessary for performing these calculations from various sources (flexibility register, markets, System Operators, etc.) and will publish the settlement results to the markets and store them in the flexibility register. Through this module the markets gain access to the flexibility register and the aggregated flexibility data that are stored there. This can assist more efficient market operation and can be considered as an important added value of the project and an incentive for markets (even commercial ones) to be connected to IEGSA.
	Single Flexibility Platform: Single Flexibility Platform will integrate flexibility resources on local, DSO and TSO levels to a marketplace that will allow valuation of these resources based on the needs of the different grid levels and market participants
	Flexibility services for congestion management: Blockchain based TSO-DSO flexibility platform in Romania and Bulgaria where flexibility services are traded amongst prosumers, TSOs and DSOs in the long-term and operational timeframe. We enable participation of distributed generators and flexibility assets on the distribution grid level via a decentralized marketplace (EFLEX) to ensure system stability.
	A Retail-To-Wholesale Market approach for DERs integration: A prototype will be developed to promote DER participation into the wholesale market, using considerable amount of data from the TSOs, DSOs, market operators and energy suppliers to provide implementation of actual and realistic representation of the wholesale and retail markets in the examined South-East Europe region, namely Romania, Bulgaria and Greece. The algorithm will implement optimal power market reserves clearing for the provision of Congestion Management services, supplementary to the Balancing (FCR, aFRR, and mFRR) services clearing.
	A EUPHEMIA-based market platform to include local flexibility resources tool: The EUPHEMIA-based market platform that includes local flexibility resources tool developed in part of the demonstration aiming Spatial Aggregation of Local Flexibility aims to provide a new auction platform-based tool to further enhance coordination of local energy and flexibility needs

Analysing data models is another important aspect of WP4 work. The data models and standards used in the reviewed projects are presented in Table 3. The table refers only to the reviewed projects that used a standard model or that developed a data model.

Table 3. Standard and data models used in H2020 projects.

Project Name	Standard or data model	Model name	Application description
CoordiNet	Standard	IEC standards (CIM, 61850)	The project will improve ENTSO-E profiles based on IEC standards: CGMES (Common Grid Model Exchange Specification), based on IEC 61970 and IEC 61968 and CIM European Style Market profile based on IEC 62325.
Crossbow	Standard	IEC 61860, IEC 61970 (Common Communication Grid Model Exchange Specification), IEC 60870, IEC 62056	
INTERRFACE	Data model	Common Information Model (CIM)	New CIM compliant profiles are developed by the project for data exchange of specific data sets which are needed. [1]
EU-SysFlex	Data Model	Data model for flexibility provision value chain	Initially a project specific data model for "Flexibility Platform" demo based on SUCs was developed. It is being translated into CIM compliant data model currently.
FLEXITRANSTORE		USEF framework	USEF delivers the market model for the trading and commoditisation of energy flexibility, and the architecture, tools and rules to make it work effectively.

Regarding the role models that the projects developed, we focused on identifying the new roles that were introduced. As new roles, we define the ones that are not currently included in the HERM list [3].

Project Name	New Role	Description
Crossbow	Automatic generation controller	Automatic Generation Control. A system for adjusting the power output of multiple generators at different power plants, in response to changes in the load.
Crossbow	Under-Frequency Reserve provider	A party that is contractually or legally obliged to increase generation and/or decrease consumption as requested by System Operator according to special control scheme in case of emergency over-frequency appearance.
Crossbow	Over-Frequency Reserve provider	A party that is contractually or legally obliged to decrease generation and/or increase consumption as requested by System Operator according to a special control scheme in case of emergency over-frequency appearance.

[1] At the time of drafting this deliverable, the profiles are not yet subject to formal community-wide review and approval or standardization.

Crossbow	Weather Forecast information provider	A party that provides, upon request, weather forecast information.
Crossbow	Frequency Restoration Reserve (FRR) provider	A party that is contractually or legally obliged to supply FRR from at least one reserve-providing unit or reserve-providing group.
Crossbow	Forecasting generation calculator	A party or entity generating the forecast.
Crossbow	DSM provider (Demand side management)	An entity that operates the DSM unit.
INTERRFACE	Flexibility Register Operator (FRO)	FRO: • Is the administrator of all the information that is stored in the Flexibility Register. • Is responsible for allocating access rights to the various actors and controlling the level of access. • Stores flexibility assets, results of qualification (both product and grid), stores market results, grid information, aggregates flexibility information and stores the results of the settlement. • Forwards activation signals to flexibility assets upon request of the SOs. The Flexibility operator should be a trusted authority due to the sensitivity level of the information being handled
INTERRFACE	TSO-DSO Coordination Platform Operator (TDCPO)	The TSO- DSO Coordination Platform operator connects the SOs to the IEGSA platform. This role can be taken over either by a TSO or a DSO or both at the same time to ensure coordination among them.
INTERRFACE	Single Interface to Market Operator (SIMO)	The Single Interface to the market operator is the responsible entity for connecting the IEGSA platform to market operators. Responsible for all actions described in the Single Interface to Market Component.
INTERRFACE	Settlement Unit Operator (SUO)	The Settlement Unit Operator is responsible for calculating the settlement, i.e., the difference between the contracted quantities and the realized quantities of energy products for the Balance Responsible Parties in a Scheduling Area and for publishing the settlement results to the markets and storing them in the flexibility register.

3.3 Use case analysis to identify business objects

For the analysis of use cases and the identification of business objects, some Business Use Cases (BUCs) were taken from previous projects. For this first stage we identified the BUCs related to Flexibility and those that foster the exchange of data between TSO, with DSO and other actors such as Market Operator or FSPs. In addition, we also identified which process phases are described in each BUC. The next steps are to identify which BUCs presented in the following table contain enough information to identify the interfaces that are used to exchange data and to identify the Business Objects. The selected use cases in Table 4 are from TSO and DSO perspective, however, in this deliverable, only the TSO perspective are covered in the detail and the rest of the use cases (DSO) are described in deliverable 4.2.

Table 4. Selected business use cases from H2020 projects: EU-Sysflex, INTERRFACE, and CoordiNet

Project	Business Use Cases (BUC)	Perspective	Mapping	Phases
EU-Sysflex	Manage active power flexibility to support FCRn in the Finnish demo	TSO	TSO-Market based Interaction	Prequalification Bidding/Selection phase Delivery Phase Settlement
EU-Sysflex	Manage active power flexibility to support mFRR/RR in the Finnish demo	TSO	TSO-Market based Interaction	Prequalification Bidding/Selection phase Delivery Phase Settlement
EU-Sysflex	Manage reactive power flexibility to support voltage control in the Finnish demo	DSO	DSO-Market based	Prequalification Bidding/Selection phase Delivery Phase
EU-Sysflex	Manage active power flexibility to support congestion management and voltage control in the German demo	DSO/TSO	TSO-DSO market-based interaction	Prequalification Bidding/Selection phase Delivery Phase Settlement
EU-Sysflex	Manage reactive power flexibility to support voltage control and congestion management in the German demo	DSO/TSO	TSO-DSO market-based interaction	Prequalification Bidding/Selection phase Delivery Phase Settlement
EU-Sysflex	Manage active power flexibility to support mFRR/RR and congestion management in the Italian demo	DSO/TSO	TSO-DSO market-based interaction	Prequalification Bidding/Selection phase Delivery Phase Settlement
EU-Sysflex	Manage reactive power flexibility to support voltage control and congestion management in the Italian demo	DSO/TSO	TSO-DSO market-based interaction	Prequalification Bidding/Selection phase Delivery Phase Settlement
EU-Sysflex	Manage active power flexibility to support mFRR/RR and congestion management in the FlexHub Portuguese demo	TSO/DSO (more TSO)	TSO-DSO market-based interaction	Prequalification Bidding/Selection phase Delivery Phase Settlement
EU-Sysflex	Manage reactive power flexibility to support voltage control and congestion management in the FlexHub Portuguese demo	TSO/DSO	TSO-DSO market-based interaction	Prequalification Bidding/Selection phase Delivery Phase Settlement
EU-Sysflex	Manage VPP active power flexibility to support aFRR in VPP Portuguese Demo	TSO	TSO-Market based Interaction	Prequalification Bidding/Selection phase Delivery Phase Settlement
EU-Sysflex	Manage VPP active power flexibility to support mFRR/RR in VPP Portuguese Demo	TSO	TSO-Market based Interaction	Bidding/Selection phase Delivery Phase Settlement

CoordiNet	Voltage control in transmission system and distribution system using flexible resources connected to transmission and distribution system under the scope of a multi-level market mechanism	DSO/TSO	TSO-DSO market-based interaction	Plan/Forecast Market Phase Measurement & Settlement

3.4 Mapping Use Cases in Generic Business Process Diagram

The scope of the analysis in this section is limited to the mapping of the selected use cases from H2020 projects (EU-Sysflex, CoordiNet) that has a TSO focus using the generic business process. For each use case, the respective diagram is created with the corresponding description for all elements. In this section, several diagrams are presented, however, other diagrams are placed in the Appendix.

EU-SysFlex GBP1.1 – Manage active power flexibility to support FCRn in the Finnish Demo

The generic business process for the Finnish use case (active power flexibility to support FCRn) that is analysed as part of the EU-Sysflex is presented in the following paragraph. This use case is based on the management of active power flexibility to support FCRn (Frequency Containment Reserves for Normal) operation. The FCRn market in Finland is a combination of a yearly capacity market and a day-ahead, single buyer market cleared on an hourly basis. The energy settlement is made according to the usual balance settlement of the associated BRPs.

The main objectives of the use case are for the TSO to stabilize the frequency in response to deviations occurring due to the normal variations in production and consumption, for the aggregator to increase the revenue associated to the operation of its resources. This will result in an increase in the income from the operation of the battery systems and of the distributed controllable heating loads. The use case is divided into four phases: prequalification, selection and bidding, delivery and settlement phases as shown by the following Figure 9.

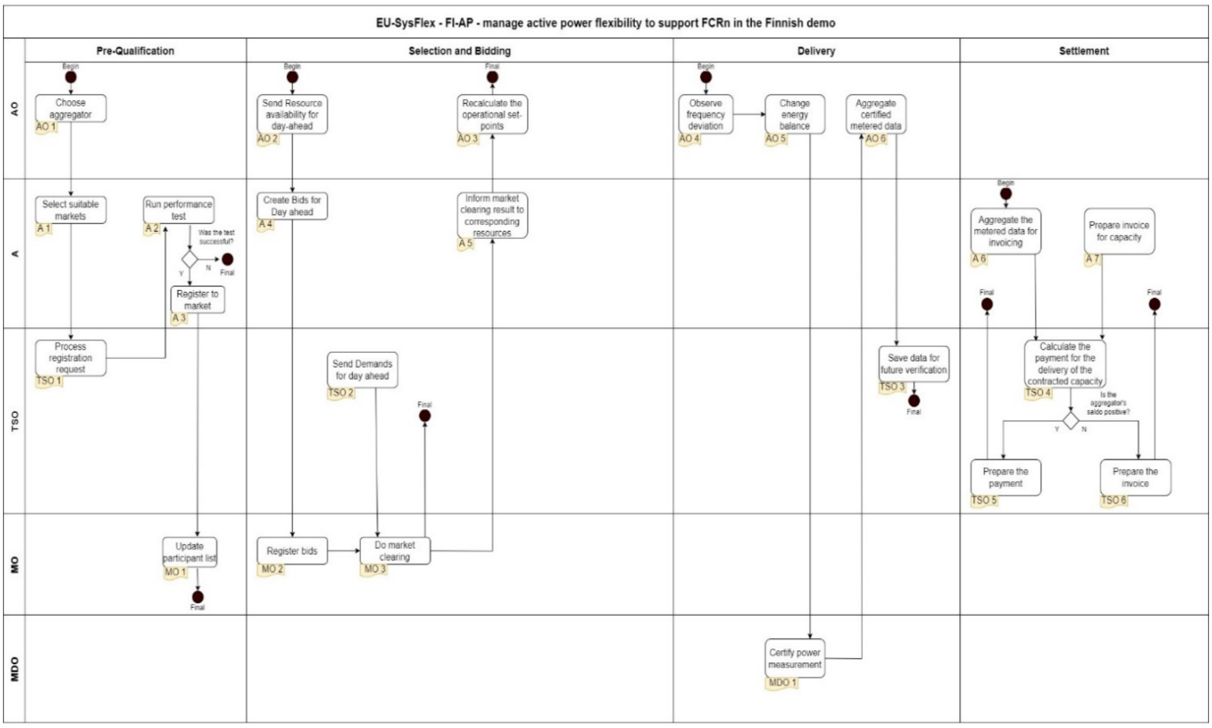

Figure 9. Sequence diagram - manage active power flexibility to support FCRn

Prequalification

The first scenario is the prequalification phase that begins with the asset operators choosing the aggregator that will get access to their flexibility to bid it on the selected market. This is followed by the selection of suitable markets to participate to by the aggregator. The system operator receives then a request from an aggregator to become a service provider after which the aggregator simulates a step change in the frequency measurements. The aggregator and TSO measure and analyse the response of the resources. If the test gives positive results, the aggregator sends the final information to register themselves to the market. Finally, the market operator updates the participant list with the new information obtained.

Selection/Bidding

The selection/bidding phase begins with the asset operator that sends the resource availability for day-ahead to the aggregator. The aggregator then creates bids for day-ahead market including forecasting of the assets and calculation of the availability of the ones that did not send it. This function is followed by the market operator that receives and collects the bids in its database. Based on the requirements agreed the TSO determines the amount of FCRn reserves that are required for the period considered. Once the market operator subtracts the reserves on the yearly market from the TSO needs, it allocates the remaining to the aggregators with the cheapest bids. Finally, aggregators inform market clearing result to corresponding resources. These operational resources are then recalculated by the asset operator.

Delivery

The delivery phase starts with the asset operator that observes and measures locally a frequency deviation. The asset operator then changes energy balance adjusting the production or consumption according to the set-points determined during previous phase and on locally measured values. The Metered Data Operator guarantees that the measured data is accurate and reliable sending back this information to the asset operator. After this, the TSO aggregates and packages the metered data and then stores the measurement data received in real time in order to have it available later for the settlement phase.

Settlement

The final phase is the settlement starting with the aggregator that sends the measured data to the TSO and prepares the invoice for the capacity maintained. After this, the TSO calculates the payment for the delivery of the contracted capacity checking the success of the capacity delivery. Hence, the TSO prepares the payment/invoice for the balance between provided and not provided capacities.

EU-SysFlex GBP1.2 – Manage active power flexibility to support mFRR/RR in the Finnish demo

This use case is based on the management of active power flexibility to support mFRR/RR in the Finnish demo. The aggregator is Helen [4] and uses distributed resources to participate to the manual balancing power market (mFRR/RR) of the TSO (Fingrid). The objective of this use case is to bring the frequency back to its set-point of 50Hz improving the aggregator's revenue by better utilizing the resources it has available.

The use case is divided into four phases: prequalification, selection and bidding, delivery and settlement phases as shown in Figure 10. (**see fig 10 in Appendix**).

Prequalification

The prequalification phase begins with the asset operator that chooses an aggregator and propose it to use their resources for this use case. After this, the aggregator selects the suitable markets they choose to participate to, considering the resources it has access to. The process ends with the BRP that updates the status of the resources and the market operator that updates the list of participants.

Selection/Bidding

In the bidding phase the asset operator, considering the forecasts, calculates the availability of its resources for mFRR/RR market. When the aggregator receives the resource availability from the asset operator, it generates bids for the mFRR/RR market. The MO receives this information and sorts the bids in price. Then it sends these to the TSO who receives it for each control zone and for each time period.

Delivery

The delivery phase begins with the TSO that identifies a frequency deviation and determines a need to activate mFRR/RR resources to restore the frequency to the desired level. The TSO determines then which aggregators should be contacted to provide mFRR/RR products. The aggregator chosen receives a request for activation of its resources. This scenario ends with the asset operator that change the production or consumption of the units according to the received request and the resources availability.

Settlement

In the last phase, the TSO modifies (adds or removes) the settlement from the balancing fees incurred by the BRP.

EU-SysFlex GBP2 – Portuguese demo Use cases

Manage active power flexibility to support mFRR/RR and congestion management in the FlexHub Portuguese demo

This BUC proposes an extension of the current Portuguese replacement reserve market (tertiary reserve market) by enabling distributed resources (industrial consumer loads, distributed generators and storage) connected to the distribution grid can provide replacement reserve (active power). Thus, the BUC was designed so that load and generation connected both at the transmission and distribution grids can provide replacement reserve in an aggregated manner. Nevertheless, disaggregated information is also needed to allow the grid operators (TSO and DSO) to ensure that no grid constraints are violated. This BUC considers several phases as explained as follows.

Prequalification

In this phase, TSO supported by DSO registers and tests the technical characteristics of the assets of the agents that intend to participate in the market. This process involves the analysis of the capability of providing the service, communication, etc. Besides, the TSO also verifies the financial guarantees according to the preestablished market rules. The DSO also needs to coordinate with the TSO by informing the assets of its grid involved in the prequalification process, to facilitate the TLQ (Traffic Light Qualification) process that will take place in real-time.

Selection/Bidding

At each new market session, every 15 minutes, the TSO publishes the profile on the expected needs of active power for the next delivery horizon. Then, the market agents can update their bids for each market session. The bids sent by the market agents include resources connected to the distribution grids. Those bids are marked when they are sent for future assessment before being accepted.

Concerning the clearing process, the TSO should order the bids according to their prices so that it can select the cheapest bids to match its active power needs. Those bids, including resources connected to distribution grids, are marked when sent for future checking before being accepted. The TSO requests that the DSO performs the traffic light qualification (TLQ) for the marked bids before clearing the market. For that purpose, this BUC runs the FlexHub TLQ tools by the DSO to check if the activation of the resources connected to the distribution grids will not cause grid constraints.

Following the TLQ procedure, three possibilities can take place:

- **Green light:** TSO can accept the bid resources fully for its activation;
- **Yellow light:** The bid can only be accepted partially to avoid distribution grid constraints violations;
- **Red light:** The bid must be discarded due to violation in distribution grids and may be replaced by the next cheapest bid;

The following information is needed to compute the TLQ:

- Load and RES forecasts of the nodes of the distribution grid for all the time intervals of the delivery horizon.
- Information about network topology ("normal" topology)
- Information about topology changes for the next hours (e.g., planned maintenance actions)
- Technical network constraints (e.g. voltage/branch flow limits)
- Information about controllable devices (OLTC and capacitor banks) and their characteristics and flexibility (e.g., number of tap positions).
- Active power bids

TSO will inform the market agents and the DSO regarding the accepted bids. As the next step, market agents can proceed to the activation of the resources, and DSO can adequately oversee the distribution grid security. The market price of each time interval is set to the price of the most expensive cleared bid for that period (pay as clear).

Delivery

An external entity (metered data operator) is responsible for measuring and storing the active power provided by the resources located at the distribution network. The TSO measures the active power provided by the resources connected to the transmission network, although an independent entity could also be responsible for this task.

Settlement

The settlement phase involves several aspects:

- TSO is responsible for requesting measurements from the metering entity concerning the resources at the distribution grid and uses its measurements in the transmission grid to compute the settlement for each market agent.
- The aggregator is responsible for solving its contractual rights and obligations with the owners of the resources providing the service (biding and settlement).
- The costs associated with the active power service are shared by the final users and by the penalties for those not complying with their active power commitments.

The mapping in GBP diagram is presented in Figure 11. (**see fig 11 in Appendix**).

The market agents update their reactive power bids according to the TSO profile needs. For each time interval of the next delivery horizon, the DSO provides to the TSO the PQ maps computed from the available bids. The PQ map has information on the aggregated amount of the reactive power available for a time interval (without violating constraints of the distribution network), and the corresponding costs (depending on the reactive power amount). This information enables the TSO to select the least costly resources (if other are also available at the connection zone) to meet its reactive power requirements. The DSO is responsible for matching the final reactive power profile decided by the TSO and determines the optimal (least costly) combination of resources to be activated for each time interval of the delivery horizon, by using a multi-period power flow clearing algorithm ensuring that no distribution network constraints are violated. The resources connected to the distribution network (including the DSO resources) that could provide reactive power to the TSO are the following:

- **DSO resources:**
    - Capacitor banks
    - OLTC
    - Storage

- **Voluntary offered private resources connected at the DSO grid:**
    - Q regulation from inverters connecting wind farms, storage facilities and PV
    - Capacitor banks of industrial customers

This BUC considers several phases explained as follows:

Prequalification

The DSO registers and tests the technical characteristics (capability of providing the service, communications, etc) of the assets of the entities that want to participate in the market, and verifies the financial guarantees needed, according to the pre-established market rules.

Selection/Bidding

Every 15 minutes, the TSO published the reactive power profile needed to the DSO for the next delivery horizon of 7 hours (28 time periods of 15 minutes). The DSO shares this profile with the market agents that can adapt their bids to the published profile or keep them as before. The DSO uses the FlexHub to compute the PQ map that informs the TSO about the aggregated reactive power available and its cost for each time interval of the delivery horizon. This computation is performed by guaranteeing that the available reactive power can be supplied without violating the distribution network constraints. The Q profile is issued by the TSO and communicated to the DSO. Then, the DSO uses the FlexHub for computing multi-period power flow (MOPF) to clear the market and select the optimal resources for the service providers without creating voltage or overload constraint violations distribution network. The final bids matching is finally published for the agents in charge of activating the corresponding resources. The computation of the MOPF and PQ maps requires the following data:

- Load and RES forecasts;
- Information about network topology ("normal" topology);
- Information about topology changes for the next hours (e.g., planned maintenance actions);
- Technical network constraints (e.g. voltage/branch flow limits);
- Information about controllable devices (OLTC and capacitor banks), and its characteristics;
- and flexibility (e.g., number of tap positions);

The MOPF is computed using the previous data, the available resources and their costs from the bids.

Delivery

When the local market clears, the resulting schedules are used by the DSO and by the market agents to activate the resources. For settlement purposes, the metered data operator (an external entity) measures and stores the reactive power provided by the market agents and resources connected to the distribution grid. Besides, TSO also measures the total reactive power provided at the TSO-DSO connection point.

Settlement

The settlement phase involves several aspects:

- DSO computes the service cost by multiplying the total reactive power provided at the TSO-DSO connection point per time interval.
- DSO also needs to estimate the cost of using the local resources in order to get the market clearing with a null TSO Q profile because some bids may have been matched to solve distribution grid constraints. In this sense, a cost-sharing mechanism can be adopted between TSO and DSO for the resources' use.
- In case deviations from the real reactive power are detected, penalties are added to the total service cost.

EU-SysFLex GBP2.3 – Portuguese demo Use cases - Manage VPP active power flexibility to support aFRR in VPP Portuguese Demo

In this business use case, management of VPP (Virtual Power Plant) in the Portuguese demo is tested and coordinated by a market agent of flexibility provided from centralized resources including pump storage plants (PSP) and wind power plants connected to the transmission level providing aFRR services (aFRR-automatic frequency restoration reserve). The main objectives of this business use case are:

- Optimal real-time management of the storage and generation portfolio
- Market bidding suite for the different markets: (day ahead, intraday, system services)
- Enhanced computational management system: integrating forecasting modules for prices, energy supply and demands
- Remuneration of Wind Power Plants
- Optimal management of generation portfolio

The BUC is divided into four phases as shown by the sequence diagram (**see the figure 12 in Appendix**):

- **Prequalification:** This phase begins with the generation aggregators that register for aFRR providers and fulfil the requirements specified by the Power System Operator. The requirements will be in a form of tests performed by the TSO on the units where the technical and operational capability will be evaluated (e.g., communications velocity, real energy generated, gradient variation of the energy produced and response to random generation requests). After this, the generation aggregator (GA) manages the request within the portfolio in which the TSO firstly sends to VPP these requests, and then these are performed through the optimal dispatch of the generation units. Once the generator receives this communication from the GA, it adjusts the operation setpoint according to the VPP orders sending back the output to GA. Finally, the VPP sends tests response to the TSO.
- **Selection/Bidding:** This phase begins with the TSO that establishes and communicates to all Market Agents the necessary aFRR market services in the system for each programming period of the following. The generation aggregator then activates the forecasting tools, that will provide decision support for the bidding at the aFRR market. The VPP then creates optimal bids considering the combined operation of RES and large-scale storage power plants participating in the electricity market (energy and ancillary services). After this, when all the market players put the offers in the aFRR market, the TSO publishes the list of resources sending to the Generation Aggregator the contracted regulation band and the price assigned.
- **Delivery:** In the delivery phase the aFRR is requested by the TSO to the Generation Aggregator that owns the VPP. The VPP, according to the request received by the TSO, activates, through the Automatic Generation Control, the service provision with the real-time management of the storage and generation portfolio. Once the operation is finalized by the Generator, the TSO verifies the correct response from the contracted generation.
- **Settlement:** The final market phase begins with the TSO checks if the capacity and energy that was promised/mobilized has been delivered. The remuneration happens at the price of the last aFRR regulation offer. The TSO prepares then the payment and the invoice sending these to the GA. The same process is followed by the GA that processes the payment and invoice to the generator.

EU-SysFlex GBP2.4 – Portuguese demo Use cases - Manage VPP active power flexibility to support mFRR/RR in VPP Portuguese Demo

In this paragraph the Portuguese demo use case is analysed. It is based on the management of VPP active power flexibility to support mFRR/RR (mFRR/RR - manual frequency restoration reserve/regulation reserve). Main objectives of this business use case are:

- Enhanced computational management system: integrating forecasting modules for prices, energy supply and demands
- Remuneration of Wind Power Plants
- Optimal management of generation portfolio
- Market bidding suite for the different markets: (day-ahead, intra-day, system services)

This BUC is aimed to provide a service in an existing market by enabling the participation of a mixed portfolio of the traditional and the new generation RES. The efficient management of a generation and storage energy portfolio will allow a future scenario with a high renewables penetration while maintain the security and quality of the energy services provision.

In the market setting described in this BUC, the TSO is responsible for all the markets activities, which in a future could be performed by a different actor that will be referred as the Market Operator (MO). The service provision will be described in three phases as shown in the sequence diagram below (Figure 13):

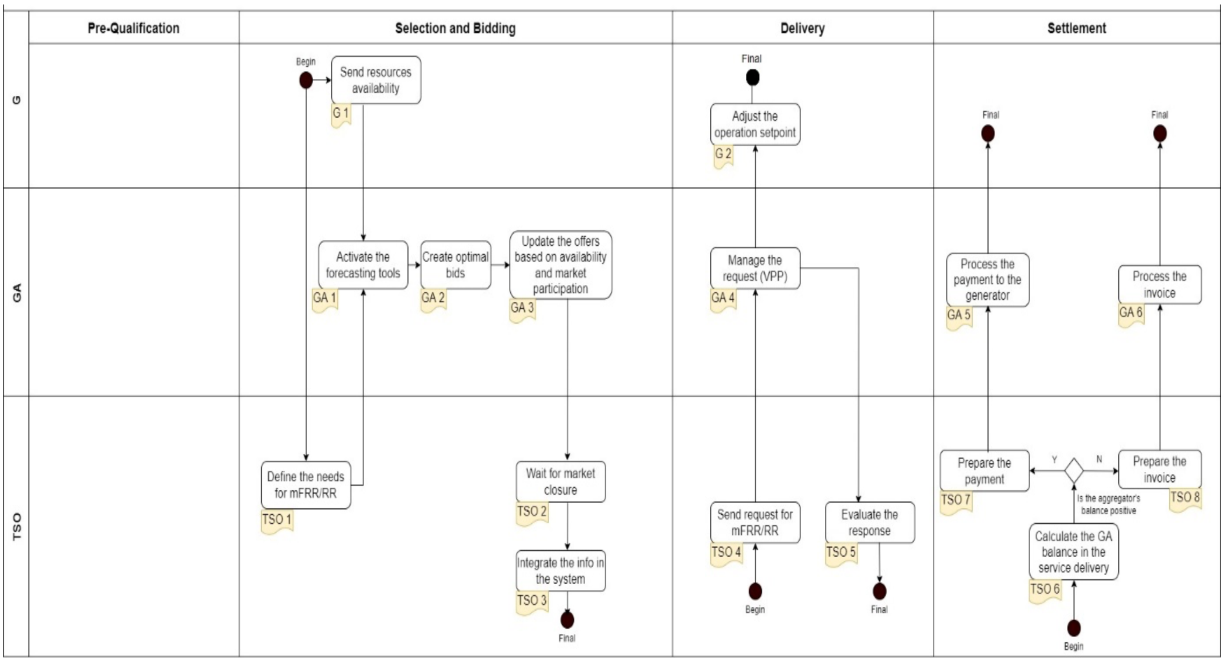

Figure 13. Sequence diagram - Manage VPP active power flexibility to support mFRR/RR in VPP Portuguese Demo

Selection/Bidding:

The TSO defines the needs for the regulations, for each hour of the day, considering the demand forecast. Generation units then send online information about their availability and real production. After this the generation aggregator activates the forecasting tools. The VPP tools, with the forecasting complex modules, will provide decision support for the bidding at the mFRR/RR market and will do optimal offers and bidding strategies for the combined operation of RES and large-scale storage power plants participating in the electricity market (both energy and ancillary services). The GA updates then the offers based on availability and market participation. The market players that participate in the RR service will update their offers within the same day of operation. Immediately after publication of the aFRR results and until 20.00 hours of the day before, the market players/generation aggregators should make available to the TSO the information regarding the mFRR/RR. Based on the offers the TSO creates the merit order for the resource activation.

Delivery: In this phase, the offers available for mFRR/RR are considered contracted at the instant of mobilization. After this TSO uses the available offers offered by the market players/generation aggregators and mobilizes those that follow the criteria defined in the bidding phase. The VPP receives the request and automatically activates the service provision with the real-time management of the storage and generation portfolio. The generation units included in the VPP portfolio adjusts the output according to the VPP orders and the TSO verifies the correct response from the contracted generation.

Settlement: this final phase begins with the TSO that calculates the GA balance in the service delivery. After this, if the energy is provided and the service fulfilled, the TSO sends the payment to the GA. The GA will follow the same approach done before by the TSO sending the payment to the generation/storage owners. The mFRR/RR energy is remunerated at the marginal price of the last mobilized offer. Finally, the TSO sends the invoice for the payment and at the end of the process, the GA determines the generator compensation by the service provision and makes the payment and sends the invoice for the generator if the service assigned was not provided.

CoordiNet Use Cases

CoordiNet GBP3 Voltage control provided to the TSO and DSO under the scope of a common market mechanism

In this use case, the FSP provides voltage control services to the TSO and DSO under a common market mechanism. The phases of this use case are:

1. Prequalifying voltage control (for long-term voltage control)
2. Enacting voltage control (for short-term voltage control)
3. Monitoring voltage control activation (for short-term voltage control)

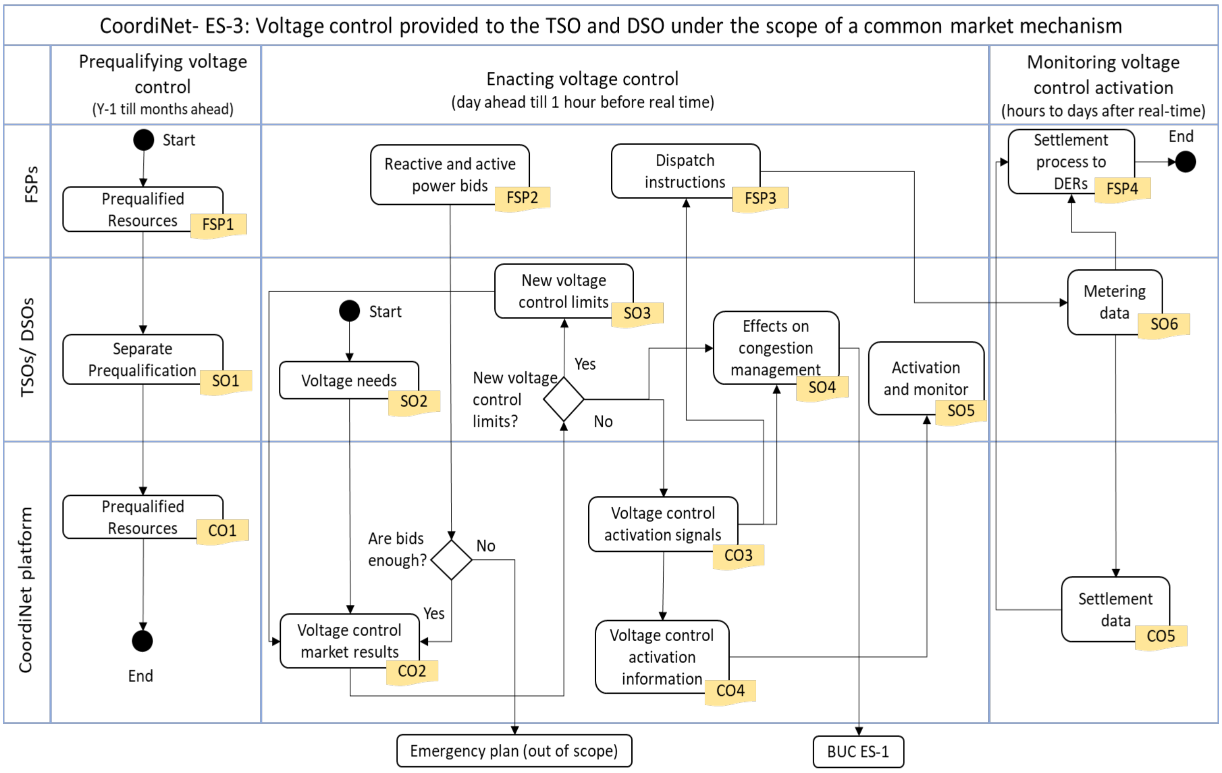

Figure 14. GBP3 Voltage control provided to the TSO and DSO under the scope of a common market mechanism.

In the sequence diagram (Figure 14) the flow of information and the performed functions are illustrated. The performed functions by the FSP are the prequalification of resources, active and reactive power bids submittance, dispatching instructions to DERS and performing the settlement process to DERs. The performed functions by the system operators are performing a separate prequalification from the one performed by the FSP, computation of voltage control needs, computation of new voltage control limits, estimation of the effects on congestion management, activation and monitoring and perform metering. The rest of the functions that can be seen in the sequence diagram are performed by the CoordiNet platform, which is the interface used for most of the data exchanges between the FSP and the system operators.

CoordiNet Procure and manage balancing services (FRR and RR) to reduce balancing cost under the scope of a central market mechanism

Currently, generation resources connected to distribution networks can provide balancing services, but with CoordiNet it was open to demand-side resources. In a similar manner to congestion management, the functions are divided into four relevant timescales which are described in detail below: the long-term (from years until day-ahead), the day-ahead, from one hour to real-time and post-real-time. In this Use Case, the FSP performs the function of Balance Service Provider (BSPs) which according to the EBGL (Electricity Balancing Guideline) means a market participant with reserve-providing units or reserve-providing groups able to provide balancing services to TSOs. In the long-term, the first steps will be to engage resources and understand their flexibility. Once the flexibility is known, the TSO performs a prequalification process to the FSPs who are interested in providing balancing services. As resources are connected to the DSO, the TSO performs the prequalification with information exchange with the DSO and informs the CoordiNet platform. In the Day-ahead, the TSO computes the balancing capacity needed based on the energy market results and its forecasts. After the TSO receives and reviews the FSP's capacity balancing bids, the next step is to communicate them to the CoordiNet platform which send them to the relevant DSOs. In turn, the DSOs forecast and identify transitory limits in their networks and if these limits can restrict completely, or only partially the bids from FSP in the balancing markets, the DSOs need to communicate to the platform, which will then notify the TSO. After the TSO runs the market, the respective results are then communicated to the platform which sends them to the DSO and the FSP.

From one hour to real-time, based on the balancing capacity and additional available information the FSP submit balancing energy bids to the TSO before the gate-closure time of the balancing energy markets. Resources that have not provided balancing capacity can, in any case, also provide balancing energy (voluntary bids). The TSO receives the balancing energy bids until the gate-closure time of each balancing service. Then, the TSO communicates these bids to the platform, which are sent to the DSO. Both the TSO and DSOs check again if new limits on their networks are foreseen which may restrict the delivery of balancing energy. Any additional limit is communicated to the platform, which informs the TSO. Considering this information, the TSO communicates the available energy balancing bids to the European Balancing Platforms and its balancing needs. The Balancing platforms perform the energy balancing market clearing also considering all relevant information and bids available from neighbouring systems and submits the results to the platform. The CoordiNet platform then submits the results to DSO and the FSP. After real-time, the TSO and DSO read the delivered and consumed energy for balancing and afterwards, the TSO performs the balancing settlement with the FSP based on the energy delivered as well as on the corresponding penalties for non-delivery.

CoordiNet Congestion management in the transmission system and distribution systems using flexible resources connected to the transmission and distribution systems under the scope of a multi-level market mechanism

The Use Case describes the steps that are followed to eliminate congestions in the transmission and distribution systems. DSO can use flexible resources connected to the distribution system and TSO not only can use flexible resources connected to the transmission system, but also flexible resources connected to distribution system whose use has been approved by a DSO. The power flows in transmission and distribution systems are permanently assessed and monitored by TSO and DSO respectively, to decide actions for keeping voltages of their systems within admissible range. This use case is structured in three main phases, namely Day Ahead Market, Intraday Market and Near Real Time market. In the Day Ahead Market both System Operators assess power flows, estimate the amounts of flexibility to eliminate congestions and procure flexibility for the next 24 hours. In the same sense, in the Intraday Market, the DSO and TSO assess power flows, estimate the amounts of flexibility to eliminate congestions and procure flexibility for the next 12 hours. Lastly, in the Near real time both System Operators assess power flows, estimate the amounts of flexibility to eliminate congestions and procure flexibility for the next 5 minutes.

Interface use Cases

The use cases from INETERRFACE project were analysed to some detail based also on the survey results presented as part of the State-of-the-art chapter, however, there were no sufficient details available to perform the mapping in the business process diagram for the selected use cases.

3.5 Mapping OneNet Demo Use Cases in GBP Diagram

Western Cluster - Exchange of Information for Congestion Management – Short Term

Flexible resources connected to transmission and distribution system can provide flexibility to system operators to eliminate congestions through a market mechanism. This Use Case applies both transmission and/or distribution system, to keep power flows within the accepted thermal limits of the lines. These information exchanges of information mechanisms should be adaptable to any future market model or governance issues.

Some different time frames will be examined:

- Day Ahead
- Intraday

The developed information exchange mechanisms will be implemented to have a verification process.

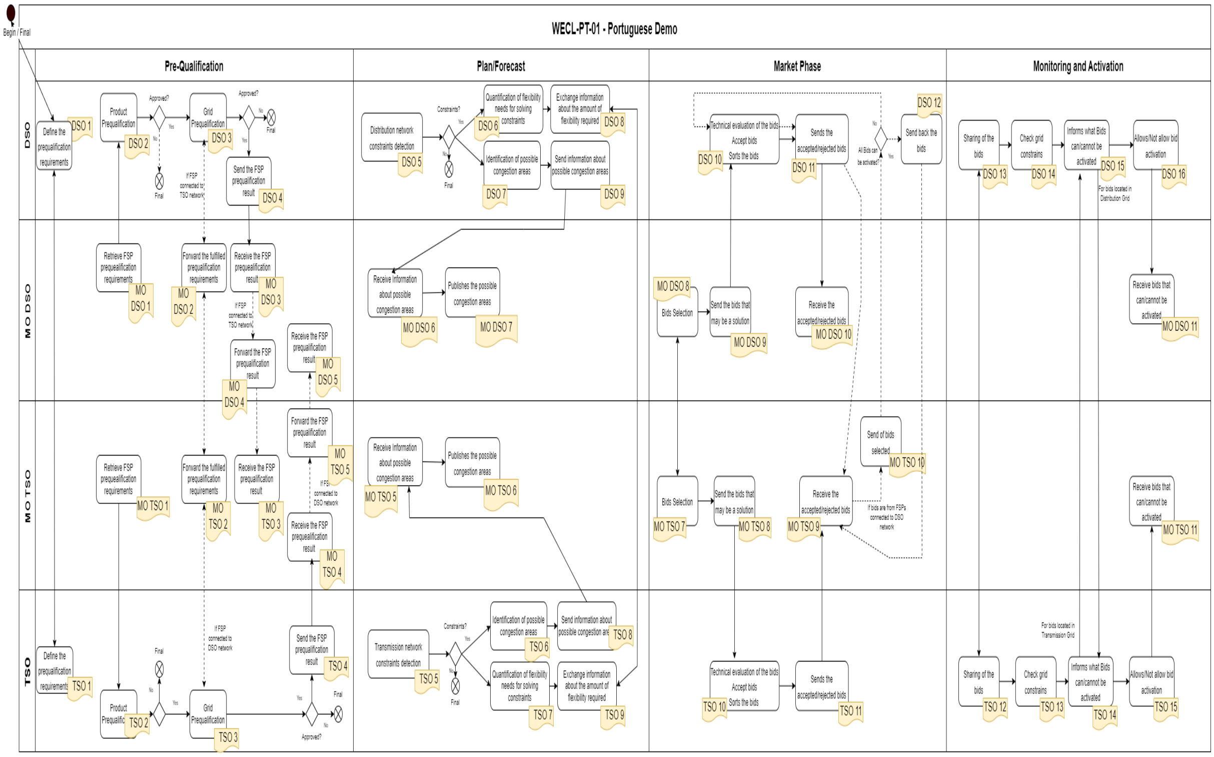

Figure 15. Exchange of Information for congestion management for short-term – process phases

The **Prequalification** process should start after a flexibility service provider expresses interest in entering the flexibility market. This process serves to ensure that a particular flexibility service provider is capable of delivering a given product. In order to do that, two types of prequalification should be considered: Product Prequalification and Grid Pre-qualification. The former ensures that the resource contains the technical requirements to be able to deliver the product and proceed to the market phase and eventually selected by a system operator. These technical requirements are defined by DSO and TSO and after the FSP indicates the attributes of the product it wants to deliver a prequalification test should be performed to verify that all attributes are in compliance with the technical requirements. This test may be repeated on a periodic basis or whenever the characteristics of the product are found to change significantly. The product prequalification can be done either by the DSO or TSO, regardless of its location. In case a system operator wants to activate a product already pre-qualified by another system operator, the former should have access to this information to make the process more efficient and not to pre-qualify the same product twice.

Regarding grid pre-qualification, this process ensures that the product provided by the Flexible Service Provider will not cause constraints in the networks where it is connected. This process can be avoided if the System Operators have already identified the areas where flexibility is always allowed. The grid prequalification should be performed by the System Operator of the network to which the product is connected to verify if the maximum capacity of the product does not impact the network it is connected to. If the results of the two types of prequalification are approved, the entry of the FSP into the flexibility market is allowed. The **Prequalification** scenario is independent of the timeframe, since it is a process that happens before the market phase.

In the **Plan/Forecast** phase the System Operators take into account the utilization of their grid. Based on forecasts the Systems Operators check the power flows to detect whether or not there will be possible congestion in the network. In case the grid capacity is insufficient to meet the forecasted electricity production or consumption, System Operators may resort to the flexibility market to resolve this type of issue. This phase is done for two different timeframes, day-ahead and intraday. On the one hand, the day-ahead forecasts are made for D-1. On the other hand, the intraday forecasts are made every 4 hours to improve the accuracy of the predicted flow of electricity that were made for the day-ahead.

The objectives of this phase are to identify possible congestions in the network and to support the procurement in the flexibility markets.

The **Market Phase** starts after the system operators forecast network congestion. In this phase, the system operators are focused on collecting and selecting bids from FSPs. These bids can be in the day-ahead market, which occurs on D-1, in the intraday market, which occurs already inside D every 4 hours, or they can come from the long-term market (BUC-2). The intraday market is a complement to the day-ahead market. The possible failures or unforeseen events that were not covered in the day-ahead should be corrected in the intraday market.

In the bid selection process, the SO should pay attention to whether the bid is located in its own network, or in another network. In the latter case, the SO should consult the SO where the bid is located so it can evaluate the constraints that may arise if the bid is accepted and activated. After this phase, the need arises to sort the accepted bids by a merit order list. This Business Use Case will address a multi-level market model.

Finally, the **Monitoring and Activation** phase occurs after the list of bids sorted by a merit order is defined. The SO selects the bid it wants to activate, if the bid is located in the network of another SO, the latter should be consulted to validate the activation of this bid. If the SO's need is not resolved this process is repeated iteratively until the SO needs are solved (Figure 15).

Western Cluster Exchange of Information for Congestion Management – Long Term

Flexible resources connected to transmission and distribution system can provide flexibility to system operators to eliminate congestions through a market mechanism.

This Business Use Case describes the exchanges of information and the rules that should be established between DSO and TSO in case of forecasted congestions in transmission and distribution system in to keep power flows in the accepted thermal limits of the lines. DSOs and TSOs should procure flexibility in advance to solve a specific system loading issue on the distribution and transmission system thus deferring/eliminating the need for traditional system upgrades. This kind of flexibility service can also be used to support the network during planned maintenance actions. These exchanges of information mechanisms should be compatible with any future market model or governance issues.

This Business Case is related to the previous one, since the phases that will be covered are the same, but in a different time frame. Although some of the phases may be similar for both Use Cases, others will have to be adapted. In this Business Use Case, the measurement and settlement phase will not be addressed. Figure 16 shows the GBP diagram for Exchange of Information for Congestion Management for Long-term (**see fig 16 Annex**)

As stated in the previous Use Case, the **Prequalification** scenario is independent of the timeframe, since it is a process that happens before the market phase, there is no change comparing to the description done for the previous use case.

In **Plan/Forecast** phase, the System Operators consider the planning of grid reinforcement to solve unexpected or forecasted physical congestions related to reduced network capacity. In case the grid capacity is insufficient to meet the forecasted electricity production or consumption, System Operators should find solutions to tackle this kind of needs and may resort to the flexibility. This planning occurs 1 to 3 years in advance and the use of flexibility should be considered as a complement or even an alternative to traditional grid investments. The objectives of this phase are to identify possible congestions in the network and to support the procurement in the flexibility markets.

The **Market Phase** starts when the system operators forecast network congestion. For the long-term timeframe, this phase is divided into two stages.

1. The SO evaluates the bids and establishes agreements to reserve and activate, or just to reserve, the products that meet its needs.
2. In the short-term market (BUC-1), these products, once reserved, can be activated to solve SO needs.

In the bid selection process, the SO should pay attention to whether the bid is located in its network, or in another network. In the latter case, the SO should consult the SO where the bid is located so it can evaluate the constraints that may arise if the bid is accepted and activated. After this phase, the need arises to sort the accepted bids by a merit order list. This Business Use Case will address a multi-level market model.

This **Monitoring and Activation** phase occurs after the list of bids sorted by a merit order is defined. The SO selects the bid it wants to activate, if the bid is located in the network of another SO, the latter should be consulted to validate the activation of this bid. If the SO's need is not resolved this process is repeated iteratively until the SO needs are solved.

Western Cluster Exchange of Information for Operational Planning

This Use Case focus on the enhancement of information exchange that enables better operational planning for DSOs and TSOs. The detailed diagram with mapping in GBP is shown in Figure 17, (**see fig 17 Annex**).

For the **Long-term**, will be defined the information that needs to be exchanged bidirectionally regarding the expected evolution of the transmission and distribution grids and their associated supply, consumption, production, and flexibility services configuration.

Concerning the **Medium-term**, the effort will be focused on the definition of the information regarding the capacity and availability for load connection in the EHV/HV substation, as well as the information regarding the load transfers availability between EHV/HV interconnecting points, providing a better management of the distribution network loops by the DSO. This allows, in case of emergency, the possibility of the DSO to manage the transfer of load between networks. For the efficient use of the flexibility services and enhancement of the operational planning, the increase of the information exchanged on **Short-term** is key. Once well-defined the observability area of both operators around the TSO-DSO border, the focus will be in the definition of information to exchange about:

- Short-circuit power at the TSO-DSO border;
- Scheduled maintenance actions in the observability area
- Aggregated consumption and production forecast by technology (solar, wind, hydro, etc)

The short-circuit power at the HV bay in the physical border of the TSO-DSO interface (EHV/HV substations) is important to keep tracking due to the increase of the DER that actively contribute to the increase of the short-circuit levels. The short-circuit levels should be tracked to ensure that they are kept bellow the rated short circuit current of the circuit breakers in the interface TSO/DSO. This information should be computed and exchanged after the gate-closure time of the day-ahead market to use the market results to robustly forecast the short-circuit levels at nodal level in the observability area. Due to the impact that distribution network loops, close to the TSO-DSO interface, can have in the transmission power flows, the share of the information about the scheduled maintenance plans becomes crucial for the TSO operational planning. On the other side, to the DSO, the TSO can share information about the connectivity status and maintenance plans of the transmission lines between EHV/HV substation with some impact in the distribution grids power flows near the border.

For an efficient and secure operation of the power system, it is fundamental to include an accurate forecast of the load and generation into the TSO operational planning framework. Having in mind that the DSO has their own forecasting methods for the DERs generation and load connected to the distribution networks. Both forecasts can be aggregated by technology and per grid node of the observability area. This information, when shared with the TSO, can have great potential to enhance the TSO operational planning activities.

Southern Cluster (SOCL-CY-02) – Reactive Power Flexibility and Power Quality

In this BUC, the DSO monitors the real-time operation to ensure the system's proper operation is within the admissible operating limits. When a voltage or power factor limit violation occurs, the DSO will coordinate the flexible resources to provide reactive power flexibility and power quality services (phase balancing). The market has already awarded the resources capable of participating in this scenario. This means that the DSO has prequalified their bids to participate in the reactive power compensation and power quality enhancement.

Smart meters and SCADA enable the monitoring of the distribution grid. The active balancing congestion management platform at the DSO control center (ABCM-D) is an important component, while the OneNet system enables the information exchange between the different actors in the distribution grid.

The use case can be summarized in the following steps:

- The DSO procures congestion management products (phase balancing and reactive support) for the DSO local market.
- The DSO sends the location-based prequalified operating limits by using the ABCM-D platform to the DSO local market to ensure the safe operation of the distribution grid.
- FSPs connected to the distribution level submitted their activation bids in the local DSO market
- After the DSO market is cleared, the awarded activations bids are sent to the qualified FSPs at the distribution grid.
- In case of a power quality or voltage limit violation, the awarded FSPs are activated through coordinating signals by the ABCM-D platform to overcome those technical issues.
- The DSO evaluates by using the ABCM-D platform the response of the FSPs to the congestion management event and sends an evaluation report to the DSO local market.

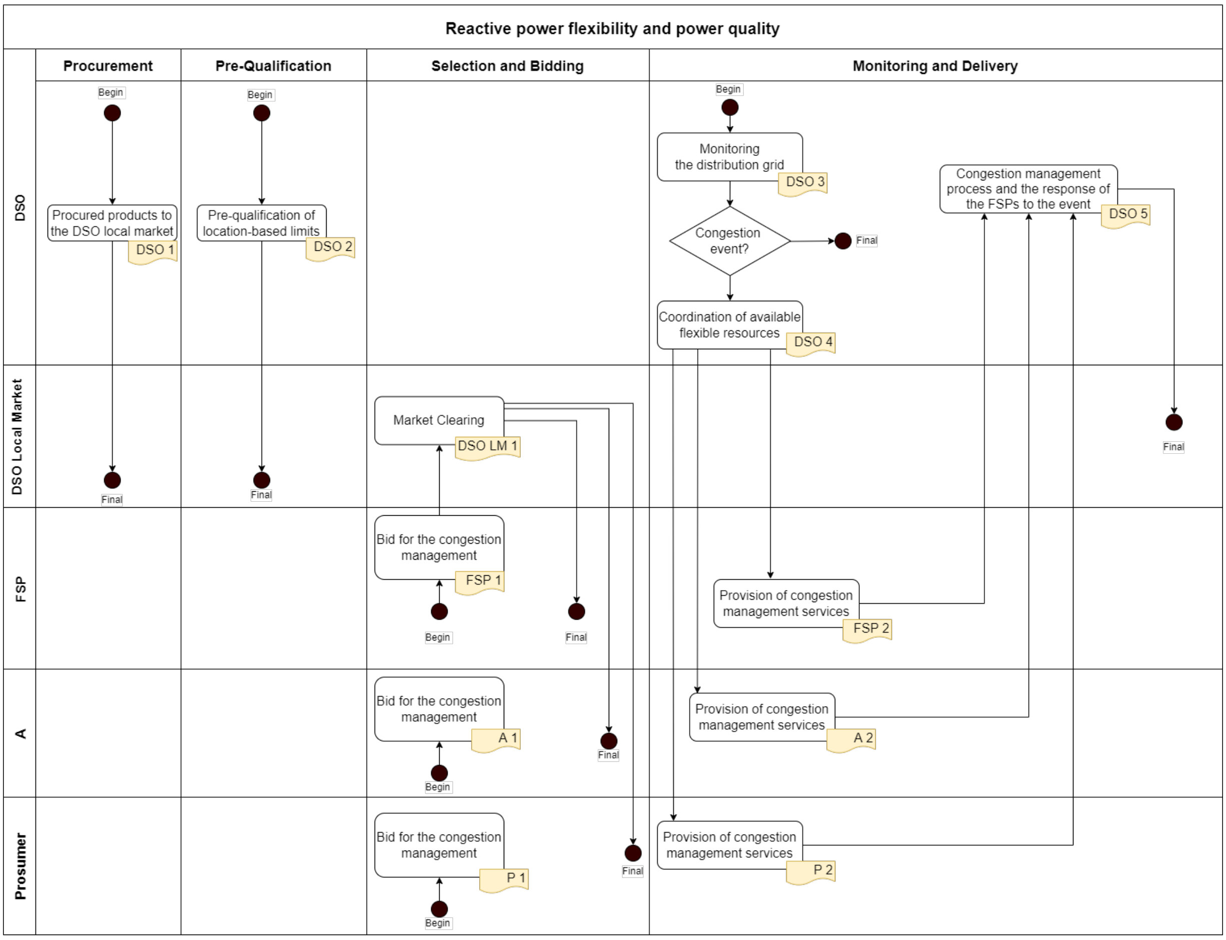

Figure 18. Reactive power flexibility and power quality in southern cluster.

Eastern Cluster-Polish Demo-Managing flexibility delivered by DER to provide balancing services to TSO

This BUC aims to ensure that the energy system is balanced, and that frequency is kept within the permitted range, to open a balancing market for resources connected to the distribution network (LV/MV), to develop rules for coordination between TSO and DSO when using flexibility services, as well as to create revenue opportunities for market participants for providing balancing services in the form of balancing capacity products and balancing energy.

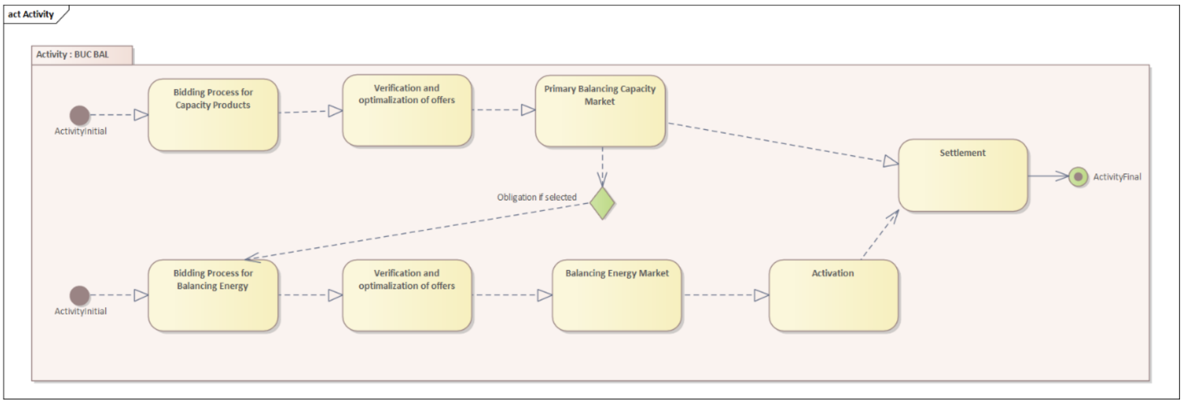

Figure 19. OneNet Polish demo BUC “Managing flexibility delivered by DER to provide balancing services to TSO” overview

The process carried out on the Flexibility Platform in day-ahead time frame consists of the following steps:

1. Determination of TSO needs in terms of capacity
2. Collecting offers for balancing capacity products from BSPs whose sources are located in the DSO network
3. Verification of technical feasibility of offers for balancing capacity products and selection of offers on the Flexibility Platform/ Verification of technical feasibility of offers for balancing capacity products and selection of offers by DSO
4. Transfer of offers for balancing capacity products to the Balancing Market within the Primary Balancing Capacity Market
5. Selection of offers for balancing capacity products on the Balancing Market
6. Information about offers for balancing capacity products selected on the Balancing Market
7. Collecting offers for balancing energy from BSPs whose sources are located in the DSO network
8. Verification of technical feasibility of offers for balancing energy and selection of offers on the Flexibility Platform/ Verification of technical feasibility of offers for balancing energy and selection of offers by DSO
9. Transfer of offers for balancing energy to the Balancing Market within the Balancing Energy Market
10. Selection of offers for balancing energy on the Balancing Market
11. Information about offers for balancing energy selected on the Balancing Market
12. Delivery of balancing capacity products and/or balancing energy
13. Settlements for balancing capacity products or balancing energy between TSO and BSPs
14. Settlements for balancing capacity products or balancing energy between BSPs and FSPs and FSPAs

Eastern Cluster-Polish Demo-Balancing Service Provider (BSP) on the Flexibility Platform

This BUC focuses on the introduction of the BSP linking it with the FSP or FSPA, the creation of a scheduling unit and its prequalification for the balancing market. This BUC is materialized in four phases:

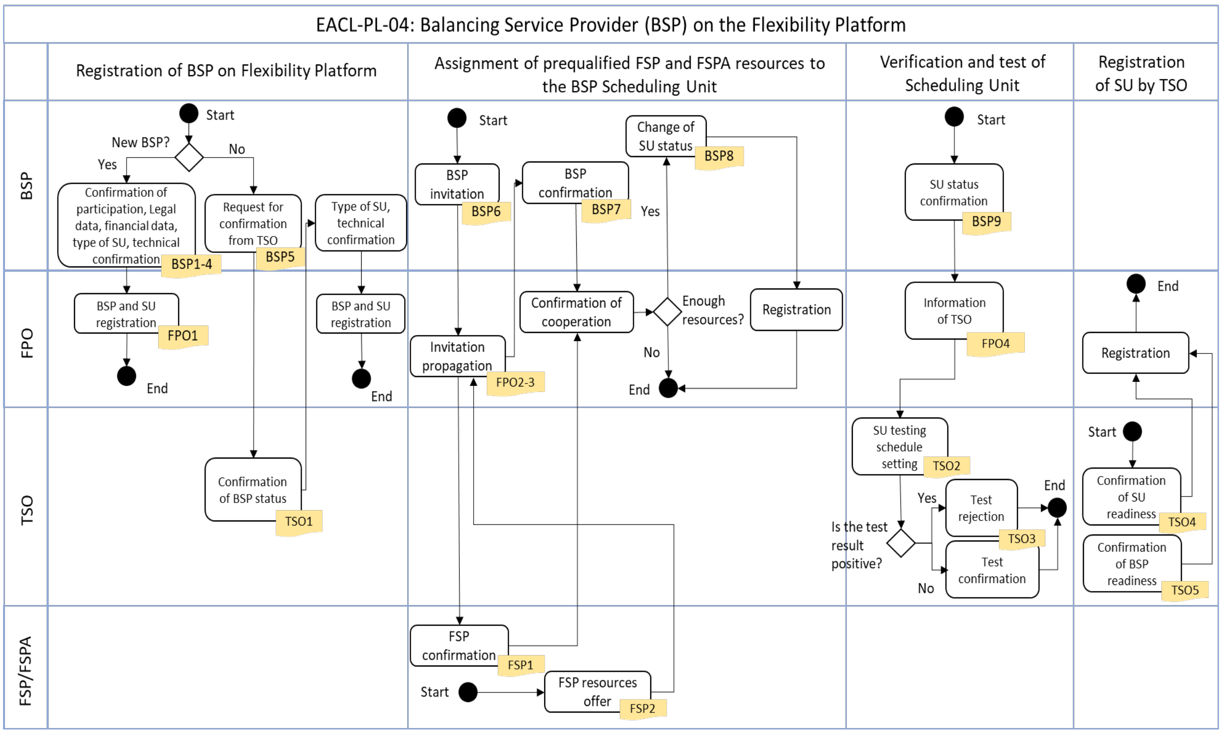

Figure 20. OneNet Polish demo BUC "Balancing Service Provider (BSP) on the Flexibility Platform" process phases

- <u>Registration of BSP on Flexibility Platform</u>: This phase falls under two scenarios, either the BSP already has a contract with TSO for the provision of balancing services or has no contract. In the first case, the BSP registers on the flexibility platform. In the second case, the BSP registers also on the flexibility platform, but the registration process includes the confirmation of fulfilment of several duties that are related to being a participant in the balancing market. Thus, the BSP must fulfil on its own or by proxy, the technical (scheduling operator) and communication requirements. For both cases, the BSP declares its intention to create a specific scheduling unit compliant with the Terms and Condition related to balancing. This declaration is publicly available on the flexibility platform with the specification of the scheduling unit type.
- <u>Assignment of prequalified FSP and FSPA resources to the BSP scheduling unit</u>: The BSP selects the FSP or FSPA resources already prequalified to balancing products, or the FSP and FSPA choose BSP by offering him their resources prequalified for balancing products. The selection is made by designating points of connection representing the resources selected by the BSP to the scheduling unit. The scheduling unit ID and list of connection points is stored in flexibility register. BSP decides to terminate the acquisition of resources if it has already obtained their sufficient volume. When the acquisition is completed, all parties involved confirm it on the flexibility platform. The BSP, based on the resources of the FSPs or FSPAs with which it has established cooperation, creates a scheduling unit that meets the criteria for providing balancing services defined in the Terms and Condition related to balancing. Finally, the scheduling unit is registered in Flexibility Register.
- <u>Verification and test of scheduling unit</u>: According to the requirements defined in the Terms and Condition related to balancing, the BSP is obliged to prequalify each Scheduling Unit. These requirements include the provision of the schedules for the scheduling unit, being ready to receive the set-point orders, as well as the provision of near real-time or real-time information about the status of the scheduling unit, including availability and information about current set-point of this scheduling unit. Moreover, the BSP is obliged to have ICT systems appropriate to the type of balancing services connected with TSO systems, in accordance with the technical requirements published by TSO in Terms and Condition related to

balancing. In this context, the BSP submits to TSO a request to conduct tests for a given scheduling unit and then tests the scheduling unit under the supervision of the TSO and with the participation of relevant DSOs.

- Registration of Scheduling Unit by TSO: If all conditions defined in Terms and Condition related to balancing, including positive run of tests are fulfilled, TSO confirms this on the flexibility platform. The status of scheduling unit with its components controlled by BSP is registered on Flexibility Register. As a result, an agreement is concluded between BSP and TSO, or if such an agreement already exists, its appropriate modification, considering a new scheduling unit.

4 Data Exchange and Interfaces for Interoperability Towards DSOs

As described in the methodology section, the last step is to identify the data exchanged in each use case interaction. In this step, we start to identify what type of data is being exchanged, such as generation and load forecasts, metered consumption data and contract data. Moreover, based on the analysis of the previous projects, we intend to identify the data needed to perform the flexibility services procurement processes. We intend to identify data exchange requirements for each category of flexibility service for recommendations for further standardisation. One aspect considered in the analysis is the usage of international standards for data exchange like CIM (Common Information Model), CGMES [5, 6] (IEC-619670-600-1, and IEC 61970-600-2) IEC 61850 and COSEM (Companion Specification for Energy Metering).

As described above, the first step in the data exchange is to identify, classify and describe the different types of data that are being exchanged among the roles. One may identify some types of data like meter data, market data, and grid data in advance. Although data identification is an important step, this is only part of the equation. Indeed, data exchange is also defined by the processes and functionalities associated with the data. For example, one can think about the customer data associated with a metering point and becomes functional only if handling these data is defined (e.g. how to do a supplier change or read a meter value from the database). Aiming to o develop new services like flexibility, it could be necessary to allow the aggregators to have access to customer data and act on their behalf. To do so, some functionality such as access to own data by customers, authorization of data access by the owner of data, registering a flexibility unit and information about grid constraints can be needed. For some of the functionalities, there may be different ways to implement them. The forecasting data can be exchanged between the roles or be provided by a third party as a service.

4.1 Characteristics and Properties of the Data Exchange

The data exchange details were collected for all selected use cases from the H2020 projects and demo use cases. The details collected were used for the mapping in the business process diagram, listing gaps, and making the final recommendations. Furthermore, our analysis also includes the communication infrastructures that were used in the previous project to exchange data among actors. We identify technical and non-technical aspects of the communication infrastructure needed to exchange data and the related requirements for that purpose. Table 5 shows an example of the data that were collected for each studied use case.

Table 5. Example of data exchange details collected for each studied use case.

Use Case ID: Manage active power flexibility to support FCRn in the Finnish demo	
Requirements	Non-functional (performance requirements, security requirements, data management requirements, interoperability issues).

Involved Roles	A, AO	AO, A	AO, A	TSO, A	A, TSO	A, DSO	DSO, MO	A, MO
Name of information								
Exchanged Data	Availability of the asset - hours of day - amount	All relevant asset data		Aggregated by BID ID: - hours - volume - price	Active power (-Market ID) - Aggregator's ID -Times -Volumes -Prices	Reactive power demo - Aggregator's ID -Times - Volumes	Reactive power demo - Times - Volumes	Reactive power demo Aggregated: - times - volumes
Data Name	Data Update Request	Asset Data	Data Updated	Accepted Bid	Bid		Reactive Power Needs	Asset Offer
Data Description	Request from the forecasting tools to update the data related to a specific type of resources or market. It includes: - type of resource ID - time period to forecast	This includes historical and status data for a specific asset or group of aggregated assets. It may include: - Historical data - Status - Planned operations (e.g. planned maintenance, advance booking, etc)	Notification that the data related to a specific asset has been updated.	Bid ID -Times -Prices -Volume	Bid for active or reactive power market. It may include: -Market ID -Aggregator's ID -Times -Volumes -Prices		Needs for reactive power. -ID of a part of the network -time periods -reactive power needed (in kvar) for each time period	Information about the assets and their willingness to provide reactive power for the upcoming time period. -Asset ID -Reactive power that can be provided during the next time period (kvar)
Volume	SMALL	SMALL	VERY SMALL	VERY SMALL	SMALL	VERY SMALL	VERY SMALL	VERY SMALL
Frequency	2/DAY	2/DAY	2/DAY	1/DAY	1/DAY, LATEST BEFORE 18:00	1/WEEK	1/WEEK	1/WEEK
Reliability	LOW	LOW	HIGH	HIGH	HIGH	HIGH	LOW	LOW
Data Model	Hierarchial			PROPRIETARY	PROPRIETARY	NaN	NaN	NaN
Communication Protocol	f.ex. REST API*	Asset to paltform used in different sub		ELCOM	PROPRIETARY	NaN	NaN	NaN

		demos: REST API, Modbus TCP, OCPP, OPC UA						

4.2 Gap Analysis for Use cases selected from H2020 Projects

In this section, the gap analysis is listed for all use cases selected from H2020 project. They show in detail for which functions or interfaces the projects are missing proper solutions. A gap could be that there is no existing solution or that the existing solutions are incomplete. It could be either gaps related to the interface in general (e.g. missing standard) or gaps related to the use of a specific standard for this interface (e.g. missing feature in existing standard). Table 6, shows the gap analysis performed in selected H2020 use cases.

Table 6. Gap analysis for the use cases of the H2020 projects.

Project Name	Use Case Name/ID	Interface	Used information model: customized solution/standard	Communication protocol used	Extension/ modification/deviation	Gaps Identified
EU-SysFlex	Manage active power flexibility to support FCRn in the Finnish demo	A, AO (Data Update Request)	Hierarchial	f.ex. REST API	N/A	
		AO, A (Asset Data)		Asset to paltform used in different sub demos: REST API, Modbus TCP, OCPP, OPC UA		In this BUC, the data exchange TSO-Aggregator, DSO-Market Operator, Aggregator-Asset Operator, and Aggregator-DSO are performed through proprietary protocols. Based on the experience of this pilot, one may infer that the data standards need to be reviewed to address the data exchange with the aggregator role. Besides, it is also needed to deal with the data exchange between the aggregator and customers' appliances. In particular, two aspects seem to be relevant: • data models for demand-response, provision of flexibility (frequency and non-frequency services), pricing and distributed energy resource communications • implementation for a bidirectional signalling system to facilitate information exchange between electric service providers, aggregators and consumers It is recommended to check and review the standards to cover the needs of flexibility
		AO, A (Data Updated)	Without information	Without information		
		TSO, A (Accepted Bid)	PROPRIETARY	ELCOM		
		A, TSO (Bid)	PROPRIETARY	PROPRIETARY		
		A, DSO (Bid)	Without information			
		DSO, MO (Reactive Power Needs)		Without information		
		A, MO (Asset Offer)				

						procurement phases, namely the interaction between energy suppliers and consumers: • IEC 62939 specifies services for symmetric interoperation between energy suppliers and energy consumers across the SGUI (Smart Grid User Interface, connecting customer systems to the power system. • IEC 62746 defines the system interfaces and communication protocols covering the whole chain between a smart grid and smart home/building/industrial area. This standard is a flexible data model to facilitate common information exchange between electricity service providers, aggregators, and end users. • Open ADR: is used in explicit demand response scenarios • when specific signals are sent to cause devices to be turned off during periods of higher demand.
	Manage active power flexibility to support FCRn in the Finnish demo	A, AO (Data Update Request)	Hierarchial	f.ex. REST API	N/A	The same gap is identified as in the above mentioned use case. (the data exchange TSO-Aggregator, DSO-Market Operator, Aggregator-Asset Operator, and Aggregator-DSO are performed through proprietary protocols. The data standards need to be reviewed to address the data exchange with

						the aggregator role. Besides, it is also needed to deal with the data exchange between the aggregator and customers' appliances
		AO, A (Asset Data)		Asset to paltform used in different sub demos: REST API, Modbus TCP, OCPP, OPC UA		
		AO, A (Data Updated)	Without information	Without information		
		TSO, A (Accepted Bid)	PROPRIETARY	ELCOM		
		A, TSO (Bid)	PROPRIETARY	PROPRIETARY		
		A, DSO (Bid)				
		DSO, MO (Reactive Power Needs)	Without information	Without information		
		A, MO (Asset Offer)				
		MO, A (Bid Activation)				
		GA 1 - TSO 1 (aFRR request)				
		TSO 1 - GA 2 (Tests)				
		GA 2 - G 1 (VPPSetPoint)				
		G 1 - GA 3 (SetPoint)				
	Manage VPP active power flexibility to support aFRR in VPP Portuguese Demo	G 2 - GA 4 (Resource availability)	Could be IEC 60870-6 (TASE.2 ICCP) and OPC UA	Could be SFTP and SIEMENS WINCC OA	N/A	It is not possible to identify each data model and communication protocol per each interface (which data model and communication protocol is used per each interface) Lack of data for a further gap analysis
		TSO 2 - GA 4 (aFRR needs)				
		GA 5 - TSO 3 (Bid)				
		TSO 4 - GA 6 (Market closure result)				
		TSO 5 - GA 7 (SetPoint)				

		GA 7 - G 3 (VPP response) GA 7 - TSO 6 (VPPSetPoint) TSO 8 - GA 8 (Payment) TSO 9 - GA 9 (Invoice)				
	Manage VPP active power flexibility to support mFRR/RR in VPP Portuguese Demo	G 1 - GA 1 (Resource availability) TSO 1 - GA 1 (mFRR/RR needs) GA 3 - TSO 2 (Bid) TSO 4 - GA 4 (SetPoint) GA 4 - G 2 (VPP response) TSO 7 - GA 5 (Payment) TSO 8 - GA 6 (Invoice)	Could be IEC 60870-6 (TASE.2 ICCP) and OPC UA	Could be SFTP and SIEMENS WINCC OA	N/A	It is not possible to identify each data model and communication protocol per each interface (which data model and communication protocol is used per each interface). Lack of data for a further gap analysis
	Manage active power flexibility to support mFRR/RR and congestion management in the FlexHub Portuguese demo	TSO 1 - DSO 1/ TSO 1 - A 1 (Prequalification agreement - Contract between a market operator entity and a market agent to allow and regulate the market participation of the agent.	Without Information	SFTP		Coverage for forecasting (load and generation) and prediction of flexibility service/product are not necessarily sufficient. Computation of forecasting for different flexibility needs not covered in standards.
		TSO 2 - MO 1 / MO1 - A2 (P profile - Profile of active power needed for the 28 time-intervals of			N/A	It is needed to reinforce the CIM coverage for data exchange between smaller DERs and system operators. The data range includes real-time data on the setpoints of devices providing services.

		15 min of the delivering horizon of 7 hours.				
		A2 - MO2 (P bids)			N/A	Further standardisation for some requirements, especially for grid impact assessment, bid selection and management of flexibility bids is needed. Needs of covering flexibility services products, mainly congestion management and voltage control.
		DSO 2 - MO 3 (TL qualification)			N/A	Verify and settle activated flexibilities
		A3 - MO 3 (P profile)			N/A	Needed to cover aggregate energy data in standards (e.g., compatibility of aggregated data sets, aggregation from data source to data user)
		A4 - TNFP 1 / A4 - DNFP 1 (Control signal)			N/A	
		TSO 3 - TNFP 1 (Control signal)			N/A	
	Manage reactive power flexibility to support voltage control and congestion management in the FlexHub Portuguese demo	A1-DSO 1 (Prequalification agreement)	Without Information	SFTP	N/A	
		TSO 1 - MO 1 (Q profile)			N/A	
		MO 1 - A 2 (Q profile)			N/A	
		A 2 - MO 2 (Q bids)			N/A	
		MO 2 - TSO 2 (PQ Maps)			N/A	
		TSO 2 - MO 3 (Q profile)			N/A	
		A3 - DNFP 1 (Control Signal)			N/A	

		TSO 3 - DSO 4 (Settlement data)			N/A	
		DSO 4 - A 4 (settlement data)			N/A	
		A 4 - DNFP 2 (Settlement data)			N/A	
		MDO 2 - FP 4 (Settlement data)			N/A	
	Congestion management in the transmission system and distribution system using flexible resources connected to transmission and distribution system under the scope of a multi-level market mechanism.	Interface DSO-TSO Interface TSO-MO Interface FSP-MO Interface MO-TSO	Customized solutions	WS-505 & IEC 62325-504 in Common platform ICCP as a real-time communication protocol to set real-time limits to the FSP generation corresponding to the generation of bundles from the DSO	N/A	Regarding this use case some details about the information exchange are missing, or at least are not public, such as the data exchanged description, volume, frequency, the data model used and the communication protocols that establish the link between
CoordiNet	Procure and manage balancing services (FRR and RR) to reduce balancing cost under the scope of a central market mechanism	TSO-DSO market-based interaction	Customized solutions	WS-505 & IEC 62325-504 in central platform	N/A	The balancing platform is in the process of integration with European Regional initiatives.
	Voltage control provided to the TSO and DSO under the scope of a common market mechanism	TSO-DSO market-based interaction	Customized solutions	IEC 62325-504 ICCP communication	N/A	Customized solutions

4.3 Gap analysis for use cases selected from OneNet Demos with TSO focus

Table 7. Gap analysis for the use cases of the OneNet demos.

OneNET Demo	Use Case Name/ID	Interface	Used information model: customized solution/standard	Communication protocol used	Extension/ modification/ deviation	Gaps identified
Western cluster WECL-PT-03	Exchange of Information for Operational Planning	DSO-TSO 1	Custom, (based on IEC 62325)	REST API	Some changes were made in respect to the daily operation of both System Operators	There was some data needed for the daily operation of the Portuguese System Operators and is not identified in IEC 62325 , and as such the PT Demo had the need to adapt the template.
		DSO-TSO 2	Custom	REST API		
		DSO-TSO 3	Custom	REST API		
Western cluster WECL-PT-01	Exchange of Information for Congestion Management – Short Term	DSO-TSO 1	Custom (based on UMEI)	REST API	UMEI extension in order to consider the information exchange with the TSO	Since there was some data that is needed for the daily operation of the Portuguse System Operators, the PT Demo had the need to adapt the UMEI framework.
		DSO-TSO 2	Custom (based on UMEI)	REST API	UMEI extension in order to consider the information exchange with the TSO	Since there was some data that is needed for the daily operation of the Portuguse System Operators, the PT Demo had the need to adapt the UMEI framework.

		DSO-TSO 3	Custom (based on UMEI)	REST API	UMEI extension in order to consider the information exchange with the TSO	The PT Demo needs to adapt the UMEI framework.
Western cluster WECL-PT-02	Exchange of Information for Congestion Management – Long-Term Term	DSO-TSO 1	Custom (based on UMEI)	REST API	UMEI extension in order to consider the information exchange with the TSO	Since there was some data that is needed for the daily operation of the Portuguse System Operators, the PT Demo had the need to adapt the UMEI framework.
		DSO-TSO 2	Custom (based on UMEI)	REST API	UMEI extension in order to consider the information exchange with the TSO	Since there was some data that is needed for the daily operation of the Portuguse System Operators, the PT Demo had the need to adapt the UMEI framework.
		DSO-TSO 3	Custom (based on UMEI)	REST API	UMEI extension in order to consider the information exchange with the TSO	Since there was some data that is needed for the daily operation of the Portuguse System Operators, the PT Demo had the need to adapt the UMEI framework.
Eastern cluster EACL-PL-02	No information available	DSO-FP (CM&VC needs) TSO-FP (Balancing needs) FSP-FP (DER details) BSP-FP (Portfolio details FP-OneNet system (KPIs results)	Specific, developed during implementation of atFlex Platform	Graphical interface, import/export of Excel files	No information available	Eastern cluster demo is intending to use CIM in the future. Currently no standardized data models is used. There is no information if the communication protocol is based on standardized format.
Eastern cluster	No information available	Same information as in Eastern cluster EACL-PL-02	Specific, developed during implementation of atFlex Platform	Graphical interface, import/export of Excel files	No information available	Eastern cluster demo is intending to use CIM in the future. Currently no standardized data models is used. There is

EACL-PL-04						no information if the communication protocol is based on standardized format.
Southern cluster SOCL-CY-02	Reactive power flexibility and power quality	DSO 1 - DSO Local Market	CIM, COSEM, CGMES, ESMP, IEC 61850, customer structures (JSON, CSV)	REST, EFI, ICCP		Currently CIM/ CGMES does not cover all DSO needs. There are missing classes and attributes to cover all DSO requirements.
		DSO 2 - DSO Local Market				
		DSO Local Market 1 - FSP				
		DSO Local Market 1 - A				
		DSO Local Market - P1				
		DSO 4 - FSP2				
		DSO 4 - A2				
		DSO 4 - P2				

5 Recommendations and Implementation Requirements

Project Name	Gap listed	Recommendations	Implementation Requirements
EU-SysFlex	Proprietary information model is used. Additional info on used information model and communication protocols may be needed for further analysis.	Alignment with the existing standards for data exchange is recommended instead of keeping the proprietary solutions. The extension of the existing data models can be used to replace the proprietary solution.	IEC 61850, and IEC 61970-600-1, and IEC 61970-600-2 should be considered.
EU-SysFlex	It is not possible to identify each data model and communication protocol per each interface. Lack of data for a further gap analysis	It is recommended to align with the common standards, and communication protocols. The alignment with CIM/CGMES (IEC 61970-600-1, and IEC 61970-600-2) is also recommended.	The existing standard: IEC 60870-6 (TASE.2 ICCP) and OPC UA should be considered for the data models.
EU-SysFlex	Computation of forecasting for different flexibility needs not covered in standards. It is not possible to identify each data model and communication protocol per each interface.	It is recommended to reinforce the CIM coverage for data exchange between smaller DERs and system operators. The data range includes real-time data on the setpoints of devices providing services.	The extensions of CIM should be considered, alignment with CIM/CGMES (IEC 61970-600-1, and IEC 61970-600-2) is also recommended.
CoordiNet	Customized solutions are used for data model instead of standards. Details about the information exchange are missing, or at least are not public, such as the data exchanged description, volume, frequency, the data model used and the communication protocols.	Communication protocol was based on the WS-505 & IEC 62325-504. The data models was customized and it is recommended to follow the existing standards.	Congestion management in transmission system is well covered by CGMES IEC 61970-600-1, and IEC 61970-600-2, therefore, this IEC standard should be further extended to cover also the DSO needs.
CoordiNet	Customized solutions are used for data model instead of standards. Limited information provided regarding the data model components and characteristics.	The development of a standard messaging system will enable the implementation of business applications that can communicate balancing requirements between all involved parties in all European countries.	The alignment with existing standards should be considered: IEC- 62325-301, IEC 62325-351, IEC- 62325-451-1. IEC - 62325-451-2
Western cluster WECL-PT-01, 02, 03	Customized solution for data model is reported in the Western cluster use cases. There are missing details regarding the data model components and characteristics.	The use of CIM/CGMES is better option and recommended as a well-established standard data model, and that eases the interoperability of the solutions, however, currently there are Insufficient classes and attributes for business objects (Bos) for TSO-DSO data exchange in CIM/CGMES.	IEC 61970-301, CGMES: IEC 61970-600-1, and IEC 61970-600-2, should be extended in the future with respective classes and attributes to cover all TSO-DSO data exchange requirements.
Eastern cluster	Eastern cluster demo is intending to use CIM in	The use of CIM/CGMES is better option and recommended and this is in line with the	IEC 61970-301, CGMES: IEC 61970-600-1, and IEC 61970-

EACL-PL-02, 04.	the future. Currently no standardized data models is used. There is no information if the communication protocol is based on standardized format	objective of the Eastern cluster, which is planning to adopt CIM/CGMES.	600-2, should be used as a data model.

Grifon Output

This output was collected from the Griphon workshop dicssuion organized in three groups, that addressed specific question related to the data exchange and interfaces for the TSOs. Besides the data exchange topic, cybersecurity questions were also involved and the output is summarizing all conclusions.

- Develop common standards,
- Increase information exchange in automatic mode,
- Create data hub or central exchange platform between TSO and DSO,
- Use of the Blockchain - as a means to give restricted access to selected data,

- Exchange in advance the information about data models, communication protocols, data formats, tools, etc.
- Improve and clarify more the data exchanges in the boundary and for specific regions,
- Improve General IT security reflecting business requirements.

6 Conclusions

The report provides some important conclusions regarding how H2020 projects and OneNet demos address topics such as interface, data models, role models, communication protocols etc, either by using common practices or by proposing innovative concepts. Most of the projects use different types of platforms and interfaces which involve a wide variety of actors. The developed tools for data exchange varied, with the ones that focused on TSO-DSO coordination receiving slightly more attention. Regarding data models, IEC standard 61970-301 (CIM) is used in most projects. The CIM is used to structure and encapsulate data in a unified format (mainly in XML messages, but also JSON) that is widely used in the energy domain for data exchange. In addition, the projects that defined role models, based their definition on the ones already existing in HERM. Only for the roles not explicitly defined in HERM, they introduced their own definitions based on what roles the different actors adopted in the context of the process of interest of each project.

There is more focus on the **a.** Information and **b.** Communication layer of the SGAM reference architecture. However, other layers of the SGAM are sometimes also considered. Use cases have a different focus, some case focus on only one model, while others opt for a combination of models. The preferred coordination models considered in most use cases are:

- TSO-Market based Interaction
- DSO-Market based Interaction.
- TSO-DSO Market based Interaction

For the interface to smart appliances, several standards or initiatives were used. However, none of them is yet sufficiently implemented by the solutions/market. CIM is proposed in many TSO and DSO interactions. However, the current CIM standard does not cover enough the energy forecast, DER, Flex data and TSO-RSC interface, which is further recommended as an output of the WP4 analysis in the recommendations chapter.

There are few dedicated platforms for energy data exchanges; some are used as input in the projects, and others are even (further) developed as part of the projects. In addition, there are some data platforms not specific to energy data but rather vendor products for any data exchanges.

Main challenges:

The common ground where most of the challenges can be grouped are:

1. Interoperability:
   a) Interfacing with other systems (either legacy systems or between new platforms)
   b) Lack of standards for certain interfaces
2. Data handling:
   a) Data ownership and data access TSO-DSO Coordination
   b) Data quality
   c) Data Harmonization.

7 References

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2. CEN-CENELEC-ETSI Smart Grid Coordination Group, 2014. SG-CG/ M490/F_ Overview of SG-CG Methodologies, version. 3.0
3. ENTSO-E, EFT and EBIX. The Harmonized Electricity Market Role Model. 2020
4. EU-SysFlex. Helen OY. https://eu-sysflex.com/partners/helen-oy-helen/
5. Common Grid Model Exchange Specification-GMES (IEC 61970-600-1).
6. Common Grid Model Exchange Specification-GMES (IEC 61970-600-2).

8 Appendix

Table 8. Description of the standards recommended as part of the implementation requirements chapter.

IEC Reference	Title	Short Description
IEC 62325-301	Framework for energy market communications - Part 301: Common information model (CIM) extensions for markets	This Standard specifies the common information model (CIM) for energy market communications.
62325-351	Framework for energy market communications - Part 351: CIM European market model exchange profile (ESMP)	This Standard specifies a package which provides a logical view of the functional aspects of European style market management within an electricity market.
62325-451-1	Framework for energy market communications - Part 451-1: Acknowledgement business process and contextual model for CIM European market	This Standard specifies a package for the acknowledgment business process and its associated message contextual model, assembly model and XML Schema for use within the European style electricity markets.
62325-451-2	Framework for energy market communications - Part 451-2: Scheduling business process and contextual model for CIM European market	This Standard specifies a package for the scheduling business process and its associated message contextual models, assembly models and XML Schemas for use within the European style electricity markets
IEC 61970-600-1	Energy management system application program interface (EMS-API) - Part 600-1: Common Grid Model Exchange Standard (CGMES) - Structure and rules	IEC 61970-600-1:2021 covers the definition of Common Grid Model Exchange Standard (CGMES), defines the main rules and application's requirements to meet business requirements for assembled and merged model to fit relevant business services
IEC 61970-600-2	Energy management system application program interface (EMS-API) - Part 600-2: Common Grid Model Exchange Standard (CGMES) - Exchange profiles specification	IEC 61970-600-2:2021 defines the profiles included in the Common Grid Model Exchange Standard (CGMES) that are based on IEC 61970-450-series and IEC 61968-13 profiles

GBP Diagrams:

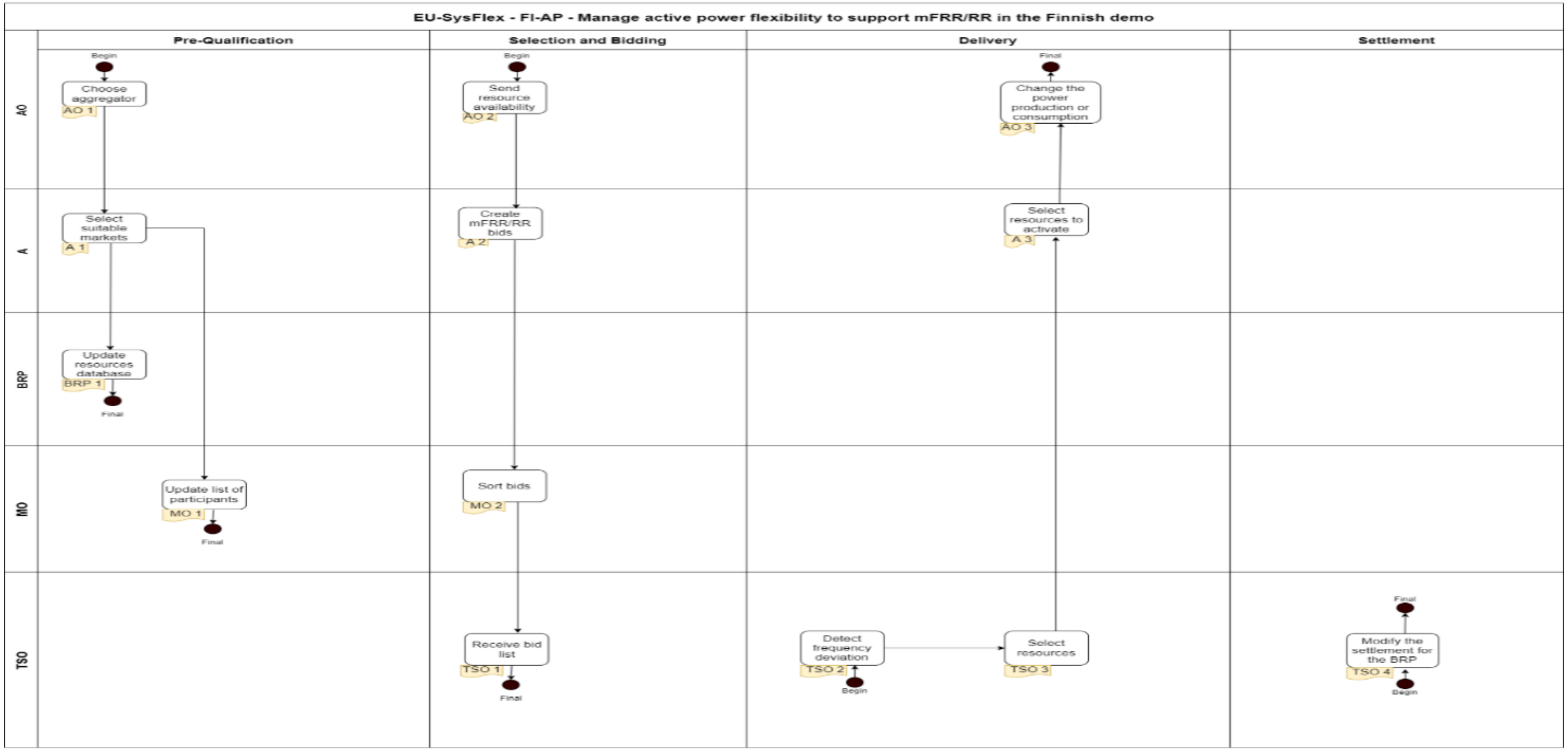

Figure 10. Sequence diagram - Manage active power flexibility to support mFRR/RR in Finish demo

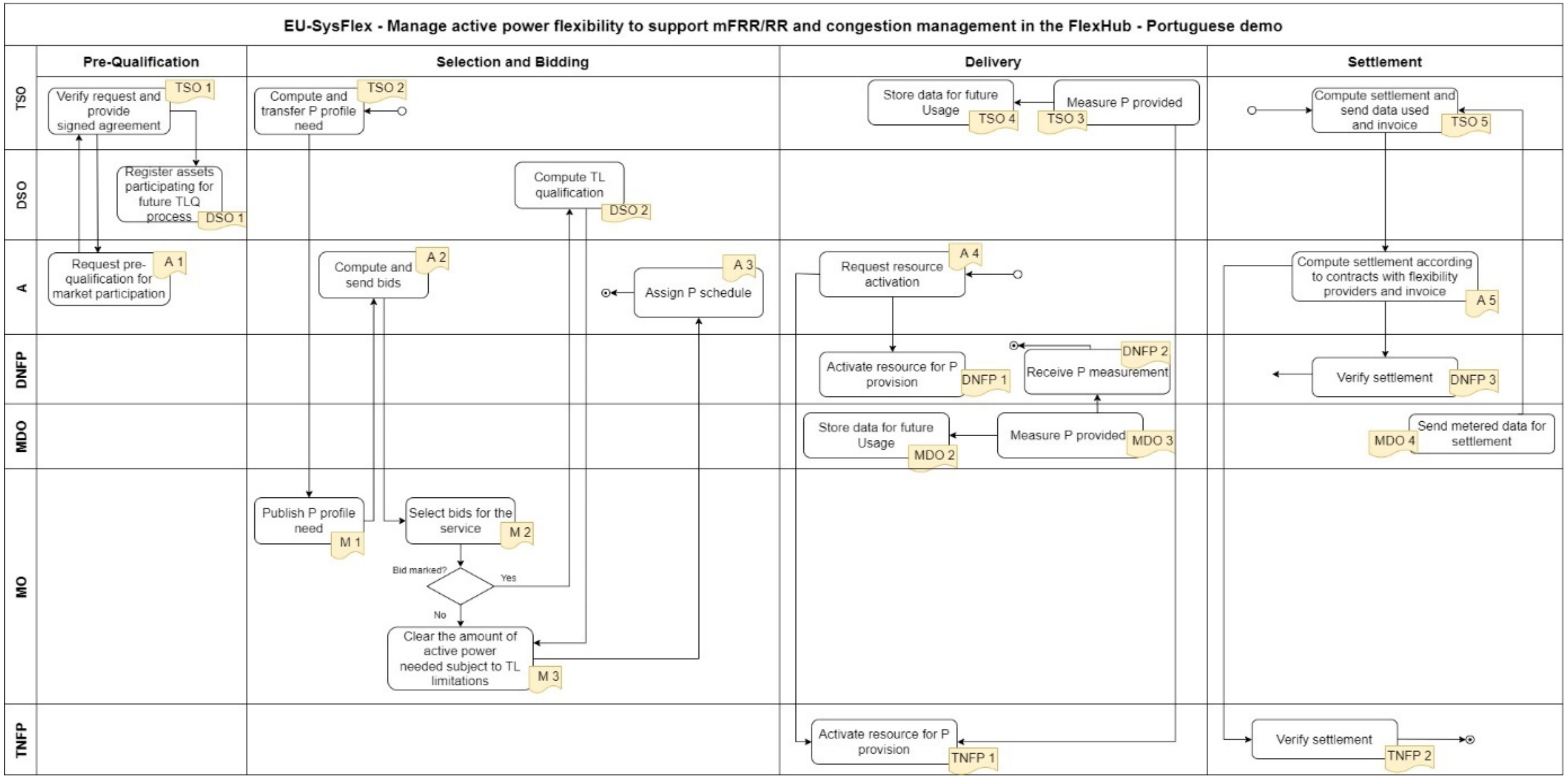

Figure 11. Manage active power flexibility to support mFRR/RR and congestion management in the FlexHub Portuguese demo

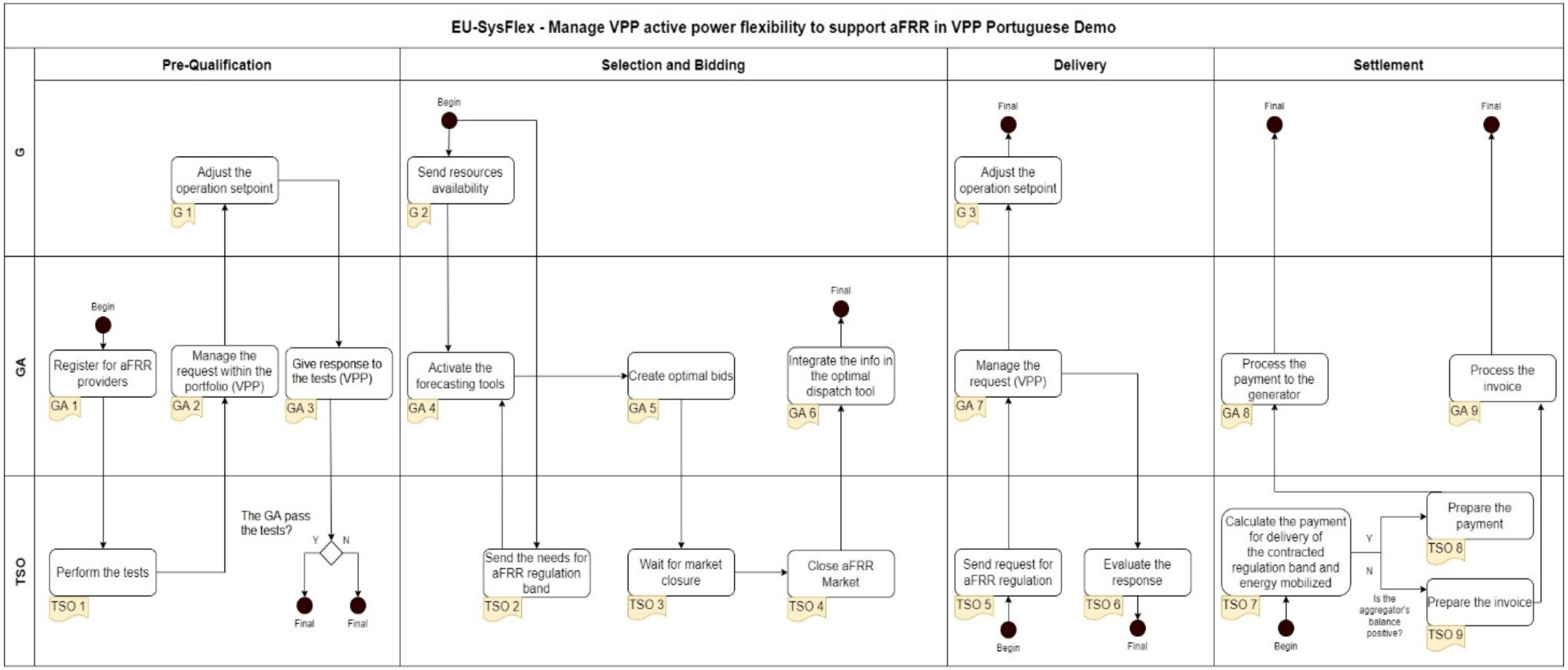

Figure 12. Manage VPP active power flexibility to support aFRR in VPP Portuguese Demo

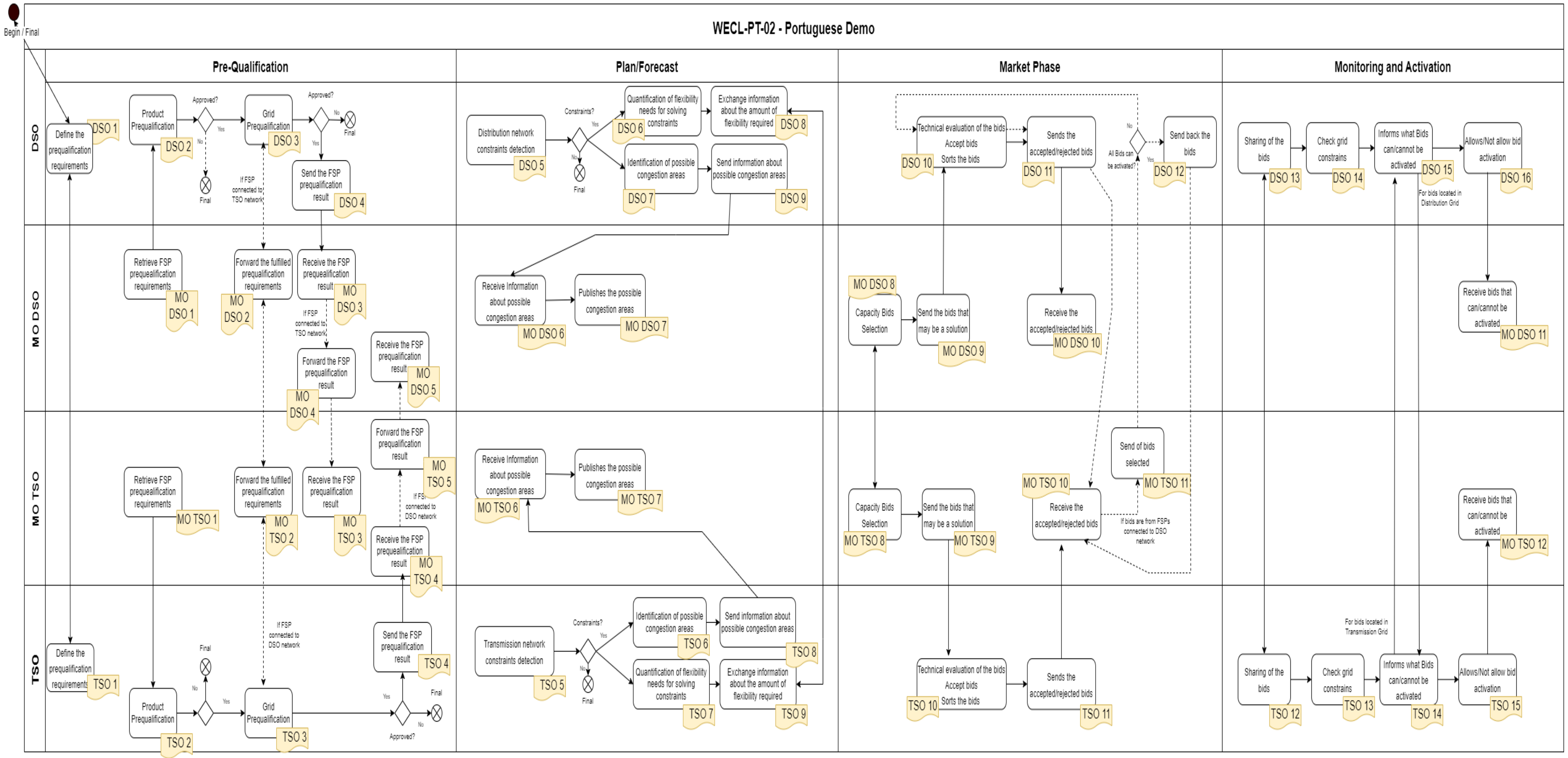

Figure 16. Exchange of Information for Congestion Management for Long-term – Process phases

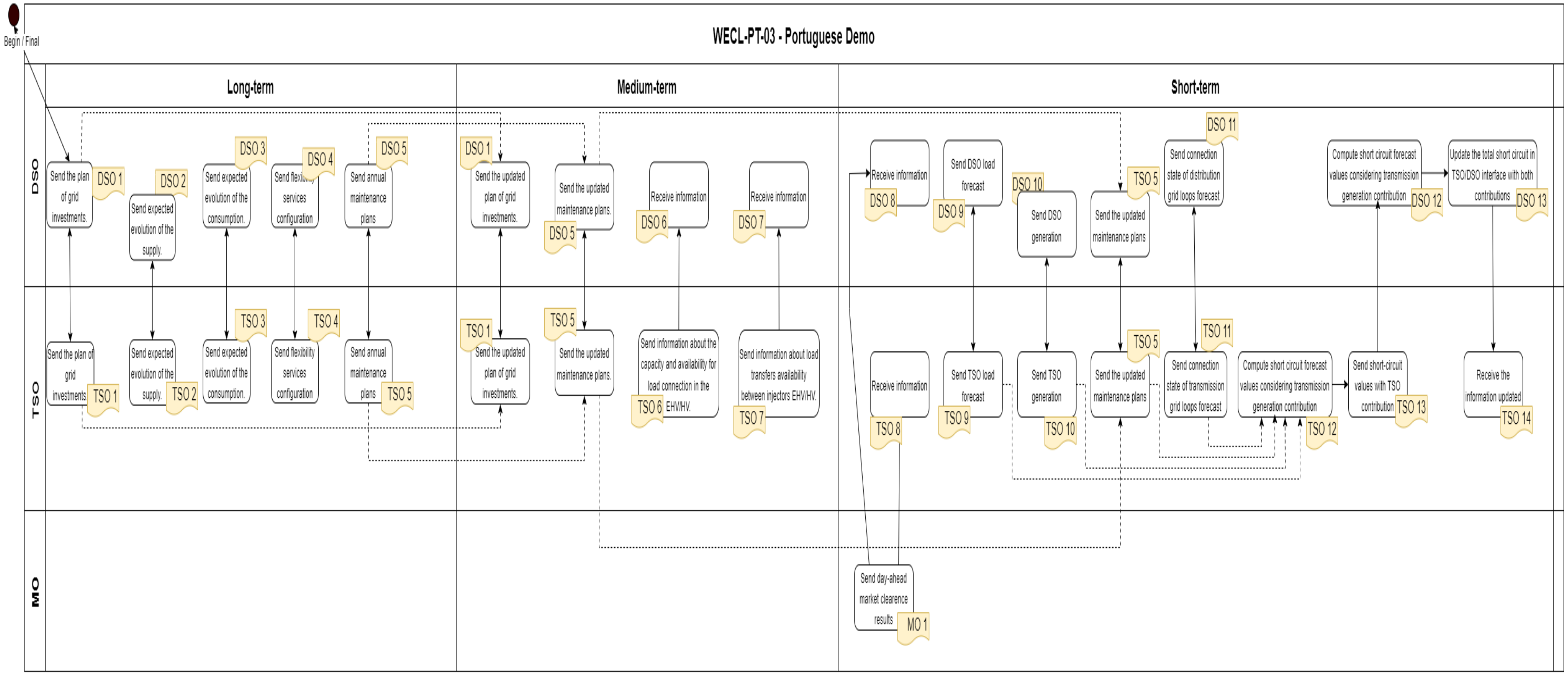

Figure 17. Exchange of information for Operational Planning – Process Phases